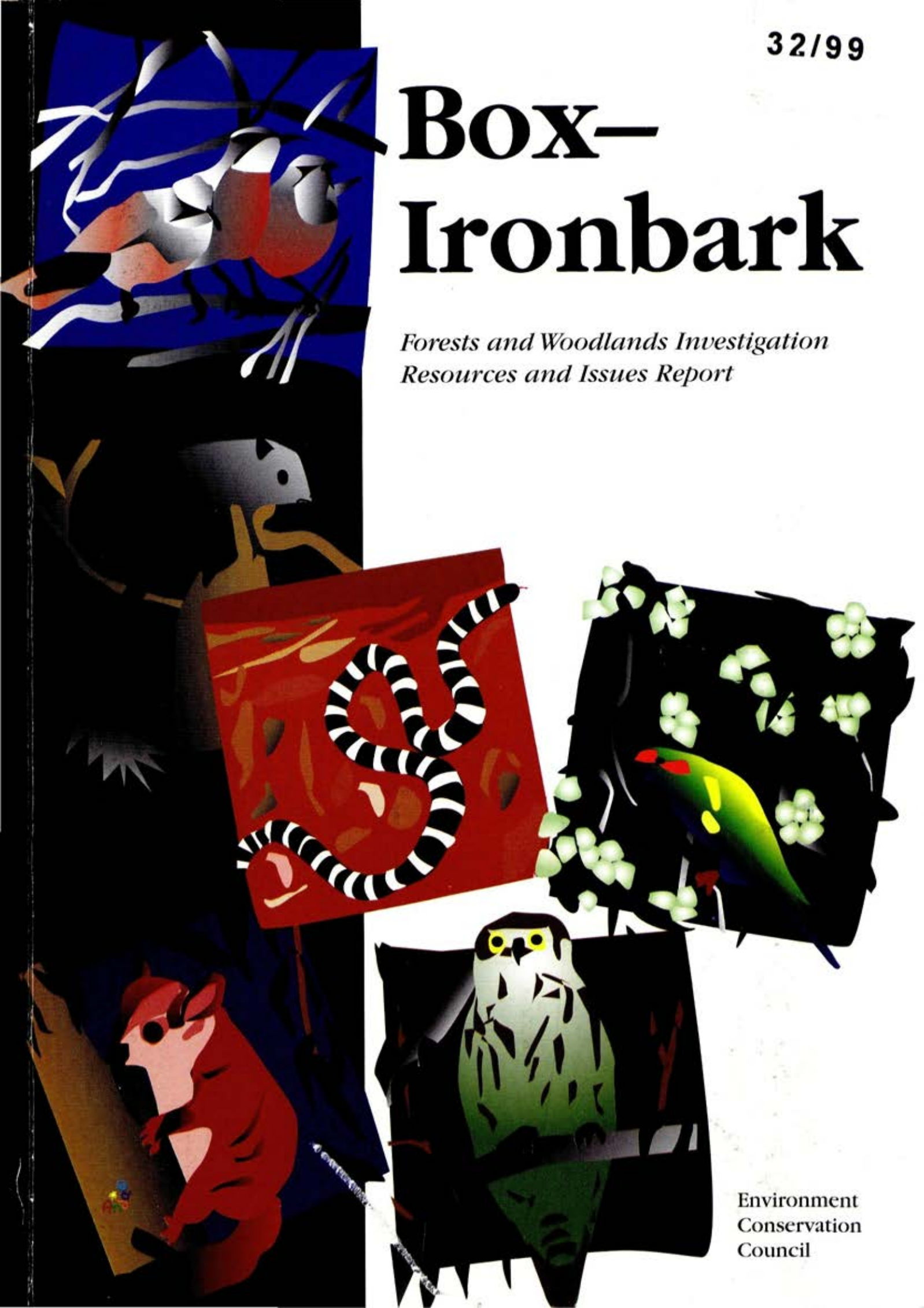


# Box- Ironbark

*Forests and Woodlands Investigation  
Resources and Issues Report*



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*Resources and Issues Report*

DECEMBER 1997

**ENVIRONMENT CONSERVATION COUNCIL**

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Price: \$14.00

Cover by Brouhaha Design, based on photographs of: grey-crowned babblers, top left (photo by Peter Adam), brush-tailed phascogale, centre left (Charles Silveira), squirrel glider, lower left and bandy bandy, centre (Peter Robertson), and musk lorikeet and barking owl, right (Paul Peake).

ISBN: 0 7306 6781 2

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## FOREWORD

The Box-Ironbark region holds a special attraction for a large number of Victorians, both visitors and residents of the region. It interests a diverse cross-section of the community — historians, apiarists, naturalists, miners, biologists, prospectors, the farming sector, foresters, food and wine buffs, firewood users, geologists, orienteers, and other recreationists. The resulting demands placed on the public lands of the region are considerable and not always compatible.

The Environment Conservation Council was established in July 1997 under the *Environment Conservation Council Act 1997*. The main function of the Council is to carry out investigations into the balanced use or development of public land and its associated flora, fauna, minerals and water. The Box-Ironbark Investigation will be the first investigation wholly undertaken by the Environment Conservation Council.

The primary purpose of this Resources and Issues Report is to satisfy the requirement, under the Terms of Reference for the Investigation, to identify and evaluate the extent, condition, values and uses of the Box-Ironbark forests and woodlands. The other main requirements of the Terms of Reference — recommendations on the balanced use of these areas — will be addressed in subsequent reports.

The characteristic grey-green box-ironbark forests and woodlands on the inland slopes of the Great Divide and adjacent plains form a distinct biogeographic region — occupying some 14 per cent of the State — between the wetter mountain forests to the south-east, and the semi-arid inland to the north-west. Although most of the native vegetation has been cleared, the areas with remaining native vegetation are well known for their diverse flora and fauna. Spectacular displays of spring wildflowers, and a large number of threatened species are particular features. The region is also the centre of the apiculture, firewood, and gold mining industries in Victoria, while around 30 per cent of the State's agricultural production (in dollar terms) comes from private land in the region.

This report documents the public land uses and values of Box-Ironbark forests and woodland areas to provide a factual basis for objective assessment and later recommendations. Of course, there is some information on Box-Ironbark forests and woodland areas of which we are currently unaware. The Council encourages groups and individuals who have such information, particularly information about the uses and values of specific areas, to become involved in the Investigation and add to the existing information base.

Submissions are now invited and should be sent to the Executive Officer, Environment Conservation Council by 9 March 1998. After considering these submissions, the Council will prepare a Provisional Report with recommendations on the balanced use of these areas, as a basis for further public consultation. The Council will then prepare its Final Report on the outcome of the Investigation for presentation to the Minister for Conservation and Land Management by 31 December 1998, and subsequent tabling in Parliament.

Public land belongs to all Victorians, and the Environment Conservation Council is keen to involve a wide range of people in its investigations. We are looking forward to your involvement in the Box-Ironbark Investigation.

Don Saunders  
Chairman

Environment Conservation Council  
4th Floor, 115 Victoria Parade  
FITZROY VIC 3065

## ACKNOWLEDGEMENTS

The Council acknowledges the Land Conservation Council's role in the initial stages of the preparation of this report.

The Council also wishes to thank the following people and organisations for their assistance and cooperation in contributing to the report.

Information and advice was provided by the study group for the Investigation — Peter Watkinson, Andrew Walker, Peter Stone, Pamela Robinson, Doug Robinson, Lynn Murrell, Annette Muir, Chris Mitchell, Mal McKinty, Donald Malcolmson, Doug Hooley, Lesley Hodges, Sue Harris, John Gray, Brendan Edgar, Susie Duncan, Caroline Douglass, Roger Buckley, Andrew Bennett, and Peter Attiwill.

Several chapters are based on text prepared by the following people and organisations: Chapter 2 — Ian Clark; Chapter 3 — Jill Barnard and Jenny Keating; Chapter 4 — Iain McHaffie, Roger Buckley, Neville Rosengren and Bernie Joyce; Chapter 7 — Susie Duncan; Chapter 8 — Susie Duncan (with assistance from M. Woodward, J. Waayers, P. Sheehan, W. Peel, D. Parkes, D. O'Bryan, A. Muir, D. Meagher, A. McMahon, J. Kellas, G. Carr, S. Berwick, G. Barrow); Chapter 9 — Charles Silveira, Alan Yen, Andrew Bennett, Geoff Brown, Simon Hinkley, Richard Loyn, Lindy Lumsden, and Bill Smith (with assistance from J. Alexander, B. Baxter, R. Brereton, P. Clunie, A. Corrick, D. Gibbons, D. Hesse, G. Horrocks, P. Johnson, B. Kirkwood, S. Krasna, R. MacNally, J. Nelson, T. Raadik, P. Robertson, J. Silins, C. Tzaros, R. Webster); Chapter 12 — Andrew Brookes and others from La Trobe University, Bendigo; Chapter 15 — Scott Ridges, with some information from Forests Service; Chapter 16 — Martin Woodward, Paul Turnbull and Mal McKinty; Chapter 17 — Iain McHaffie, Roger Buckley, Guy Hamilton, Phil Roberts, and Doug Sceney; Chapter 19 — Peter Watkinson.

Several organisations provided information for the Investigation: the Department of Natural Resources and Environment (NRE), Environment Australia, Goulburn-Broken and North Central Catchment and Land Protection Boards, the Roadsides Conservation Advisory Committee, Trust for Nature.

The following people made significant contributions to several aspects of the study: Rob Price, Rae Moran, Paul Foreman, and Ian Davidson.

Editorial assistance was provided by Penultimate Publication Services, with report design by ArtMind Pty Ltd, layout by Janet Hainsworth and word processing by Joy Vine. Most maps and figures were drafted by George Mifsud, Phill King, Roger Heeps, and Peter Smith of Natural Resource Systems, using information from NRE (in particular Flora Branch for vegetation mapping, and Minerals and Petroleum for geological mapping and earth resource data), Council's records, consultancies, and the Bureau of Meteorology. Artwork for maps 5, 6 and 7 was supplied by Ian Clark.

The Commonwealth Government, through Environment Australia and the Department of Primary Industries and Energy, funded or contributed to: a study of recreation use; a heritage data audit; surveys of historical sites; an environmental history; selected small blocks study; and a survey of sites of geological and geomorphological significance, as part of the regional forest agreement process. The assistance of Peter Channells, Terence Uren, Tom Aldred, Katie Saxby, Brendan Edgar, Keith Lamb, Ian Miles, and Daniel Catrice in facilitating these projects is appreciated. Main personnel included Brendan Marshall, Rebecca Jones, Graeme Butler, Gary Vines, David Bannear, Ian Davidson, Paul Foreman, Neville Rosengren, Bernie Joyce, and the contributors to Chapters 3 and 12.

The report was prepared by Simon Ransome, Paul Peake and Anita Brady with assistance from Colin Dimech, Sally McCormick, Simon Kennedy and Jean-Marc Porigneaux.

Photographs were provided by Bernie Young, Michele Summerton, Charles Silveira, Linda Sharpe, Neville Rosengren, Peter Robertson, Rob Price, Paul Peake, Annette Muir, Ian McCann, Simon Kennedy, Denis Hersey, Roger Handy, Susie Duncan, Andrew Brookes, Peter Adam, and La Trobe Picture Collection, State Library of Victoria (page 19).

Preparation of the report was directed by Michael Crowe and Shane Dwyer, the Council's Executive Officer.

# 1. INTRODUCTION

## BACKGROUND TO THE STUDY

Over 80 per cent of Australians live in urban areas on the south-eastern seaboard, yet Australia's image is strongly flavoured by the 'outback' — the sparsely populated central and northern regions of the country. In the centre of this paradox is the box-ironbark country, with as great a claim as any to shaping the icons and self-image of Australia over the last 200 years. The quintessential Australian term 'digger', for example, originated on the 1850s goldfields in the box-ironbark country of Victoria and New South Wales. Both Henry Lawson and 'Banjo' Paterson were raised in box-ironbark country, and its distinctive landscape and effect on its inhabitants resonate through works such as 'The Ironbark Chip' and 'The Man from Ironbark'. And, more than anywhere else in Australia, box-ironbark was the home of bushrangers, particularly the most famous — Captain Melville, Frank Gardiner and Ben Hall, Dan 'Mad Dog' Morgan, Captain Moonlite and, of course, Ned Kelly.

This cultural heritage is very much a function of the box-ironbark country's natural features and resources. Between 1851 and 1861, approximately 35 per cent of the world's gold production came from Victoria, nearly all of it from the box-ironbark goldfields. It was a dominant force in the shaping of colonial Victoria. The signs of this wealth remain evident in many aspects of modern Victoria. The wealth generated by gold was also an incentive for a great increase in the numbers and activity of bushrangers. The diversity of landscapes in and adjacent to the box-ironbark country provided open country for rapid escape on horseback, and dense, hilly or rocky country for secluded hide-outs, which were also essential preconditions for the bushranging era.

The characteristic box-ironbark plants and animals, with their added mix of both inland and Dividing Range species, recur in the defining literature and other elements of the national identity. Box-ironbark forests and woodlands are dominated by eucalypts and wattles, and are the home of golden wattle - the bright green and gold national floral emblem. Similarly, many box-ironbark eucalypts are rich in the oils which give the bush its distinctive aroma,



*Typical box-ironbark vegetation of the sedimentary hills, dominated by red ironbark, Webla Forest.*

and commercial production of eucalyptus oil dates from the earliest days of settlement in the box-ironbark country.

Box-ironbark eucalypts are also notable for the density of their timbers and their volume of nectar production, features which play a conspicuous role in both the natural processes and the human utilisation of box-ironbark ecosystems. Some 70 per cent of Victoria's honey and around 50 per cent of its firewood are produced in box-ironbark forests and woodlands.

The large numbers of visitors attracted to the natural and cultural values of box-ironbark forests and woodlands serve to emphasise their important social and recreational values, which also have consequent economic benefits. In addition, box-ironbark forests and woodlands provide a distinctive character to the landscape for the people who live within or visit the box-ironbark country.



*Characteristic grey box grassy woodland on the northern plains near Violet Town.*

None the less, until recently, box-ironbark forests and woodlands remained Australia's 'forgotten forests', according to Calder *et al.* (1994). While controversies have flourished over wet mountain and coastal forests, box-ironbark forests and woodlands have been barely mentioned in the national forests debate. However recent major studies have highlighted both the diversity of the box-ironbark flora and fauna, and its limited representation in conservation reserves. In south-eastern Australia, box-ironbark country comprises the core of the temperate woodlands. Broad-scale, often nation-wide assessments of biodiversity and its decline by Garnett (1993) and Biodiversity Unit (1995) have identified woodlands, especially temperate woodlands, as key areas where biodiversity decline is evident. In the last few years, a number of government and other initiatives have begun to focus attention on the box-ironbark country. Several of these are listed in the references.

At the same time, there have been significant developments in the technologies used to detect mineral deposits, leading to a re-evaluation of the mineral resources of the area, particularly of gold remaining after the 1850s gold rushes and subsequent mining.

There has been no systematic assessment of public land use of the box-ironbark country as a single system, and no public land use assessment in a substantial section of the box-ironbark country since the Land Conservation Council (LCC) Murray Valley Study concluded in 1985. A great deal of new information has become available in the decade since, while the poor reservation status of the box-ironbark forests and woodlands has not improved significantly.

In 1996 the Government required the LCC to carry out a special investigation of box-ironbark forests and woodlands in northern Victoria. That investigation was commenced, and much information was collected, with assistance from the Department of Natural Resources and Environment (NRE) and Commonwealth agencies. A draft report was prepared describing the resources, values and uses in the area, and that has formed the basis of this report.

## Environment Conservation Council

The *Environment Conservation Council Act 1997* was debated and passed in the Autumn 1997 Parliamentary Session, and came into operation on 1 July 1997. This revoked the *Land Conservation Act 1970*, abolished the Land Conservation Council, and established a new 3-member Council.

The functions of the Environment Conservation Council (ECC) are to carry out investigations requested by the Minister into the balanced use or development of public land or associated resources or values.

Appendix I contains selected extracts from the *Environment Conservation Council Act 1997*. 'Public land' defined in the Act includes reserved or unreserved Crown land, State forest, parks and other areas under the *National Parks Act 1975*, and land vested in public authorities other than municipal councils. Water authority land in sewerage districts is also not public land. Crown land and other publicly held land in cities and rural cities is included.

The Act provides the opportunity for public submissions to be made to the Council, within 60 days or other specified

time after published notice. For complex investigations, a further period for submissions may be advertised.

In her Second Reading Speech on the Act, the Minister for Conservation and Land Management indicated that the Council would pick up and complete work already done by LCC, in accordance with a new reference.

## Terms of Reference

In December 1997 the Council received from the Minister a request for an investigation of Victoria's Box-Ironbark Forests and Woodland Areas, as reproduced in the box below.

The Minister, under Section 17 of the *Environment Conservation Council Act 1997* requires the Environment Conservation Council to carry out an investigation of Victoria's Box-Ironbark Forests and Woodlands occurring on public land in northern Victoria. The area to be investigated is the box ironbark ecosystem stretching from the Grampians in the west to Wodonga in the north-east. The investigation area is shown on the attached map.

In accordance with Section 23 of the Act the Environment Conservation Council is required to present a written report on the outcome of its investigation in the prescribed form by 31 December 1998.

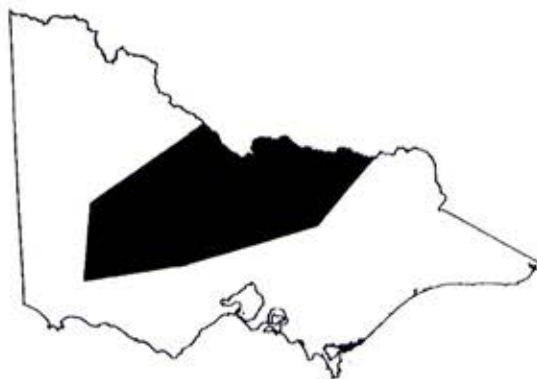
Having regard to the matters to be taken into account in investigations as provided in Section 20 of the Act, including the economic and social value of any existing and proposed development or use of the land or resources, the investigation must:

- identify and evaluate the extent, condition, values and uses of the Box-Ironbark Forests and Woodland areas in Northern Victoria.
- make recommendations on the balanced use of these areas.
- in making recommendations on the balanced use of Box-Ironbark Forest and Woodland areas the Council should have regard to the Nationally Agreed Criteria for the establishment of a comprehensive, adequate and representative reserve system recognising that informal reserves and prescriptions will be established through the regional forest management planning processes.

The area indicated on the map referred to in the Terms of Reference is denoted in Figure 1. It defines an investigation area of approximately 5.9 million hectares. The actual area being studied is substantially less than that, as explained below.

## Figure 1: The Box-Ironbark Forests and Woodlands Investigation Area

The shaded area is that depicted in the map attached to the Minister's request for the investigation.



## Investigation area and land included

Stated simply, the Terms of Reference embrace three criteria, all of which must be satisfied for land to be included in the investigation:

1. it must be a 'box-ironbark forest and woodland area';
2. it must be public land (as defined in the *Environment Conservation Council Act 1997*); and
3. it must occur within the investigation area delineated on the map attached to the Minister's request (see Figure 1).

Because the investigation area covers vegetation not found in 'box-ironbark forests and woodland areas', it is necessary to define within the investigation area a smaller study area which will be the focus of the study. In summary, the two terms as used in this report are defined as follows:

- **investigation area** — the area shown in Figure 1; and
- **study area** — the area of public land where box-ironbark forests and woodland areas are the natural vegetation type.

Thus, box or ironbark forests or woodlands which occur outside the delineated investigation area, for example in southern Victoria, are not included in the investigation, nor are areas of other vegetation types such as grasslands which

occur within the delineated investigation area. The definition of 'box-ironbark forests and woodland areas' is clearly central to the demarcation of the study area. A precise definition, including the requisite technical, botanical discussion, is provided in Chapter 7. The following description provides a simpler characterisation.

#### Characterisation of the Box-Ironbark study area

While the term 'box-ironbark' refers to common tree species in the study area, especially grey box, red ironbark and mugga ironbark, these species are not found at all sites in the study area. For example, patches of mallee, associated with gravelly clay soils on low rises are found between Wychitella and Whroo. These vegetation communities are dominated by green mallee, blue mallee and bull mallee. However, they contain a suite of understorey plants that has more in common with communities dominated by non-mallee box-ironbark eucalypts such as those listed above, than it does with mallee vegetation in the north-west of Victoria and elsewhere. This pattern is largely a reflection of soils: mallee vegetation between Wychitella and Whroo occurs on shallow clay soils, usually with ironstone gravel, that contrast to the mallee of north-west Victoria on deep sands.

On the other hand, many areas which are dominated by box-ironbark eucalypts — such as parts of the Brisbane and Otway Ranges and the Upper Snowy Valley — are generally thought of as botanically distinct from box-ironbark forests and woodlands in northern Victoria because of differences in the understorey flora. Understorey vegetation is often the predominant determinant of vegetation types.

In northern Victoria, box-ironbark vegetation occupies the zone between the Murray River and the dense, wet mountain forests of the Dividing Range. There are two distinct physiographic units within this area — the inland hills and the northern plains. The inland hills are mostly composed of Palaeozoic sediments, although many other geologies are apparent, particularly granites and associated metamorphics. Consequently, topography and soils in the inland hills are comparatively variable, and there is a corresponding diversity of vegetation types — including heathy, grassy, sedge-rich, and herb-rich woodlands and forests, several communities associated with granitic and metamorphic outcrops, mallee communities, and woodlands on low rises and alluvial terraces which are

similar to those on the northern plains. Several authors — Muir *et al.* (1995), for example — have referred to the inland hills component as the 'box-ironbark ecosystem'.

The comparatively uniform northern plains consist of alluvium deposited on the former floodplains of ancient watercourses over the last 2 million years. The plains are almost flat, broken with sand ridges and low, eroded Palaeozoic rises, and dropping to the lower elevation floodplains of the major present-day waterways. The vegetation on the lower elevation floodplains is dominated by grassy river red gum and black box forests and woodlands. The adjoining elevated plains or terraces are dominated by grassy and shrubby grey box woodlands. Other habitats, particularly wetlands, are scattered through both physiographic units. The absence of steep slopes and the presence of more fertile soils on the northern plains, make them better suited to many types of agriculture, particularly a range of crops, than the poorer soils and steeper slopes of the inland hills.

The LCC considered that the Box-Ironbark special investigation should:

- include box-ironbark forests and woodlands on the inland hills and on the elevated terraces of the northern plains, but
- not include native grasslands on the elevated terraces, or river red gum and black box forests and woodlands on the lower elevation floodplains, although the relationships between these habitats and those included in the investigation have been noted and should be considered.

The Minister for Conservation and Land Management agreed to these clarifications.

#### The Box-Ironbark study area

The study area, then, comprises those parts of the investigation area which supported box-ironbark vegetation at the time of European settlement — grey box woodlands on the northern plains, and a variety of vegetation types on the inland hills. Map 1 indicates the approximate extent of the Box-Ironbark study area, which is around 3.1 million ha, or about 14 per cent of the total area of Victoria. The northern plains and inland hills components each occupy about half of the study area. Public land comprises approximately 437 255 ha, or about 14.3 per cent of the study area.



Map 2 indicates the municipalities within the investigation area. Approximately 300 000 people live in the study area (ABS 1996 Census).

The extent of the study area is also shown on the major maps located in the back pocket of this report. Map A illustrates the distribution of public land in and adjoining the study area, and its uses. Map B characterises vegetation on public land. Map C depicts the extent of gold and other earth resources across the box-ironbark goldfields.

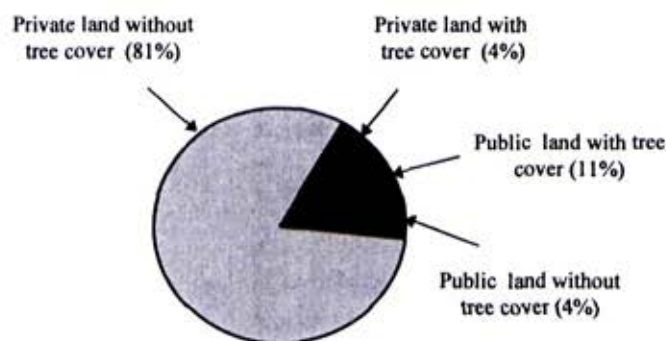
**Vegetation — before European settlement and in 1993**

At the time of European settlement virtually all of the study area would have been timbered with forests or woodlands — see Map D which shows an approximate prior extent of vegetation types. In 1993, the extent of tree cover in the study area was around 453 600 ha, or about 15 per cent of its pre-European extent. Of this, 325 705 ha of land with tree cover occurred on public land. Table 1 and Figure 2 summarise these data. In general, both public land and remaining tree cover are much less well represented on the northern plains than the inland hills.

**Table 1: The area of public and private land in the study area with and without tree cover in 1993**

Tenure	With tree cover (ha)	Without tree cover (ha)	Total (ha)
Public	325 705	111 550	437 255
Private	127 895	2 497 073	2 624 968
Total	453 600	2 608 623	3 062 223

**Figure 2: The proportion of public and private land with and without tree cover in 1993**



The relationships and distinctions between box-ironbark and adjacent vegetation types are explored more fully in Chapter 7. Detailed descriptions of the floristics of vegetation types included in the study area are provided in Chapter 8.

**THE INVESTIGATION PROCESS**

This Resources and Issues Report forms the first major stage of the investigation process: it contains no recommendations for land use — its purpose is to provide a factual basis for the formulation of future advice to the Minister for Conservation and Land Management.

A first period for public submissions is now open. Following this period, the Council will develop proposals for balanced public land use and development, for publication in the Provisional Report.

A second submission period will follow, to obtain community views on the proposals in the Provisional Report, before the Council formulates its Final Report to the Minister.

**PREVIOUS LCC STUDIES**

To investigate public land use in Victoria, the LCC divided the State into 13 study areas, four of which were subdivided into districts (Map A).

The Box-Ironbark investigation area completely encompasses the North Central study area, and all but about 40 300 ha (or 2.4 per cent) of the Murray Valley study area. Together these two study areas cover approximately 59 per cent of the Box-Ironbark investigation area. Portions of six other study areas (see Map A) make up the remaining 41 per cent.

In addition to the systematic regional assessments of public land use, LCC completed six reviews and special investigations of relevance to the Box-Ironbark forests and woodland areas investigation:

- North-eastern Area (Benalla - Upper Murray) Review — Districts 1, 2 and 4
- Melbourne Area District 1 Review
- Melbourne Area District 2 Review

- Mallee Area Review
- Rivers and Streams Special Investigation
- Historic Places Special Investigation, South-western Victoria

The LCC's 1988 Statewide Assessment of Public Land Use reviewed policies and collated new information, including geomorphic units and land systems (see Map E).

Under the *Environment Conservation Council Act 1997*, previous approved LCC recommendations for the study area have continuing operation.

The definition of 'public land' under the *Land Conservation Act 1970* previously excluded land in the municipal districts of city and rural city councils, and earlier, land in towns and boroughs. Land in country cities and towns excluded from previous studies by that clause is shown on Map A as 'uncategorised public land'.

## OTHER CONCURRENT PROCESSES AND PROGRAMS

The ECC Box-Ironbark investigation is being undertaken in parallel with a number of other programs and processes relevant to box-ironbark in northern Victoria. Where appropriate, the Box-Ironbark investigation and other programs are working cooperatively to maximise mutual benefits. These programs are discussed in detail in the appropriate chapters; for example, the Victorian Initiative for Minerals and Petroleum is discussed in Chapter 17. Pertinent Commonwealth programs and processes, and the Victorian *Catchment and Land Protection Act 1994* (and associated developments) are introduced in the following sections, and discussed in later chapters. Appendix II summarises relevant Commonwealth legislation and agreements.

### National Forest Policy Statement and Regional Forest Agreements

The National Forest Policy Statement (1992) agreed by the Commonwealth and all State and Territory governments, outlines objectives and policies for Australia's forests. The Statement puts forward a regionally based assessment process, that of Regional Forest Agreements (RFAs), to resolve the conflicting demands on forests of conservation and industry.

In Victoria, five regions have been identified for developing RFAs, based on East Gippsland, Central Highlands, North East, Central Gippsland and the West (Map 3). The development process requires that comprehensive assessments be undertaken of the natural, cultural, economic and social values of forests. Information collected by Council for the Box-Ironbark investigation will also assist the Victorian and Commonwealth governments in meeting their objectives relating to box-ironbark forests and woodlands, for State and Commonwealth public land.

### Interim Forest Agreements

In January 1996, the Commonwealth and Victorian governments agreed on a strategy to provide interim protection for high conservation value forests in the period pending finalisation of Regional Forest Agreements. The resulting Interim Forest Agreement identified areas that may be required for a comprehensive, adequate and representative (CAR) forest reserve system, by evaluating current levels of forest reservation against criteria for old-growth, wilderness and biodiversity.

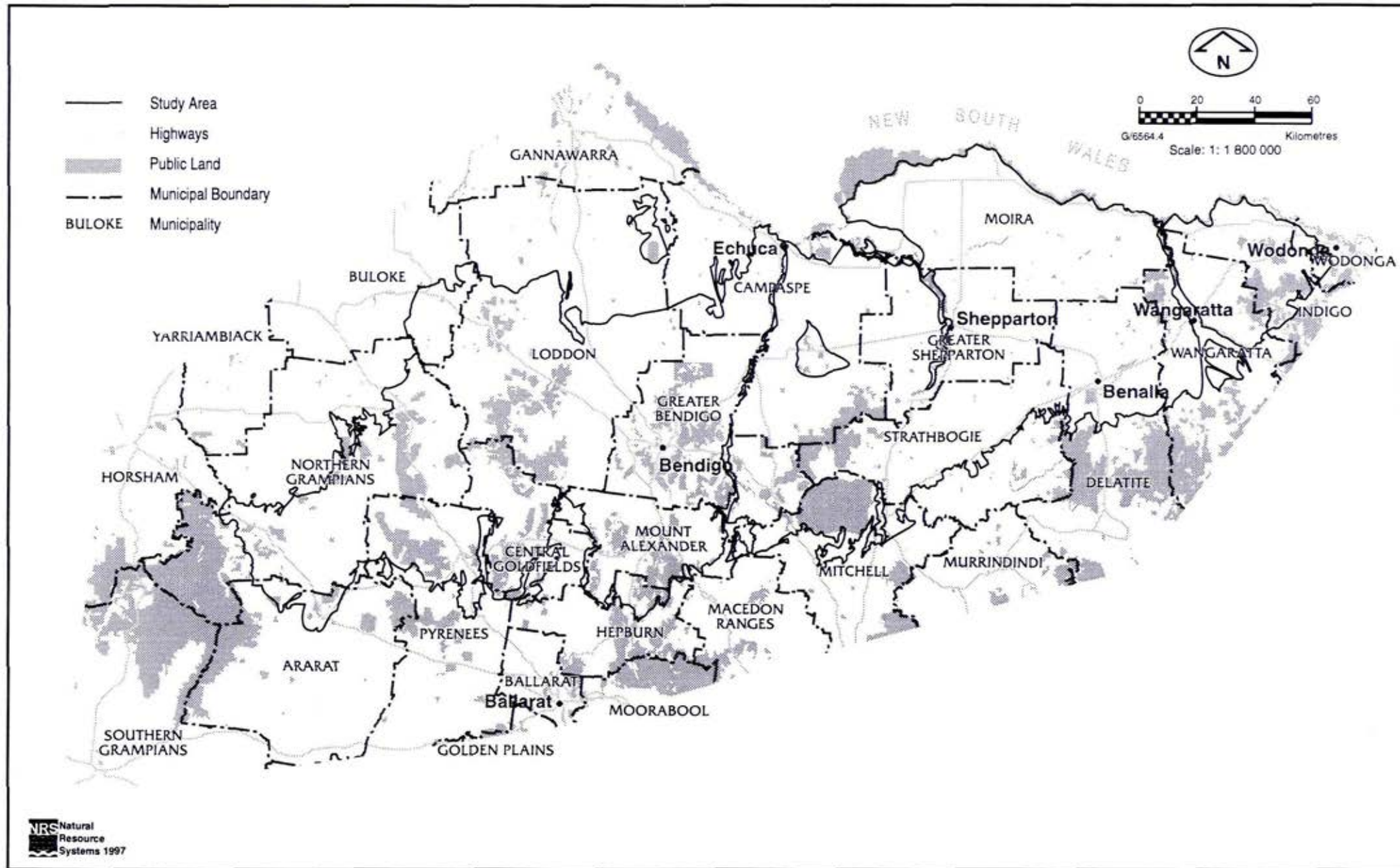
The Interim Forest Agreement addressed box-ironbark forests and woodlands on the inland hills, and stated that the level of reservation was 4.8 per cent of the pre-European extent of vegetation (all vegetation types combined). The Agreement also indicated that a further 18.6 per cent of the pre-European extent of inland hills box-ironbark forests and woodlands exists on State and Commonwealth public land, and as a result stated that there was:

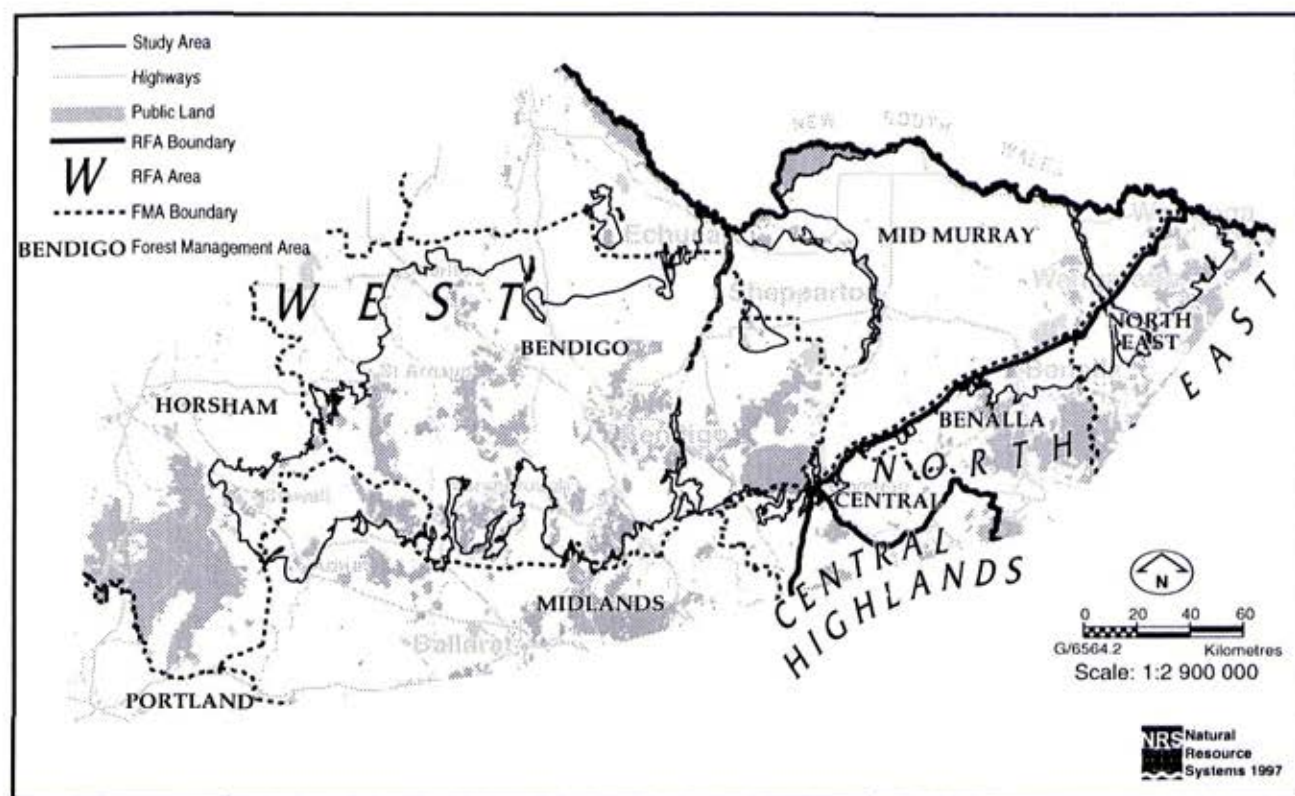
...sufficient forest available from which to establish a CAR reserve, and this will not be significantly diminished through the next three years' planned timber harvesting.

Accordingly, no areas were deferred from harvesting as a result of the Interim Forest Agreement covering box-ironbark in Victoria. Note that the conclusions from the Interim Forest Agreement cannot be readily applied to the northern plains or the ECC Box-Ironbark study area as a whole.

The Commonwealth agreed to participate actively in the LCC's investigation, to assist with the funding of projects, and to include the Puckapunyal Defence Area (approximately 44 000 ha) in the investigation.

Map 2: Local Government Areas.



**Map 3: Boundaries of Regional Forest Agreement Areas and Forest Management Areas.**


### Legislation and the RFA process

There are several key pieces of Commonwealth legislation linked with the RFA process: the *Endangered Species Protection Act 1992*; the *Environment Protection (Impact of Proposals) Act 1974*; the *Australian Heritage Commission Act 1975*; and the *Export Control Act 1982*. The implications of these Acts for the RFA process are discussed in Appendix II, where other relevant Commonwealth agreements and policies are also listed.

### National Reserves System Program

The National Reserves System Program — formerly the National Reserves System Cooperative Program — was initiated by the Commonwealth in 1992 to develop a cooperative arrangement with the States and Territories for the establishment of a comprehensive, adequate and representative reserve system that encompasses all major ecosystems (not just ‘forests’). Because many principles of reserve system design are applicable across a range of ecosystems, the National Reserves System Program has developed alongside the National Forest Policy and Regional Forest Agreement process.

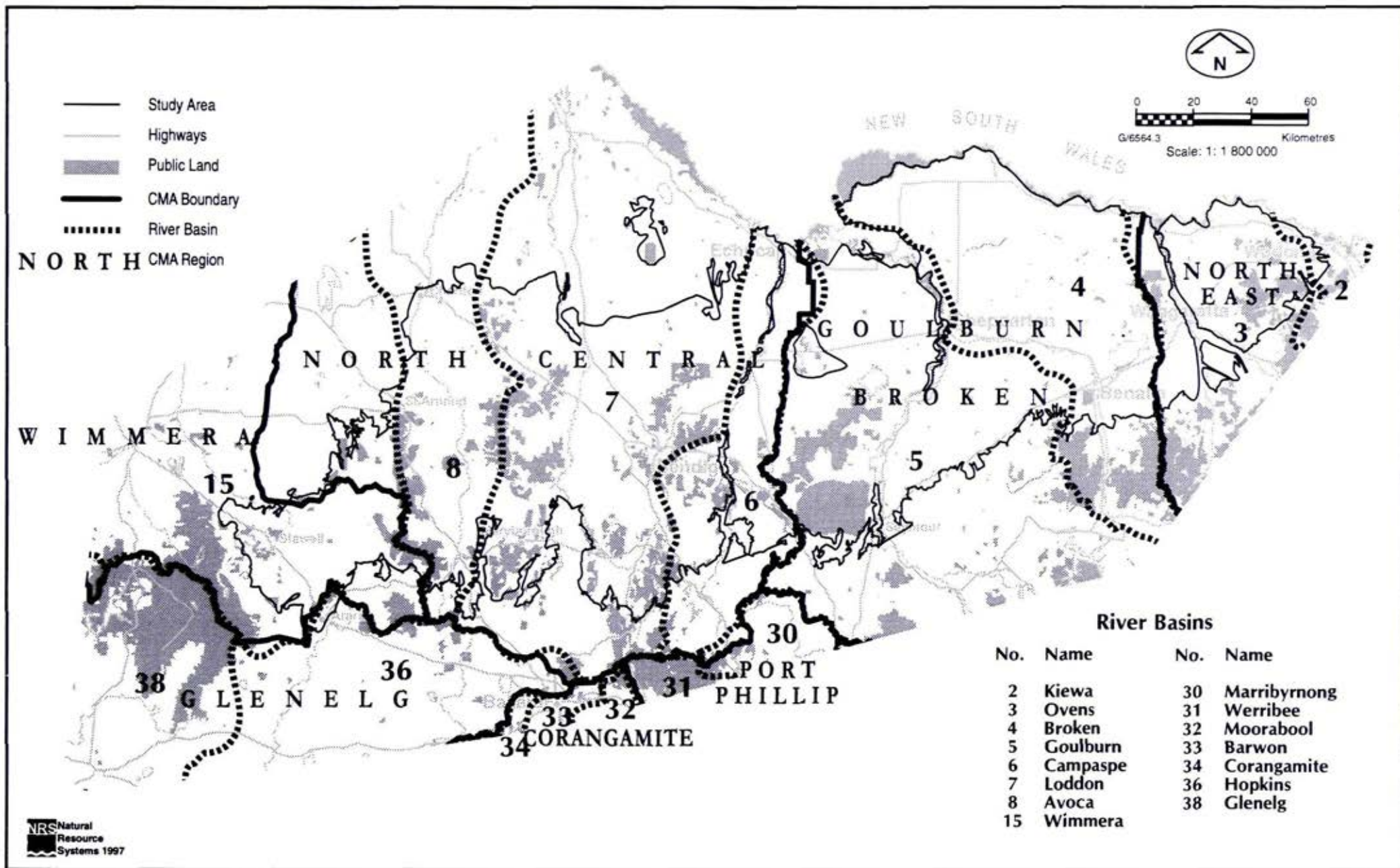
This program and the design of reserve systems for nature conservation are discussed more fully in Chapter 11.

### Victorian Catchment and Land Protection Act 1994

The *Catchment and Land Protection Act 1994* aims to give community ownership to aspects of natural resource management. The Act covers both public and private land within Victoria. Its objectives are:

- to establish a framework for the integrated and coordinated management of catchments which will:
  - maintain and enhance long-term land productivity while also conserving the environment; and
  - aim to ensure that the quality of the State’s land and resources and their associated plant and animal life are maintained and enhanced;
- to establish processes that can be used to assess the condition of the State’s land and water resources and the effectiveness of land protection measures;

Map 4: Catchment Management Authority regions and river basins.



- to establish processes to encourage and support participation of landholders, resource managers and other members of the community in catchment management and land protection;
- to establish and support the operations of the Victorian Catchment and Land Protection Council, Regional Catchment and Land Protection Boards and the Pest Animal Advisory Committee; and
- to provide for the control of noxious weeds and pest animals.

Under the *Catchment and Land Protection Act 1994*, 10 catchment-based regions were established across Victoria (Map 4). In each region, the Minister established a Board to implement the Act, and a 15-member State-wide Catchment and Land Protection Council to advise and report to the Minister on all aspects of the Act. The Boards were established primarily as advisory and planning bodies, responsible for providing an overview of priorities across the region largely through the preparation of Regional Catchment Strategies. These strategies were published in 1997.

In July 1997, the Government replaced the nine non-metropolitan Boards, that is, in all regions except Port Phillip (see Map 4), with Catchment Management Authorities (CMAs). The CMAs are responsible for:

- developing, reviewing and coordinating implementation of the Regional Catchment Strategies;
- providing advice to Government on both Federal and State resourcing priorities at a regional level;
- providing waterway and floodplain-related service delivery; and
- negotiating with the Department of Natural Resources and Environment on an annual project-based works program for regional service delivery that is in line with

the implementation of the Regional Catchment Strategies.

Each CMA comprises:

- A Board of seven members appointed by the Ministers for Conservation and Land Management, and Agriculture and Resources, with direct responsibility for developing strategic direction for land and water management in the Region, and ultimately responsible for all the functions undertaken by the Authority; and
- an Implementation Committee, appointed by the Board and with responsibility for developing detailed action plans and overseeing on-ground program delivery for specific issues or sub-catchments.

That is, CMAs have taken on the roles of salinity implementation groups, waterway management authorities, water quality groups, and sustainable regional development committees, including responsibilities for on-ground works. After the 1997/98 financial year, CMAs will take over the collection of the waterway management rate, currently collected by Waterway Management Authorities.

### **Victorian initiative for minerals and petroleum**

In recent times, the Victorian Government has introduced initiatives aimed at improving the contribution of mining to the State's economy. The key initiative for exploration is the Victorian Initiative for Minerals and Petroleum (VIMP) program (see Chapter 17), which commenced in 1994. This provides state-of-the-art geophysical data and regional scale maps of the most under-explored and prospective mineral areas of the State. The objective of this work is to establish more clearly Victoria's geological framework and to provide a vastly improved knowledge base for the design of private exploration programs.

## 2. ABORIGINAL ASSOCIATIONS

### ABORIGINAL LANGUAGE GROUPS

Aboriginal associations with the Box-Ironbark investigation area date back many thousands of years. The associations are demonstrated by hundreds of archaeological and art sites, places of spiritual importance, the retention of indigenous names for places, and the use of box-ironbark species as food sources and for the making of tools and other implements. Historic and ethnographic records also support the associations by documenting aspects of Aboriginal life in the region after the arrival of Europeans. These associations continue today, with Aboriginal communities concentrated at Shepparton, Echuca, Ballarat, and Bendigo.

As seen in Map 5, 11 Aboriginal language groups fall wholly or partially within the investigation area. In relation to the study area, however, eight language groups are primary: *Barababaraba*; *Daung wurrung*; *Djab wurrung*; *Djadja wurrung*; *Jardwadjali*; *Jodajoda*; *Ngurailam wurrung*; and *Waywurru*. With the exception of *Jodajoda*, these language groups and other dialects outside the investigation area formed a continuum or a chain of dialects of a single mutually intelligible language, often called *Kulin*. *Jodajoda* was different from all but its northern neighbour, *Jabulajabula*, outside the Box-Ironbark region.

At least 50 clans were situated within the investigation area (see Map 5). Clark (1990; 1996a) provides more information on these groups.

### ARCHAEOLOGICAL SITES

Marshall *et al.* (1996) have listed some 4200 Aboriginal sites in the investigation area. Of these, over 1300 occur in forested areas (see Table 2 for the range of site types).

Rock paintings are known in the Black Range near Stawell, and rock shelters are found in the Kooyoora Range. Ceremonial stone alignments are located at Carisbrook, Mt Franklin near Daylesford, and at Mt Kooyoora. Remarkably well-preserved direction indicators are also known at Charlton.

Rock wells are found near Benalla, Mt Kooyoora, Maryborough, and in the Whroo Historic Reserve. Mounds are a predominant archaeological feature of central western Victoria and 252 are recorded in the investigation area.

**Table 2: Aboriginal archaeological site-types in the Box-Ironbark investigation area**

Mound	252
Rock shelter	49
Quarry	4
Fish trap, grinding rock, hearth	4
Artefact scatter	145
Art site	92
Burial	14
Shell midden	11
Scarred tree	558
Isolated artefact	184
Exposure in bank	5
Rock well	14

Scarred trees, the most common archaeological site-type in Victoria, are found throughout the region, particularly along streams and around lakes and swamps. In the Kooyoora district there are several dozen scarred trees in the open box forest south and east of Melville Caves. They have also been found throughout the open forest along the Ordovician ridges north-west of Kingower, and at least 17 have been recorded at Reedy Lake, south-east of Whroo.

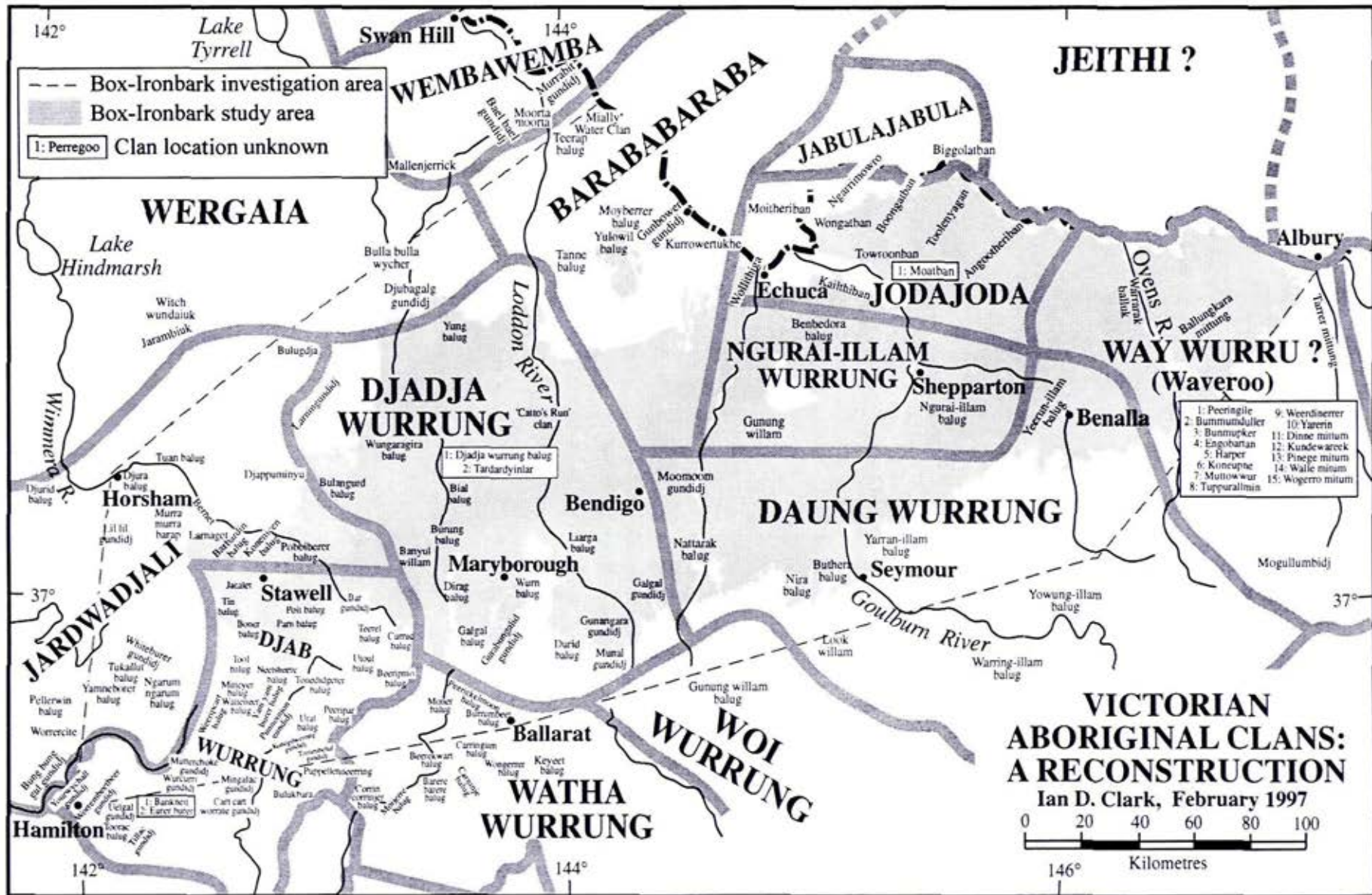
Given that skeletal remains from Kow Swamp on the Murray River have been dated to 13 000 years before present, Gunn's (1990) suggestion that the Whroo district was occupied and exploited by Aboriginal people from at least that time is probably applicable to the study area generally.

### INDIGENOUS NAMES

#### Box-ironbark tree species

George Augustus Robinson, Chief Protector of Aborigines in the Port Phillip district from 1839 to 1849, made numerous expeditions throughout the region, visiting squatters and Aboriginal groups. His journals and papers, and those of other early observers and writers, are a primary source of information on Aboriginal associations with the Box-Ironbark investigation area (see 'References').

Map 5



The ethnographic record indicates a variety of indigenous names for box-ironbark tree species (Table 3).

**Table 3: Aboriginal names for box-ironbark tree species**

Language name	Tree species	Local name
Woi Wurrung	ironbark	Yirrip (Yeer.Ip)
	box	Birrbirr (Bulwidj)
	yellow box	Dhagurn
Djadja Wurrung	ironbark	Yee-Rip
	grey box	Boo-Loitch
	yellow box	Tarrk
	red box	Tee-Ring
	brown box	Wy-All
Wergaia	box	Bulloitch
Wergaia (Djadjala dialect)	black box	Buludj
Djab Wurrung	black box?	Puloitch
	seed of box tree	Koreok
Wembawemba	black box	Buledj

**Note:**

Some common names for flora which appear in early European accounts (including those cited in the table above and in the text below), cannot always be related with certainty to a particular tree species or group. 'Ironbark' can with some confidence be considered red and/or mugga ironbark, but others (such as 'brown box') cannot be readily associated with a species or group.

**Place names**

The Aboriginal names of at least five places and two parishes in, or just outside, the investigation area, were derived from local words for ironbark and box trees. In these instances the use of the name may indicate a concentration of ironbark or *yeerip* at these locations, and possibly a location where excellent sources of ironbark could be obtained for spears and other uses.

- Robinson (11/8/1841) noted that a wooded hill near present-day Smythesdale was called *Eer.rip*, and was known for the good quality of its timber for making spears. This hill is now known as Mt Erip.
- A hill at the back of E.S. Parker's station, in what is now the Sunbury district, was also recorded by Robinson (11/1/1840) as *Yei.rip* Hill.
- Smyth (1878) recorded Pleasant Creek, near Stawell, as *Yerip*, and noted *Yehrip*, a parish in the County of

Kara Kara, west of the Avoca River, as the name of the ironbark tree.

- *Yeerip* is the name of a farming district in the former Shire of Tungamah.
- *Bulertch*, the name of a parish west of the Avoca River, is listed in Smyth as the box tree.
- *Pullut* is derived from the name of the box tree, according to Massola (1968b).

**ABORIGINAL USE OF BOX-IRONBARK RESOURCES**

**Food plants**

In 1836, while on his exploratory expedition (see Chapter 3), Major Thomas Mitchell came upon some red ironbark in flower near Heathcote. One of Mitchell's Aboriginal companions, a *Wiradjuri* speaker from the Bathurst district of New South Wales, explained to Mitchell that the blossoms were cut in quantity and steeped overnight in water, to make a sweet beverage, which the *Wiradjuri* knew as *bool*.

According to G.A. Robinson (25/5/1840) the *kulin* people called this sweet beverage *yeerip korr*, and the ironbark blossom *korr*. The beverage was made from soaking boughs or small branches in a vessel resembling a small *corong* (bark canoe). *Kor.rer*, manna, said to be like sugar, was obtained from the *yeerip* trees when in season.

Alfred Joyce, whose letters were later edited and reproduced in James (1942), resided at 'Plaiستowe' near present-day Newstead from 1844. On one occasion, he observed a large spring gathering of a hundred or more Aboriginal people assembled in the forest near his homestation. They gathered and soaked the blossom of eucalypts, in round and oval bark bowls cut from the knobs and elbows of eucalypts. They also roasted long oval-shaped yams, which were at that time abundant, and hunted 'opossums'. At night numerous camp fires lit up the forest, presenting quite a picture of a festive Aboriginal gathering.

In April 1843, Robinson was in box-ironbark country north of Mt Hope and saw numerous places where Aborigines had been digging for worms called *kokar*, peculiar to the natives of this country. Dawson (1881) recorded *cho'or* as *Djab wurrung* for earth worm. Robinson also saw numerous indications of where Aborigines had

been, including notched trees where they had been in pursuit of possums and birds' eggs, and disturbed ground where they had been grubbing, in country east of Mt Bolangum. Hercus (1966) records that the *Djadjala* people (*Wergaia*) spoke of *ngabul-ngabul*, an edible grub from black box trees.

Smyth notes that the *Dieri* people of Cooper's Creek in South Australia called the seed of the box tree *patharapowa*; it was ground and made into loaves. Whether Victorian Aboriginal people used this food source is not confirmed in the ethnographic record.

### Implements, dishes, canoes and other social uses

Smyth noted that ironbark wood was used for canoes, and the limbs of ironbark trees were commonly used for returning boomerangs, called *wonguim*. The *wonguim* were generally regarded as a plaything, but occasionally used in battle and for killing birds and small animals. He also noted that wood from yellow gum was made into a long, sharp weapon known as a *lil-lil*, which was most dangerous in the hands of an experienced combatant, capable of breaking limbs, fracturing ribs, and even penetrating the skull. Ironbark and yellow gum were used to make shields, called *mulka*, for warding off blows, mostly in single combat. To prevent injury to the knuckles and to ensure a secure grip, strips of possum skin were wrapped around the handles.

In western Victoria, war spears were made from ironbark saplings. In Gippsland, the inner bark of a variety of ironbark, called *toondung*, was reputed to get into the chests of humans and cause disease. Gippsland throwing sticks, *murruwun*, were also made of ironbark wood. When calling a meeting to settle grievances or to arrange attacks on enemies, a *branjep* (man's belt) was hung on a jag-spear made of ironbark wood.

The bark of box trees was used for constructing *willams* or bark huts. Robinson came upon such huts in April 1840, beside the Ovens River near its junction with the Murray River. At this camp he also saw several small vessels for holding water, made from bark from the excrescence of stunted box trees.

Box bark was also used as a medium for ceremonial sculptures. For example, a bark sculpture of the giant snake *Mindi* was used in a corroboree at Mt Franklin in late 1843,

and a sculpture of an emu was collected from the Loddon River district, and displayed at an exhibition at Sandhurst (Bendigo) in 1854.

Cooper (1996) has suggested that the narrative art of bark drawings, with its concern to relate specific, notable events, appears to have been common along the Murray River and its southern tributaries.

## THE CONTACT AND POST-CONTACT ERA

### Port Phillip Aboriginal Protectorate

With the establishment of the Port Phillip Aboriginal Protectorate in 1839, the Port Phillip district was divided into four districts, each assigned to an assistant protector. The Goulburn District, which was initially the responsibility of James Dredge, and the Loddon District (Edward Stone Parker) are central to this study. The Western District, initially under the charge of Charles Wightman Sievwright, is marginal.

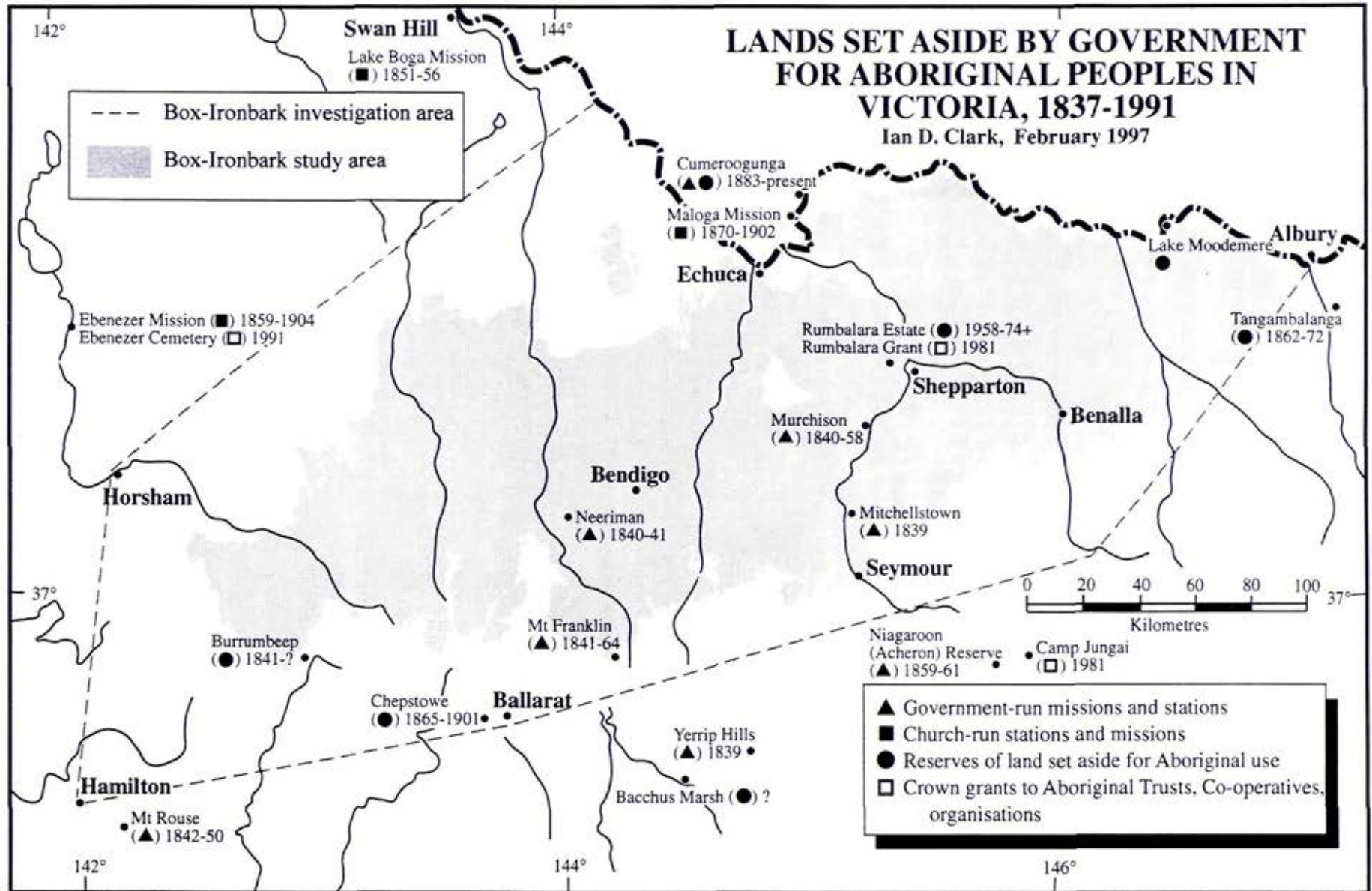
Parker first sited his protectorate station at Yerrip Hills, on Jackson Creek, near present-day Sunbury (1839–40), then at *Neeriman* near Tarrengower Hill (1840–41), before settling at Mt Franklin in 1841. He concentrated his efforts on *Djadja wurrung*, northern *Watha wurrung*, northern *Djab wurrung*, eastern *Jardwadjali*, and *Barababaraba* clanspeople. In 1839 Dredge first located his station at Mitchellstown near present-day Nagambie, before relocating in 1840 to the Goulburn River near Murchison, at a site called *Murneyong*. Dredge was concerned primarily with *Daung wurrung*, *Ngurai-illam wurrung*, *Jodajoda*, and *Way wurru* clans. Sievwright concentrated his efforts on Aboriginal peoples whose countries were primarily outside the investigation area.

Map 6 shows the location of lands set aside for Aboriginal use between 1837 and 1991.

### Conflict and resistance

Although there is insufficient information to speak with any certainty of the varied reactions of every Victorian Aboriginal tribe to European intrusion, there are detailed records for several including the *Djadja wurrung* and *Daung wurrung*.

Map 6



The ethnographic record confirms that the *Djadja wurrung* were conscious of the loss of their lands and their rapidly declining ability to continue their traditional modes of living. The *Djadja wurrung* were dispossessed in two waves: in the south from late 1839 and in the north from 1845. Clark (1995) documents 13 killings and massacres in *Djadja wurrung* lands (see Map 7) occurring between 1838 and 1846. Thomas in 1844 (see Nance 1981) reported a remark by a *Djadja wurrung* speaker showing helplessness and disappointment: 'poor blackfellows white man take blackfellows country and frighten him too'.

Edward Parker believed that by the time he had established his permanent station at Mt Franklin in 1841 the *Djadja wurrung* had recognised the overwhelming power of the whites to exclude them from their lands and had adopted an attitude of appeasement towards them, according to Nance. Joseph Parker, Edward's son, recalled that the Aborigines were terror-stricken by violent settlers. When they first met his father, they approached carrying a green twig, something he interpreted as an emblem of peace. It was more likely an attempt to enact the ceremony of *tanderrum*, or 'freedom of the bush', a diplomatic rite symbolising the landholder's hospitality, in which strangers were allowed temporary access to clan resources after a ritual exchange of gifts.

The *Daung wurrung* people were regarded as the most violent Aborigines close to Melbourne. Peter Snodgrass, who squatted in the Yea district in 1838, informed Governor La Trobe in 1853 that Aboriginal attacks along the Goulburn River were well led and carefully coordinated. In May 1840 the *Daung wurrung* attacked David Waugh's run on the Delatite River, killing two shepherds and scattering sheep. Christie (1979) records that Waugh was eventually forced off *Daung wurrung* land through financial ruin.

Christie has argued that the *Jodajoda*, *Ngurai-illam wurrung*, and *Waywurru* conducted an extensive campaign of resistance against the whites that involved disrupting stock routes, harassing shepherds and pastoral workers and dispersing sheep and cattle. In the Murray district, *Jodajoda* people attacked George Faithfull's overlanding party in April 1838 at the Broken River, killing seven of his men and scattering his flocks. Faithfull took up a run on the Ovens River but Aboriginal attacks were so persistent that he sold out to the Rev. Joseph Docker in September 1838. Dr George Mackay squatted at Myrhee station on the King

River in March 1838 only to be forced to abandon the run a few months later and settle at Whorouly Creek where he was attacked in May 1840. Horses and cattle were speared, outbuildings set alight, and a hutkeeper who was notorious for abusing Aboriginal women was killed. For the next 18 months Faithfull and Mackay engaged in bitter reprisals.

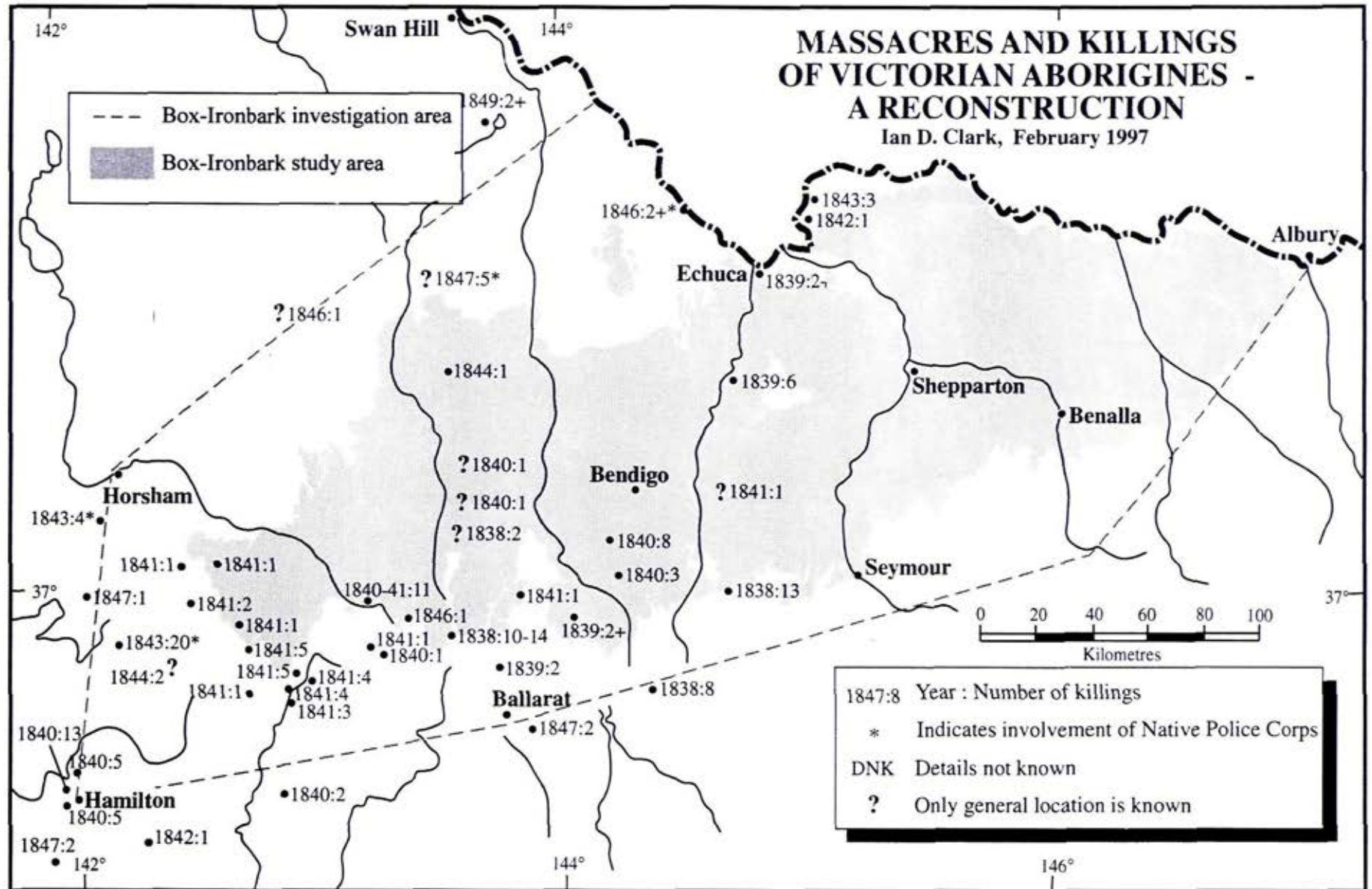
During the winters of 1843 and 1844, between present-day Echuca and Corryong, *Jodajoda* and *Waywurru* continued to harass settlers, attacking homesteads and outstations and driving sheep into swampy river flats. The Border Police were stationed in the district from 1844, and in 1845 a detachment of the Native Police Corps was sent to quell disturbances. Christie believes that conflict in this region continued well into the late 1840s.

G.A. Robinson saw bark drawings which are now believed to have depicted traumatic events associated with the arrival of Europeans and the takeover of Aboriginal lands. On 30 March 1843 on the Murray River, possibly near Deep Creek, Robinson and his party stopped at an abandoned Aboriginal camp site. Robinson noted drawings on the inside of a bark hut, of humans and drays. Cooper (1996) considers this may represent an instance of the initial intrusion by European outsiders, possibly even a depiction of Mitchell's pioneering journey through the region in 1836. In April, Robinson came upon another abandoned camp, and found inside a hut a drawing of natives spearing a white man, 'through and through'. Cooper suggests this may depict a real event.

Map 7 shows the location of known killings and massacres in the study area, depicted by Clark (1995, 1996b). The absence of entries for north-eastern Victoria may reflect that research into the contact history of this region has not been as extensive as in the south-west.

With the abolition of the Port Phillip Aboriginal Protectorate in 1849, William Thomas, who had been employed as the assistant protector responsible for the Melbourne or Westernport District, was appointed 'Guardian of Aborigines', and although responsible for all of the colony, concentrated on the environs of Melbourne. Parker, at the Mt Franklin protectorate station, was allowed to continue operating the station as a pastoral run, thus providing a continuing home for the *Djadja wurrung*. The school at Mt Franklin was also maintained for a time.

Map 7





*Aboriginals' farm near Mt Franklin in about 1858, with four people sitting in front of the buildings.*

## Impact of the gold rushes

Gold was discovered in Victoria at Clunes in 1851 (see Chapter 3). The ensuing gold fever affected Aborigines in many ways, not least of which were new opportunities for employment on stations, where the European hands had deserted to the goldfields. Jobs given to Aborigines included shearing, harvesting, wood cutting, stock keeping, lambing, sheep washing, shepherding, bullock driving, ploughing, dam construction, sheep dipping, stripping bark, and a variety of lighter tasks.

Aborigines on stations generally lived a more comfortable existence than their counterparts on the outskirts of mining settlements, who continued to eke out a living largely through traditional hunting and gathering, supplemented with begging and prostitution. Aborigines were particularly at risk from drunken and unruly miners.

Aboriginal mortality increased in Victoria after the discovery of gold (Select Committee 1858). This was attributable primarily to venereal diseases, intemperance, and influenza. Alcohol abuse became a characteristic feature of Aboriginal life from the 1850s, as alcohol became more widely available with the advent of mining settlements. Some people at the diggings were believed to take pleasure in inducing Aborigines to drink liquor.

In May 1854 gold was discovered at Yandoit Creek, within the boundaries of the Mt Franklin Aboriginal station. News of the find soon brought a large influx of miners to the reserve, which as Culvenor (1992) reports, made its operation difficult. The following year the reserve was subdivided to meet the needs of the rapidly growing rural population. One square mile of good land near Mt Franklin, however, was retained for use by a small

number of Aborigines who wished to continue farming. Mt Franklin was made a public reserve in the 1855 survey.

Edward Parker advised an 1858 Select Committee on Aborigines that there was 'great practical difficulty' associated with setting aside reserves for Aborigines in auriferous country, as there could be no certainty in the continuing preservation of the land for Aboriginal purposes. The increasing value of land in Victoria, for both agriculture and mining, mitigated against the establishment of Aboriginal reserves. Parker's perception that the conferred value of land containing gold deposits would be detrimental to Aboriginal interests, may well explain the striking absence of lands set aside for Aboriginal peoples in the investigation area, despite the recommendations of the 1858 Select Committee (see below).

### Aboriginal resettlement

The 1858 Select Committee recommended the formation of a Central Board in Victoria to watch over the interests of Aborigines. Reserves and stations were to be established for the various tribes on their traditional hunting ranges, where they could combine agriculture and the grazing of livestock. The establishment of permanent reserves also reflected the Board's policy of confining Aborigines, for their better management and control. Aborigines on such stations were to be prohibited from visiting towns and goldfields. Local guardians were also appointed to function as honorary correspondents to the Board, and as suppliers of foodstuffs, clothing and other items. Though no reserves or stations were set aside for Aboriginal communities in the investigation area, the communities were served by these guardians, honorary correspondents, and supply depots.

For many Aboriginal people, the 1860s and 1870s was a time of dispersal, some voluntary, most involuntary. Table 4 summarises the resettlement in this period of Aboriginal communities from the investigation area to various stations and reserves.

The impact of the establishment of these stations, and the consequent removal of Aboriginal peoples from their traditional lands, is such that the stories of the peoples belonging to the Box-Ironbark investigation area now become fused with those of the stations where they were resettled. Some people, mostly aged, refused to leave their natal lands and were allowed to remain near their ancestral areas for as long as their health permitted.

As discussed by Atkinson and Berryman (1983), Aboriginal communities continue to nurture their association with these ancestral areas, such as those surrounding Cumeroogunga and the Barmah/Moira Forest. There are also native title interests in the study area.

**Table 4: Resettlement of Aboriginal communities from the Box-Ironbark investigation area**

Language group	Reserve/station
Djadja wurrung	Coranderrk (Healesville)
Djab wurrung	Coranderrk
	Framlingham (Warrnambool)
	Lake Condah (Heywood)
Jardwadjali	Ebenezer (Dimboola)
	Lake Condah
Wergaia	Ebenezer
	Lake Condah
	Coranderrk
	Lake Tyers*
Daung wurrung	Coranderrk
	Maloga (New South Wales)*
	Cumeroogunga (New South Wales)*
Ngurai-illam wurrung	Coranderrk
	Maloga
	Cumeroogunga
Jodajoda	Coranderrk
	Maloga
	Cumeroogunga
Waywurru	Coranderrk
	Maloga
	Cumeroogunga

\* Relocation to Lake Tyers, Maloga and Cumeroogunga occurred after the 1870s.

### 3. POST-CONTACT HISTORY

This chapter provides a thematic overview of the post-contact history of the Box-Ironbark study area. It summarises the history of European occupation and exploitation of the region, beginning with the early exploratory journeys of Hume and Hovell, and Major Thomas Mitchell, and the gradual spread of pastoral land use which followed. Selection and closer settlement are examined, as is the discovery of gold and the extensive development of goldfields in the region. The chapter also covers the history of timber production and forest management, and other environmental themes such as water supply, soil erosion, and nature conservation. Finally the development of roads, railways, recreation and tourism is examined, along with the localised theme of military training at Puckapunyal.

Farming and pastoralism became established principally on the northern plains of the study area, with goldmining, timber and forest production concentrated in the inland foothills. This basic land-use pattern, however, has been subject to increasing diversity in recent decades.

Chapter 14 describes the cultural heritage of the region, and Appendix III lists selected, significant historic places on public land.

#### EUROPEAN EXPLORATION

The earliest European explorers in the Box-Ironbark region were Hamilton Hume and William Hovell. In 1824 they crossed the Murray River, which they named the Hume, somewhere near today's Bonegilla, then reached what they named the Ovens River, near Wangaratta. They then crossed and named the Goulburn River, passed through the Great Dividing Range to the Werribee Plains and Corio Bay, and returned via today's Kilmore, Seymour, Avenel, Longwood and Violet Town, then south of Benalla to rejoin their earlier route just south of the Ovens Valley. A chain of memorial cairns was built along Hume and Hovell's route in the centenary year of their expedition, 1924. The Hume Highway also commemorates their journey, and approximates their route in places.

The New South Wales Surveyor General, Major Thomas Mitchell, and his team entered the region in 1836. In the

initial phase of their expedition they saw Pyramid Hill and passed just south-east of what is now Korong Vale, Wedderburn and St Arnaud. After exploring south-west to the Grampians, and on to the Glenelg River and Portland, Mitchell returned to the study area via the Pyrenees Ranges (which he named), went north-east to Newstead and Castlemaine, made a detour to climb Mt Macedon, and then moved in a northerly direction through what is now Violet Town and Wangaratta, before crossing the Murray at Howlong.

*Even as they returned to New South Wales, the expedition encountered the first overlanders bringing cattle down to Port Phillip, following the deep cart tracks left by the expedition's heavily loaded drays. The tracks remained visible for many years and became known as 'the Major's line'.*

#### EUROPEAN SETTLEMENT

Major Mitchell's enthusiasm for the country he named 'Australia Felix', encouraged more overlanders to cross the Murray and seek suitable land for grazing. In this period, settlers from Van Diemen's Land were also crossing Bass Strait to claim squatting runs for themselves. The squatters became quickly established in the central and northern parts of the Port Phillip District. They were attracted to the region because of its open aspect, rolling plains and favourable climate. By 1841 there were nearly 1.5 million sheep in the colony and over 100 000 cattle. By 1851, sheep numbers exceeded 5 million (Dingle 1984). Most of the runs carried both sheep and cattle but in the northern and western areas of the colony, sheep predominated. East of the Goulburn River, cattle were more common.

#### Pastoralism

In 1843, between a half and two-thirds of the study area was subject to grazing leases. Squatters quickly identified the land which was most suitable for pastoralism — typically fertile soils in valleys and on plains — and occupied these areas first. By 1849, squatting runs covered most of the Box-Ironbark region. Some of these runs extended for 8000 ha or more, though stock numbers varied widely.

Initially, the squatters erected makeshift buildings and stock yards, using the abundant native timbers of stringybark, box and red gum. Large trees were split into slabs for the walls of buildings, and bark was used for roofing. Later, more substantial buildings appeared and improvements were made to the pastoral properties. Many squatters set up pit saws to cut timber for building.

Land degradation and soil erosion sometimes followed pastoral expansion in Victoria, particularly in areas of sensitive soils. The problems were caused by introduced livestock, which trampled and compacted the soil with their hard hooves. Deep-rooted perennial native grasses were replaced by introduced grasses and weeds. Soils became degraded in some areas, and sheet, gully and tunnel erosion occurred. These problems were compounded as more sheep, in particular, were brought onto runs to increase wool production.

Many squatters, from the earliest years of settlement, valued fire as a method of improving pasture. Some squatters regularly burnt grassy woodlands before the rains every year, and it was not unusual for these fires to spread into nearby forests. There is evidence of this practice near Tongala in the study area, where E.M. Curr had a sheep run in the 1840s. There, the preferred time for 'burning off' was in March or April, in anticipation of the autumn rains (Curr 1965). It is not known if this practice was widespread in the study area.

From the 1870s a licencing system allowed pastoralists to graze sheep and cattle within reserved forests. The deliberate lighting of fires was still practiced in some areas, however, as graziers continued to use fire as a tool in managing their grazing areas.

## Selection and farming

The goldrushes of the 1850s attracted vast numbers of people to central Victoria. Many who remained in the colony after the rushes hoped to acquire land for farming. According to Powell (1970) agriculture had already developed on the goldfields during the 1850s, including in the counties of Ripon, Talbot and Dalhousie in the study area. To free up Crown land for agriculture, including land occupied by pastoral leases, the Government passed a series of Land Acts, beginning in the 1860s.

Between 1860 and 1862, surveyed land near Echuca, Whroo, Dunolly and Avoca was thrown open for selection.

Many squatters exploited loopholes in the legislation, and retained some of the best land, including water frontages and the core holdings of their original pastoral runs. The land legislation generally enabled blocks of up to 320 acres to be selected, and the selectors were required to reside on the blocks and to make improvements by clearing, fencing, planting crops and building houses, sheds and yards. Clearing was often achieved through ring-barking, followed by pushing over and burning the dead trees. Pasture grasses or crops were eventually grown on the cleared land. The timber on selection blocks was also used for fence and building materials, and firewood, but much of it was wasted. Some selectors near Seymour were accused of taking up blocks merely to harvest the timber for commercial purposes, before forfeiting or selling their land (Martindale 1982).



*Chock and log fence, near St Arnaud.*

By 1865 nearly 6 million acres had been made available across the State, and extensive areas in the south-west of the study area had been taken up by selectors. The 1869 Act allowed selection before survey, and ushered in the peak period of selection in the mid-1870s. The legislation, however, had limited success in permanently settling selectors on the land. Many small farmers failed because of inadequate capital, insufficient or poor quality land and a scant knowledge of farming methods. Some selectors eventually walked away from their blocks, forfeiting their leases to the Department of Crown Lands and Survey, or selling out to neighbours or local squatters. In the Echuca district, only half the original selectors stayed on to purchase their leases. Victorian forests today sometimes contain evidence of former selections which were returned to the Crown, and were later included within the boundaries of parks or State forests. Former selections can be

found in the Whipstick and Kamarooka State Parks near Bendigo.

### Later settlement schemes

There were subsequent schemes aimed at settling small farmers on remaining areas of Crown land (or freehold land purchased by the Government for settlement purposes) in the region. They included 'village settlements' (for unemployed people during the 1890s depression) at Kilfeera south-east of Benalla and at Echuca, a string of villages through the Nathalia-Numurkah district and a few north of Bendigo such as Colbinabbin, Corop, Kamarooka and Wanalta.

Later schemes included the 'closer settlement' activity from the late 1890s to the beginning of the First World War. Wyuna Station near Kyabram, of 23 000 acres, was divided into 105 farms of between 100 and 440 acres and 12 agricultural labourer's blocks of about 20 acres each. This scheme was also tried in other parts of the Goulburn Valley, with the most successful blocks being those in the irrigation areas. 'Soldier settlement' schemes after both world wars also saw hundreds of soldiers and their families settled on blocks in the Box-Ironbark study area, but not always successfully.

## MINING

Gold was discovered at Clunes in 1851, but the rush to this field was soon overshadowed by discoveries at Ballarat and Bendigo later in the year. By November 1851, 10 000 diggers had congregated on the rich surface and shallow deposits of Forest Creek at Castlemaine, which was one of the first goldfields to achieve sensational success. Golden Point at Bendigo was another very successful field, where the alluvial deposits yielded 5700 kg of gold by January 1852.

The landscape of the region in the 1850s was studded with major and minor fields. Alluvial gold production reached its peak in 1856, with discoveries made throughout the golden decade: Amherst, Wedderburn, Beechworth, Heathcote, Moliagul and Tarnagulla (1852), Stawell, Avoca, Maryborough, Dunolly, Kingower, Costerfield and Rushworth (1853), and Alma and Maldon (1854). Discoveries at Inglewood, Navarre and Whroo were made later in the decade. The goldfields west of the Loddon and north of Dunolly were particularly famous for the number of nuggets produced.

At the peak of the goldrushes, thousands of hectares of the study area were covered with miners' tents, diggings and equipment. Hastily constructed 'shanty' buildings housed traders and Government administrators alike. On many former goldfields today, however, the physical evidence of all this activity is sometimes very poor, though some significant sites have survived (see Chapter 14, and Appendix III). The forests have regenerated in many areas, including in the Chiltern-Rutherglen district where 13 000 miners were at work in 1859, compared to a present-day population of less than half that number — very few of whom live within forests. Small hamlets, such as Whroo, Coy's Diggings and Baileston, also mark the locations of what were once quite extensive and bustling goldfields communities.



*A typical post-goldrush landscape in box-ironbark forest at Lightning Hill, near Bendigo.*

For shallow sinking on the alluvial fields, the diggers used shovels, picks, buckets and ropes and washed the gold from the dirt with either a tin pan, a tub, or a cradle. Alone or in small groups, they worked along existing or ancient watercourses. Puddling machines — circular wooden troughs with a central pole to which a horse was attached — were often used to break up the clay and loosen the gold particles. Water was essential for this process and was obtained via a dam or water race. Sluicing also required water, and was most effective for retrieving gold from 'cement', a conglomerate of gravel from buried ancient river beds. Bannear (1996) notes that cement mining was particularly common at Castlemaine, Bendigo, Dunolly, Tarnagulla, Strangways, Inglewood, Carapooee and Amphitheatre.

Deep lead mining occurred on hillsides, escarpments and valleys, where miners sunk shafts and excavated drives to uncover gold-bearing material in the beds of ancient rivers.

The earliest of these leads were relatively shallow, and miners could find gold at about 30 m below the surface. Horse-drawn whims were used to bring material to the top. As the leads went deeper, however, miners were more apt to strike water, necessitating more sophisticated machinery to pump water out and to convey material to the surface. Individual miners, unable to finance such machinery, increasingly formed companies to manage the deep leads. From the 1860s to the First World War, large-scale deep lead mining was undertaken at Avoca, Betley, Carisbrook, Havelock, Homebush, Majorca, Talbot and Timor in the Maryborough district.



*Magenta Mine, Chiltern Box-Ironbark National Park.*

Quartz reef mining, which became common in the mid-1850s, was the most enduring method of mining in the central goldfields, although not as widespread geographically as alluvial mining. Gold production from quartz reefs exceeded that of alluvial mining in 1878. At Bendigo, the first quartz reef mines opened at Specimen Hill and Victoria Hill in 1853. Gold was taken from the quartz by 'roasting'

the material to soften it, then crushing it in stamper batteries, and finally washing or using various chemicals on the crushed quartz to extract the gold. As quartz mines went deeper, steam power was used both for pumping out water and retrieving the quartz deposits. Crushers or batteries were also powered by steam, and sometimes, when water was more abundant, by water wheels. By the late 1870s some mines, such as those at Bendigo, had been sunk to depths of 300 m and more. Hundreds of metres of tunnels, levels and crosscuts led off from the main shafts.

Quartz mining continued intermittently until after the Second World War, especially at larger centres such as Bendigo and Maryborough. Other important quartz mining localities in the study area included Baileston, Castlemaine, Chewton, Costerfield, Dunolly, Eaglehawk, Heathcote, Inglewood, Moliagul, Redbank, Rushworth, St Arnaud, Stuart Mill, Tarnagulla, Wedderburn and Whroo. In some areas quartz mining continued sporadically, with a minor revival in the last decade or so.

In more recent times, the invention of relatively cheap metal detectors has stimulated a return to gold prospecting, particularly as a hobby. Dunolly, Kingower, Wedderburn, Inglewood, Moliagul and Tarnagulla have become popular centres of weekend prospecting. Professional gold seekers also use detectors for 'doze and detect', a form of strip mining. With earth-moving equipment (bulldozers) they remove vegetation and layers of soil, which they then survey with detectors. Such mining has taken place in recent times in the Golden Triangle region and near Maryborough.

Historically, miners used timber in prodigious amounts. Thousands of men could descend upon a field within days of its discovery, all needing wood for fires, shelter, whips and whims, puddling machines, sluices and water races. Timber was also required for deep lead and quartz mining, for props, to line shafts and tunnels, and to feed the steam engines and furnaces. Forests in proximity to the major goldfields were worked by licensed woodcutters, but by the 1870s they were becoming depleted (see below).

## TIMBER PRODUCTION

The red gum, grey box, red ironbark and yellow gum trees which characterise the study area are hard, durable timbers. They have been used since the mid-19th century

for sawmill logs, sleepers, fence posts, piles, firewood, and for building and mining timbers.

Early sawmills were usually located close to the source of timber, and during last century operated with few restrictions on the volume of timber they could harvest on Crown land. Logs were hauled to the mill, initially by bullock teams and later by steam winches. Sometimes chutes and bridges were used in steep terrain to slide logs down hillsides. In some parts of the study area timber tramways were used to transport logs to the mills. Such tramways were constructed at Havelock near Maryborough, and at Heathcote, Mitchellstown and Seymour.

Sleepers were in particular demand with the spread of the railway network in the latter decades of last century. Both red ironbark and grey box were especially sought after sleeper timbers, with the latter considered the most durable. Grey box was believed to last from 30 to 35 years in the track. In 1898, when it was estimated that over 500 000 sleepers were required for line construction and maintenance in the following year, more than 800 000 ha of forests in the study area were available for sleeper production. Forests in the Heathcote and Rushworth districts, however, had been stripped of suitable trees 'in some parts' (Royal Commission 1898).

Firewood production was also influenced by the arrival of the railway. Firewood mills were established at many centres with access to the growing railway network, to facilitate the transportation of box-ironbark timbers to the firewood market in Melbourne. Even small centres, such as Violet Town and Baddagannie, had firewood mills.

The over-exploitation of forests in the early decades of settlement almost eliminated large trees of millable size. Today, over 95 per cent (by volume) of forest produce from the study area is made up of fencing timbers and firewood, largely produced from silvicultural operations and forest thinnings (see Chapter 16).

### Other forest produce

The natural tannin found in some species of wattle, such as black, golden or silver wattles, was used in Victoria from the early days of settlement as an agent for tanning leather. The bark of young trees was stripped, soaked in a brew, dehydrated into a powder and rolled into hides.

As seasonal work, wattle-bark stripping was an additional source of income for many poor selectors, and was practised in the St Arnaud and Nathalia districts.

The production of eucalyptus oil (through distillation) was initiated in Victoria in the 1850s. Many farmers established their own stills to supplement incomes, although it was also carried out by larger commercial operators, such as Joseph Bosisto. The oil is extracted from a number of eucalypts but one of the best sources, the blue mallee, is found near Wedderburn, Inglewood, St Arnaud and in the Whipstick Forest. In the nineteenth century distillers were issued with licenses and, by the turn of the century, some Crown land areas were expressly reserved for the harvesting of suitable species. In the 1920s the Forests Commission established experimental stills at Tarnagulla and Wellsford. Stills continue to operate in the study area today at Bendigo, Maryborough, Inglewood, Wedderburn, Rushworth and St Arnaud.

Charcoal production was another minor forest industry in the study area. Suitable timbers include red ironbark, red box, grey box, yellow box and red gum. Charcoal is produced by slowly burning the durable timbers in reduced oxygen conditions for several days, preferably in a kiln. The kilns could be conical stacks of timber covered with turf (bee-hive kilns), pits covered with iron sheeting, or metal structures. The Forests Commission engaged in charcoal production during the Second World War, when petrol rationing led to the use of producer gas as an alternative fuel. Forests Commission kilns were located at Dunolly, Ballarat and Bendigo.

There is a long history of beekeeping in the Box-Ironbark study area (see Chapter 7). European honey bees were introduced to Australia in the early 19th century. From at least the 1860s populations of feral bees in Victoria were encountered by settlers engaged in clearing native vegetation. In the north-east, some settlers supplemented their diet, and bolstered meagre incomes, through harvesting bush honey. Commercial bee-keepers, who were well established in Victoria by the turn of the century, derived their initial stocks from the original feral bee populations. Today, the industry is focused on the inland hills of the study area, and concentrated on the Box-Ironbark Forest Ecological Vegetation Class (see Chapter 7 for details on vegetation types).

## FOREST MANAGEMENT

Although regulations as early as 1839 stipulated that timber cutters were required to hold licences to cut wood on Crown land, holders of pastoral licences were exempted from this rule, if the cut timber was used for their own purposes. By the 1850s, those holding miners' rights or buying or leasing Crown land were also exempted. Much valuable timber was wasted under this poorly regulated system.

The goldfields forests were the first in Victoria to attract the concern of foresters, largely because of demands placed on them by the mining industry. The first timber reserves were set aside in the 1860s, ironically in an attempt to preserve the resource for future mining needs. Early forest reserves in the study area were located at Bendigo, Castlemaine, Ararat, Maryborough and Inglewood. Regulations concerning sawmilling, cattle depasturing and wattle-bark stripping were introduced in the 1870s, though insufficient forests staff were available (within the Department of Crown Lands and Survey) to police the regulations.

In 1890, the Chief Conservator of Forests, George Perrin, identified State forests at Havelock, Ballarat East and Bendigo as priorities for improvement. The forests were thinned through the removal of stunted and diseased trees, understorey debris was burned and fire breaks were created. Over the next decade similar work was carried out in forests near Maryborough, Tarnagulla, Kamarooka, St Arnaud, Heathcote and Killawarra.

A Royal Commission into State forests, timber reserves and their management, was constituted in 1897. The Commission's findings eventually led to the first effective forests legislation in Victoria, the *Forests Act 1907*, which in turn created a Department of State Forests (the precursor of the Victorian Forests Commission) to more effectively manage forests in Victoria.

The management of box-ironbark forests in the Chiltern and Beechworth areas was particularly criticised by the Royal Commissioners. Much of the timber coming out of these forests was still being used for mining purposes, chiefly for fuel, and of that it was estimated that three-quarters came from saplings under 12 inches (30 cm) in diameter. Large areas were completely denuded of live trees by this activity.

The work of 'improving' forests continued into the 1920s and 1930s, under the direction of the newly established Forests Commission of Victoria. In the latter period unemployed men and boys were given the task, and housed in rough camps in the forest areas. Men's camps were established at Bealiba, Castlemaine, Chiltern, Heathcote, Rushworth and Tarnagulla, while boys' camps were located at Bendigo, Maryborough and St Arnaud.

During the Second World War, when the Forests Commission was involved in supplying firewood for Melbourne, alien internees, and later German and Italian prisoners of war, were made available for forests work. These men were also accommodated in bush camps, located in the Killawarra and Carapooee forests, and at Graytown near Heathcote, and Dunolly. Later post-war 'displaced persons' camps provided labour for firewood cutting, silviculture, planting and road construction. Displaced persons were housed near Rushworth and Castlemaine.

## WATER SUPPLY AND MANAGEMENT

Water was a crucial requirement for European settlers. Squatters, where they could, established their runs along rivers and creeks. Water was also essential for mining, and it was common for miners to dam creeks, divert water courses and dig or construct lengthy water races to ensure adequate supplies for their operations.

After a severe drought in 1865-66, water from the Coliban River was supplied to Bendigo, Harcourt, Chewton and Castlemaine, via a primary reservoir at Malmsbury and through a system of reservoirs interconnected by a 100-km channel and viaduct. The scheme opened in the mid-1870s, and has been enlarged at intervals, usually in response to droughts, to the present day.

Individual towns established their own reservoirs, but water supplies for people on the land were mostly left to local authorities to organise through Waterworks and Irrigation Trusts. Large headworks constructed to supply the trusts included the Goulburn Weir north of Nagambie in 1890, and Laanecoorie on the Loddon River near Dunolly in 1891. In 1905 the State Rivers and Water Supply Commission was formed and assumed a central

role in managing irrigation and coordinating water supplies outside the Melbourne area.

Irrigation water from the Goulburn River supplied the Shepparton, Rodney, Tongala, Rochester, Dingle and Tragowel Plains districts. Since the 1950s a new irrigation area has been developed around Cobram and Numurkah. Other major storages built in the region since the 1950s include Cairn Curran on the Loddon (1956), Eppalock on the Campaspe (1962), and Mokoan on the Broken River (1971) (see Chapter 18 for more details).

## SOIL EROSION

Many aspects of European land-use had a deleterious effect on soils in the Box-Ironbark study area. The impact of domestic grazing animals and introduced pasture grasses has already been described. When the soil became compacted it was less able to absorb water, leading to increased runoff and soil erosion.

The widespread ransacking of forests during the goldrushes also contributed to soil erosion, as did the mining practices of surface digging, tunnelling, sluicing and the diversion of water courses. Many mining areas still bear the scars of deeply eroded gullies.

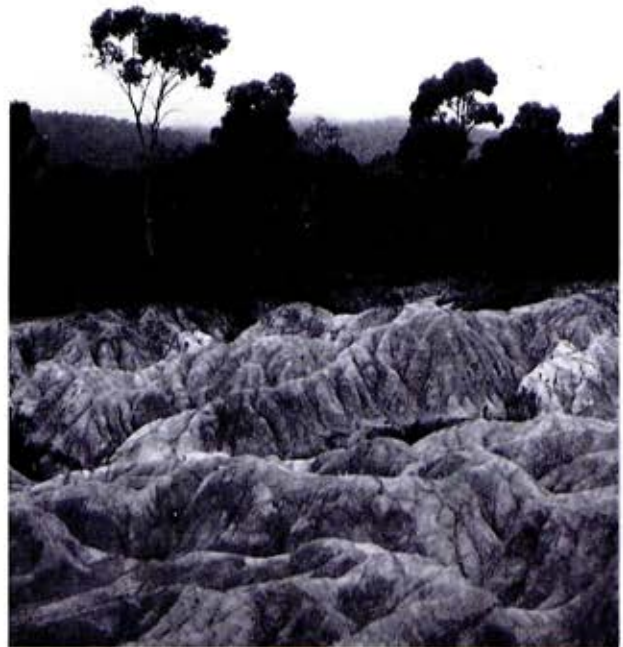
The process of deforestation continued by the selectors and small farmers resulted in an extensive belt of gullying and sheet erosion in numerous localities, right across the study area, from Ararat to Maryborough, Benalla and on to Beechworth. The erosion was increased by overgrazing stock and rabbits, especially in times of drought. Farmers sometimes compounded the problem by ploughing furrows up and down their slopes, and making gullies for the rain to run down bringing more of the surface soil with it.

Eroded dry soil also silted up waterways, channels and reservoirs. The capacity of the Laancoorie Reservoir, built to store water from the Loddon River, was reduced by more than half within 50 years of its construction, because of siltation. Irrigation also had profound effects on the soil. The action of adding extra water to land affects the natural watertable, and groundwater gradually rises through the soil and kills tree roots as it reaches them. Eventually, when saline, it may surface to form a white crust on the soil, which is then too salty for vegetation growth. In much of the study area the natural watertable is about 30 m below

the surface, but in most irrigation areas today it is now within 3 m of the surface.

## NATURE CONSERVATION

The use of public land explicitly for nature conservation commenced in the study area at least as early as 1934 (and possibly late last century) when McDonald Park (62 ha) near Ararat, was designated as a Special Purposes Reserve for the preservation of flora and fauna. The reservation of McDonald Park reflected early attitudes to nature conservation, as the reserve also contains many introduced plant species from Western Australia, Queensland and New South Wales.



*Erosion following sluicing, Pink Cliffs Scenic Reserve, near Heathcote.*

Subsequently, many generally small areas have been set aside for nature conservation under various Acts. Up until the 1960s, the preservation of wildflowers and koalas was given particular prominence — for example

Mt Alexander Koala Park (31 ha, set aside in 1939), and Paddys Ranges Wildflower Reserve (38 ha, set aside in 1957). In the 1970s and 1980s, several larger areas were reserved under the *Forests Act* (e.g. Bendigo Whipstick Forest Park) and the *National Parks Act* (several State parks). As more areas were set aside for nature conservation, natural history and nature study became more explicitly recognised as recreational and tourist activities (see below) in the study area.

## TRANSPORT AND COMMUNICATION

### Roads

'Major Mitchell's line' was the first European line of communication through the Box-Ironbark study area. Other early roads and tracks were created by new settlers establishing the easiest course over streams, along ridges or gullies and through forests. These pioneering routes gradually became the accepted paths.

The first public transport in the region was the fortnightly overland mail to Sydney which started in 1838. A group of young Americans founded the fast Cobb and Co coach service to Forest Creek (Castlemaine), in the 1850s.

In 1852 a Central Roads Board became responsible for forming seven main roads through the colony. The Sydney Road, a busy route through the study area, began to be improved after this time, and bridges were constructed across all the rivers. What is now the Calder Highway was also built from Melbourne to the Murray River, via the Mt Alexander diggings.

The Country Roads Board was established in 1912 to oversee the construction and maintenance of major country roads. By 1930 half the State's highways had been reconstructed. Since the 1960s a number of sections of the major highways in the Box-Ironbark study area have been, and continue to be, turned into freeways.

### Railways

The second half of the 19th century was the golden era of rail, when an extensive railway network was established across the State. The first rail line in the Box-Ironbark study area was an extension of the Melbourne to Sunbury line, which opened in stages to Woodend, Kyneton, Castlemaine and Bendigo by October 1862. This latter part

of the construction involved considerable engineering feats — a 260 foot (88 metre) stone bridge over the Coliban River at Malmsbury, a 650 foot (220 metre) iron viaduct over Back Creek near Taradale and two 1200 foot (410 metre) tunnels at Elphinstone and Big Hill. The final extension of this line, through flat country to Echuca, was relatively easy to construct and opened in 1864.

The North-Eastern Railway, begun in 1867, reached Wangaratta in 1873 and Wodonga a year later, although it was some years before a rail line joined up with it on the other side of the Murray River.

In many areas newly opened to selection, agriculture was not feasible unless there were rail links to markets, and townspeople and farmers alike agitated for rail connections to their areas. Branch lines spread out from the main country lines, many built principally to transport wheat or other produce. Wheat storage sheds (later grain silos) appeared at many railway stations.

By the 1930s, however, when motorised transport was more readily available, many of the small railway lines declined and became uneconomic to run. The Government also began to direct money into road improvements rather than railways. The progressive closure of railway lines became common in rural areas, and former railway stations (some of which are quite substantial buildings) are now a feature of many country towns.

## MILITARY ACTIVITY

At the outbreak of the Second World War, the Australian Army required accommodation and facilities for training recruits, particularly in areas associated with modern warfare — communications, electrical and mechanical engineering, motorised and armoured transportation, surveying, mapping and intelligence.

According to Miller (1990), the Seymour district had already been a focus for military training, with the Seymour Army Camp established in 1918. The locality was regarded as ideal — it was central, close to rail transport, away from the main population centre, and had suitable terrain and a favourable climate. Puckapunyal was purchased in 1939, when the Army required additional land in the district. The new camp then developed into a critically important training facility, with virtually all facets of the army represented there. Puckapunyal was



*Public buildings, Beechworth.*

also a focus for National Service activity in the 1950s and during the Vietnam War. The extensive Puckapunyal Range Area, with its box-ironbark vegetation, has been a particular focus for training in armoured warfare.

## RECREATION

Horseracing has been extremely popular from the earliest days of the colony and a racecourse was often the

first public reserve established in a country town. Ballarat and Bendigo held substantial race meetings on their courses, but even tiny townships like Redbank, north of Avoca, had a racetrack.

Public recreation reserves, for a variety of purposes, were also usually set aside in the initial survey of a township. Recreational boating became popular this century, and water storages such as the Hume Reservoir and Lake Eppalock are used for water sports.

## TOURISM

In the late 19th century many Victorians began to have sufficient leisure time and income to visit other parts of their State. Railways made many places more accessible, and the well-off could take holidays and eventually travel by car.

A number of resorts developed in the study area during the late 19th and early 20th centuries. Beechworth was prized for its surrounding mountains and bracing air; camping became popular and with motoring more common, campers travelled inland to places such as Castlemaine, where the Borough Council established a recreational camping ground in 1929.

Since the Second World War, and particularly in the last two decades, *tourism* has become a much more organised and promoted industry in the study area. The region's 19th century heritage is used extensively as a marketing tool. Ballarat has Sovereign Hill, and Glenrowan promotes its Ned Kelly associations. As mentioned earlier, prospecting, metal detecting, bushwalking and nature study are examples of other tourist activities that have become popular in the study area since the Second World War (see Chapter 12 for more details).

## 4. GEOLOGY, GEOMORPHOLOGY AND SOILS

### GEOLOGY

#### Introduction

In recent years the Geological Survey of Victoria has acquired an enormous amount of new information on the regional geology of Victoria, in an effort to encourage mineral exploration and development. New, high quality aerially mapped geophysical data are now available for most of the State, and important bedrock areas have been geologically remapped on the ground. This, together with new geological work by industry and academia has greatly advanced our understanding of the geology and mineral potential of the State. In particular, the structural complexity of the Palaeozoic and older rocks, including those lying beneath a cover of younger rocks, is now being unravelled. This work provides a greatly improved framework for the generation of new mineral exploration targets.

In brief, the Palaeozoic bedrock of the study area belongs to a belt of folded sedimentary and volcanic rocks (Tasman Fold Belt) which extends along the eastern side of the Australian continent. The fold belt appears to have developed as a consequence of arc-continent collisions. These caused the Palaeozoic rocks to be accreted onto the eastern edge of older, more consolidated and metamorphosed rocks of Pre-Cambrian age that formed the Australian Craton. During this process the sediment/volcanic pile was fractured and displaced by major thrust faults and intruded by numerous granitic bodies. In the Cainozoic Era, following a long period of erosion of the fold belt mountains, and continental separation, a thin veneer of sediments was deposited over the erosion surface in the north, and basic volcanics were extruded over it in the south.

The following is a history of the main events in the geological evolution of the study area. This geology is summarised in the geological timescale, Figure 3, and major outcropping rock is shown on Map 8. This history is presented to provide a background understanding of the region's current earth resources.

### GEOLOGICAL HISTORY

#### Adelaide Fold Belt

Late Precambrian to Late Cambrian (about 550–490 million years).

The known geological events of the study area began with a period of volcanism and deep marine sedimentation at least 500 million years ago, possibly during the Late Precambrian to Early Cambrian period. The Glenelg River Bed sediments, part of the Glenelg Zone, were probably derived from highlands in South Australia, and deposited in a rift zone. During the Delamerian Deformation — a mountain-building episode in Early to Middle Cambrian times — the sediment and volcanic pile was deformed and uplifted by east-west compressional forces. This deformation was accompanied by metamorphism and intrusion of granites, with further intrusion in the Early Ordovician period. The Delamerian rocks are thought to extend as far east as the Moyston Fault, but originally would have extended much further east.

#### Lachlan Fold Belt

Late Cambrian to Late Ordovician (about 490–435 million years)

Following the mountain-building, rifting took place in the Glenelg Zone crust, and a major basin known as the Tasman Geosyncline began to develop in Victoria, to the east of the Grampians area. It is thought that the Mt Stavely and Mt Dryden volcanics were erupted through thinning Delamerian crust immediately before or during the rifting episode. Most of the Palaeozoic sedimentary bedrock of the study area was formed by rapid deposition in the subsiding oceanic area, which extended from Queensland to Tasmania. Opening of the rift was marked by extensive volcanic activity in the Cambrian period. The volcanic rocks, or greenstones, are now exposed in narrow, north and north-west striking belts lying adjacent to major fault zones at Stawell, Mt Ararat, and in the Colbinabbin-Heathcote-Lancefield and Dookie-Tatong areas.

Map 8: Geology.

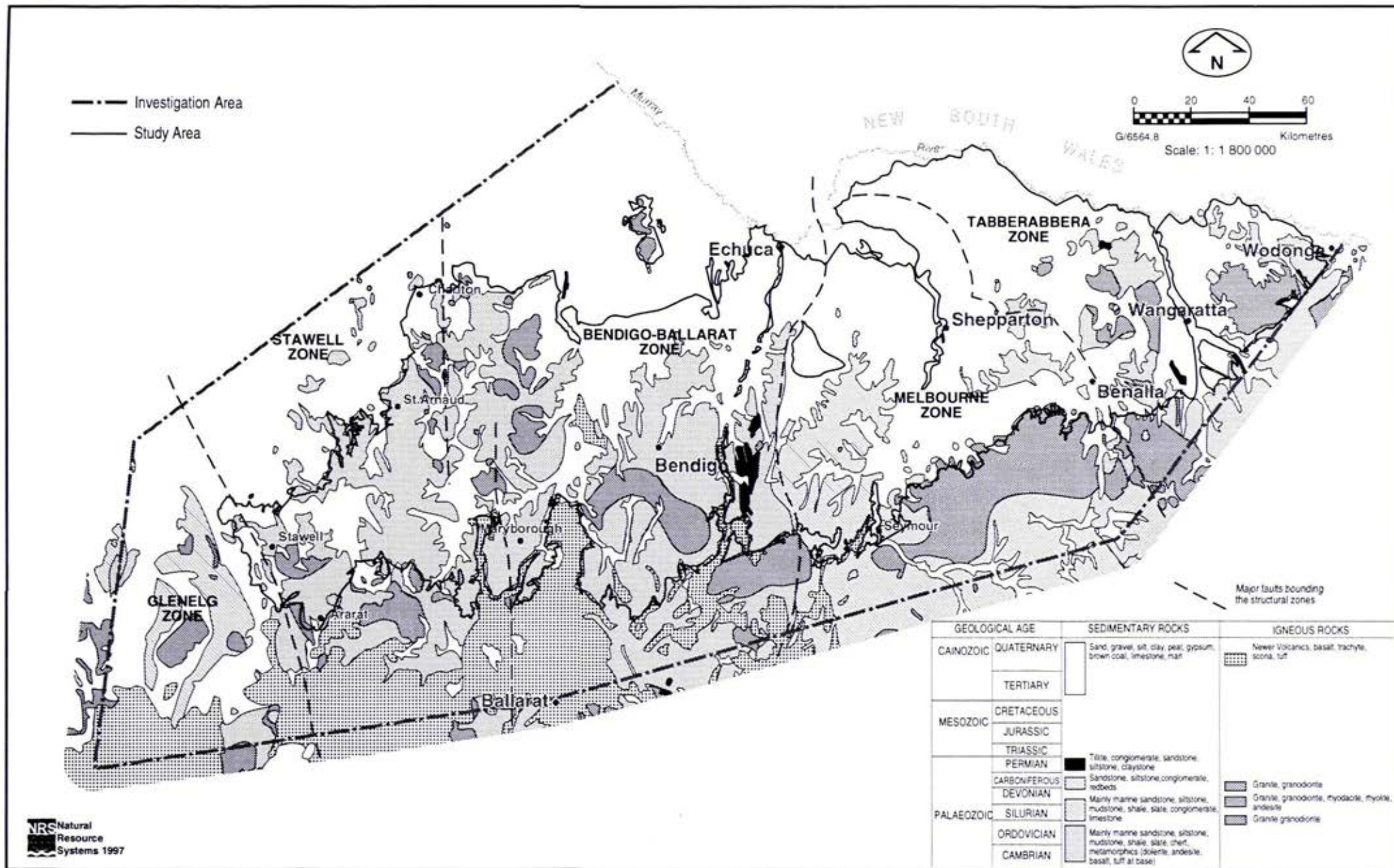
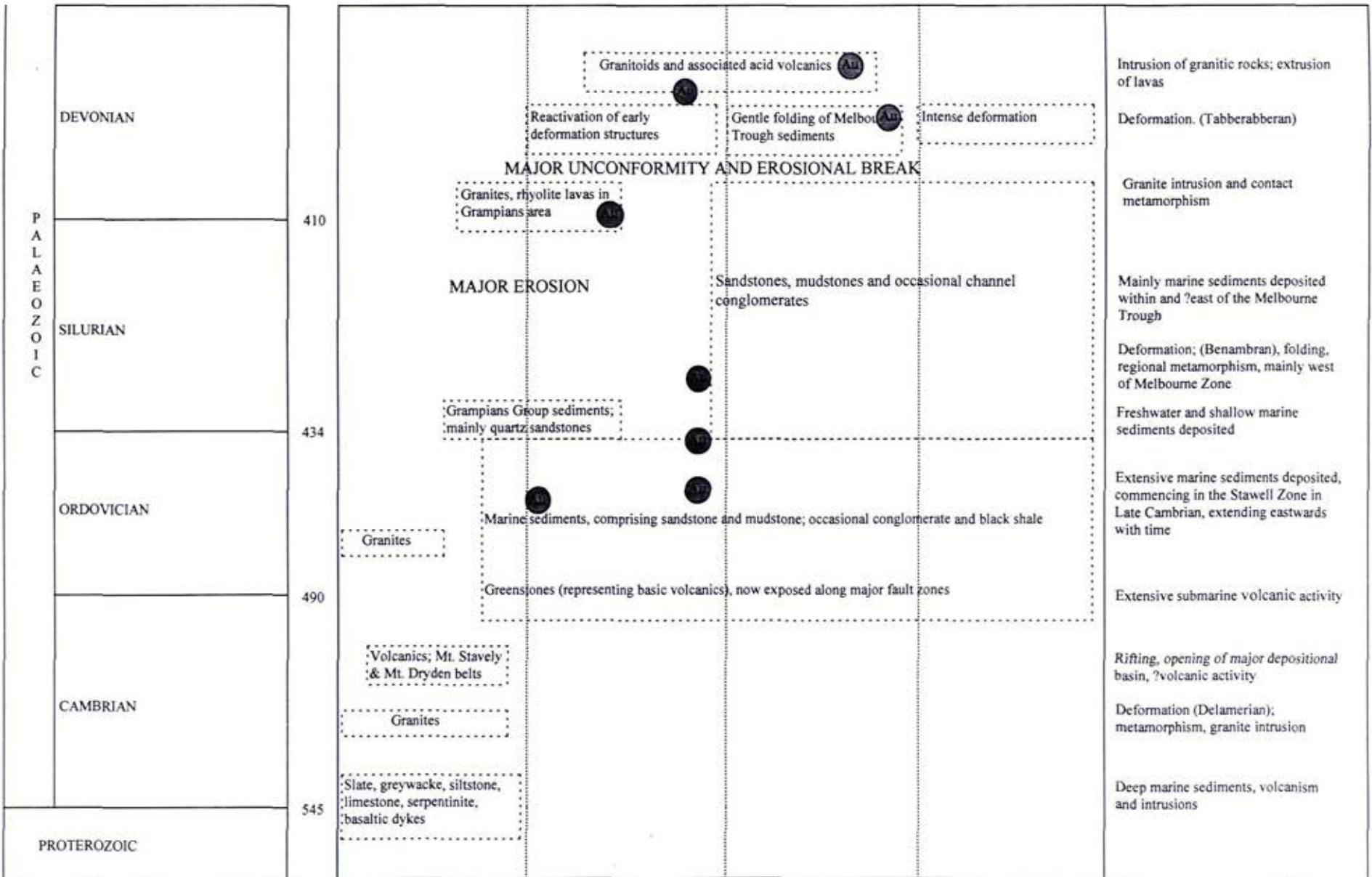


Figure 3: Major geological events and rock distribution

ERA	PERIOD	EPOCH	AGE (Ma)	ADELAIDE FOLD BELT	LACHLAN FOLD BELT			MAJOR EVENTS
				GLENELG ZONE	WEST STAWELL & BENDIGO - BALLARAT ZONES	MELBOURNE ZONE	EAS TABBERABBERA ZONE	
C A I N O Z O I C	QUATERNARY	RECENT		Generally fine sediments; silt, clay, sand				Deposition of sediments in rivers, lakes and swamps; wind blown deposits
		PLEISTOCENE	1.8	Basaltic lavas and pyroclastics			Volcanic activity (Newer Volcanics); mainly in south	
	TERTIARY	PLIOCENE		Clay, silt, minor sand				Deposition of sediments in north; mainly in lakes and swamps; minor stream channel deposits (Shepparton Fm.)
		MIOCENE	5	Marine sand & silt			Marine incursion & sedimentation in north; (Parilla Sand)	
		OLIGOCENE	24	Quartz sand, silt, carbonaceous clay, brown coal				Murray Basin deposition of sediments in rivers, lakes & swamps (including Renmark Group)
		EOCENE	34					
		PALAEOCENE	55	Gravel, sand; minor silt & clay				Mainly high energy river sediments in north (White Hills Gravel)
		M E S O Z O I C	CRETACEOUS	65	<b>MAJOR UNCONFORMITY AND EROSIONAL BREAK</b> Glacial sediments; tillites, sandstone, mudstone			
	JURASSIC		141					
	TRIASSIC		205					
PERMIAN	251							
	CARBONIFEROUS	298	Red bed sandstones, mudstones, ignimbrites			Non-marine, river and lake sediments deposited with volcanic activity		
		354						



Intrusion of granitic rocks; extrusion of lavas

Deformation. (Tabberabberan)

Granite intrusion and contact metamorphism

Mainly marine sediments deposited within and east of the Melbourne Trough

Deformation; (Benambran), folding, regional metamorphism, mainly west of Melbourne Zone

Freshwater and shallow marine sediments deposited

Extensive marine sediments deposited, commencing in the Stawell Zone in Late Cambrian, extending eastwards with time

Extensive submarine volcanic activity

Rifting, opening of major depositional basin, ?volcanic activity

Deformation (Delamerian); metamorphism, granite intrusion

Deep marine sediments, volcanism and intrusions

**Au** Denotes a phase of gold/quartz mineralisation - after Foster *et al.*, (1996)

The volcanics are conformably overlain by a thick, extensive sequence of marine sediments, which accumulated rapidly in a series of fault-controlled troughs. They were sourced from a continental slope to the west, and moved eastwards with time. Within the study area, these sediments are found in three major tectonic zones or provinces: the Stawell, Bendigo–Ballarat and Melbourne Zones. The Stawell Zone is characterised by thick, unfossiliferous sandstone and mudstone successions of the presumed Late Cambrian St Arnaud group. The sandstones largely consist of quartz, and are probably derived by erosion of quartz-rich metamorphic and granitic rocks in the highlands to the west. Exposures are found in the Pyrenees and St Arnaud ranges.



*Folded Cambrian chert and shale at Ladys Pass near Heathcote.*

The Bendigo–Ballarat Zone contains Lower Ordovician sediments of the Castlemaine Supergroup. They consist predominantly of sandstones and mudstones, deposited along the foot of the continental slope. In the Melbourne Zone to the east, the Ordovician rocks are largely concealed

beneath a cover of younger Siluro–Devonian rocks, but outcrop further east again. Deposition in central Victoria continued throughout the Ordovician, building up layers of sediment thousands of metres thick. In addition, the sequence in the eastern portion of the Bendigo–Ballarat Zone contains channel sandstones, grits and fine conglomerates. Occasional thin beds of black shale represent deposition in relatively deep, still water, beyond the influence of ocean currents. Graptolite fossils are commonly found preserved in these black shales and they allow subdivision of the sequence into time zones.

Phases of gold and quartz mineralisation occurred in the Stawell and Bendigo–Ballarat zones in the mid- to late-Ordovician. These and later phases are shown in Figure 3.

#### Early Silurian Benambran Deformation (around 425 million years)

During this deformation, the soft, water-laden St Arnaud and Castlemaine Supergroup sediments were compressed by forces acting in a north-east – south-west direction. This produced a regular series of north-west to north trending folds, strong slaty cleavages and major west-dipping thrust faults. Generally weak regional metamorphism converted the sediments to schists, slates and phyllites. Locally, in an area of complex faulting in the west Stawell Zone, the metamorphic grade became higher.

#### Silurian to Early Devonian (435–385 million years)

Uplift movements associated with the Benambran Deformation caused the earlier deep marine basin to contract, leaving the Melbourne Trough area in central Victoria as a depositional region. This Trough contains a thick unbroken sequence of Silurian–Lower Devonian sediments which lie conformably upon Ordovician turbidites and black shales. The source areas lay mostly to the west. Some rock fragments (rhyolite, basalt, schist, granite) in the coarser sediment suggest quite distant sources, while much of the finer material was probably derived from the Ordovician terrain nearby. In contrast, the thick sediments of Early Devonian age in the eastern part of the trough (Walhalla Group), had their source to the east. The present-day margins of the trough are major faults which appear to have truncated the original sedimentary basin to some extent, forming the Melbourne structural zone. The western margin lies against the north–south elongated Heathcote Greenstone belt.

### Late Silurian — Bowring Deformation

At the close of the Silurian, the Bowring Deformation caused folding, faulting, uplift and metamorphism in eastern Victoria but produced little effect in the Melbourne Trough. At about the same time, many large granite masses were intruded in north-eastern Victoria, some of which extend into the study area.

### Early Devonian granite intrusion (around 395 million years)

Granites intruded the Grampians, the Stawell Zone and parts of the Bendigo–Ballarat Zone in Early Devonian times. In the Grampians area, the intrusions were preceded by the eruption of associated volcanics. They consist of interbedded rhyolite lavas and ash layers, known as the Rocklands Rhyolite. The granite intrusions produced contact metamorphism of the surrounding rocks, altering them to biotite slate and phyllite, schist, and hornfels.

### Early-Middle Devonian Tabberrabberan Deformation (395–380 million years)

The Tabberrabberan Deformation affected the whole of south-eastern Victoria in the Early to Middle Devonian period. In the Cambro–Ordovician rocks of the Stawell and Bendigo–Ballarat Zones it mainly caused reactivation of some of the major structures developed during the earlier Benambran Deformation, minor recrystallisation of the still cooling granites, and ductile deformation of relatively hot, plastic rocks surrounding them. In the Melbourne Zone, the deformation produced the major faults that now form its eastern and western boundaries, and the folding of sediments within it. In the eastern part of the zone the folding was tight, becoming less intense in the west with more rounded, widely spaced folds. Fold axes generally trend north to north-west (east–west compression), but locally, in the northern part of the zone, east–west trending folds predominate. By the end of the mountain building episode, the eastern coastline of Australia was similar to its present conformation, the crustal foundation had been laid for all subsequent deposition, and all of Victoria lay above sea level.

### Late Devonian to Carboniferous (370–325 million years)

The Late Devonian period in central Victoria was characterised by intrusion and extrusion of acid magmas.

Granitoid magmas intruded to high levels in the crust, and many broke to the surface, where they formed thick volcanic piles. Most of the volcanic material consisted of rhyolitic to rhyodacitic ignimbrites. In places the rapid evacuation of the magma chambers caused the overlying crust to collapse, thus forming depressions or calderas, which filled up with ignimbrites. Erosion has removed much of the volcanics, but major parts of some cauldrons remain, for example near Violet Town. Some of the volcanic complexes were intruded by granites, for example Strathbogge Granite. The intrusions are discordant — that is, their form was not controlled by host rock structure — and their outcrop patterns tend to be ovoid or rectangular.

### Late Carboniferous to Permian glaciation (325–250 million years)

During this period most of Victoria consisted of dry land, but a shallow sea existed in the north, possibly extending up to 50 km south of the Murray River. Victoria lay close to the South Pole, and glaciers originating in the south advanced and retreated several times. Sediments deposited during this time reflect a variety of environments, including:

- glacial — tillite, with pebbles and boulders set in a rock flour matrix;
- fluvial — sandstone and mudstone;
- lacustrine — thinly bedded mudstone, and
- shallow marine — sandstone, mudstone, beach gravels.

Erosional remnants of Permian rocks outcrop near Derrinal, Glenrowan and Beechworth. Thicker sequences are preserved in several fault-bounded basins located beneath the Tertiary Murray Basin in northern Victoria and south-western New South Wales, for example the Oaklands–Ovens Graben.

### Mid-Permian to end Cretaceous (270–65 million years)

Prolonged erosion took place in the study area between the mid Permian and start of the Tertiary periods, during which several thousand metres of Palaeozoic rocks were stripped away. In the Jurassic to Early Cretaceous, Australia and Antarctica began to separate and rapid sedimentation occurred to the south, in the Otway Rift.



*Ordovician granite tors, Mt Korong.*

### Cainozoic (65 million years to present)

It was not until the Early Tertiary that sedimentation resumed in the study area. A broad area of gentle subsidence developed in north-western Victoria, western New South Wales and eastern South Australia, forming the Murray Basin. Tertiary strata outcrop poorly, and are known largely from subsurface data. Generally the beds dip very gently, and the sequence thickens towards the north-western corner of Victoria, where it is over 600 metres thick.

Deposits of high-level Tertiary alluvial gravel and sand with occasional kaolinitic clay lenses are found scattered across the highlands in north-central Victoria and extend into subsurface deep lead systems. They belong to the White Hills Gravel of possible Palaeocene age. The coarser sediments signify a period of high energy deposition from streams flowing northwards into the basin from the highlands.

Within the basin, sediments were deposited over the Palaeozoic basement in stream, lake and swamp environments, as subsidence continued from Palaeocene to Middle Miocene times. The older sediments form the Renmark Group, consisting of quartz sand, silt, carbonaceous clay and brown coal. The thickest sequences accumulated in broad valleys eroded by the ancestral Loddon, Campaspe and Goulburn Rivers. Stream dissection in the adjacent highlands resulted in sand and gravel — the Calivil Formation in part — depositing over the Renmark Group and lapping onto the bedrock. Intermittent fault movement occurred throughout Tertiary times, with reversal of movement along some major faults, and sea levels rose and fell. The sea extended into the deeper

parts of the basin in the Oligocene. A shallow sea advanced into the study area from the west in the Late Miocene–Early Pliocene, with deposition of sand and silt in littoral to near-shore environments forming the Parilla Sand.

The bordering highlands, elevated by movements associated with the Kosciusko Uplift, provided the source material. As the uplift progressed and affected an increasing area, the sea retreated from the basin and a series of subparallel coastal edges were formed on the surface of the Parilla Sand, for example the Gredgwin Ridge. The most recent major phase of fluvial deposition in the Murray Basin is represented by the Shepparton Formation of Pliocene to Pleistocene age, whose upper surface forms the Riverine Plain. Its sediments consist mainly of clay and silt deposited in periodically flooded lakes and swamps. Narrow, sinuous lenses of sand are scattered throughout the formation, marking the courses of ancient streams.

Widespread volcanic activity occurred in the southern part of the investigation area during the Pliocene to Pleistocene. The basaltic lavas of the Newer Volcanics filled the major valleys of south flowing streams, and formed the Western District basaltic plains in the south. Commonly, several flows have been superimposed, each varying in thickness from a few metres to tens of metres. The most recent flows display almost unaltered volcanic features, including characteristic stony rise topography in places.

Quaternary deposits of the study area include the alluvium in present day streams and their recent ancestors — the Coonambidgal Formation in the Murray Basin — and generally fine sediment in swamp, lake and wind blown (aeolian) deposits. The latter occur in extensive sheets: as lunettes; and as source bordering dunes, which have accumulated adjacent to lakes and stream channels during dry periods.

## GEOMORPHOLOGY

The Box-Ironbark study area is a region of modest to low relief with subdued topography and extensive areas of plains. It encompasses parts of three of the major geomorphic divisions of Victoria, namely:

- the West Victorian Uplands (Midlands)
- the East Victorian Uplands
- the Murray Basin Plains.

## The West and East Victorian Uplands

The extent of the West Victorian Uplands (geomorphic unit 2.1) and East Victorian Uplands (unit 1.1) is depicted on Map E in the map pocket. The boundary between the East and West Uplands in Victoria is traditionally taken to begin at the Kilmore Gap extending via the Mt William Range towards Heathcote and north along the Mt Camel Range. Only a small area of the East Victorian Uplands is contained in the Box-Ironbark study area.

The uplands extend east-west across the study area in a belt of irregular width, the lower boundary approximating the 200 metre contour. There are no mountainous tracts in the study area and the dominant upland landforms are gentle hills and ridges with small areas of plateau. The highest terrain is just over 700 metres elevation in the Pyrenees Range west of Avoca. The uplands constitute a dissected surface sloping north with moderate slopes, broad valleys of low gradient, and typically low internal relief. Distinctive geological formations such as granitic intrusions, metamorphic aureoles and hard sandstones provide the basis of areas of higher relief and also account for prominent ridges, isolated hills and locally steep slopes.

While the form and orientation of some major landform elements is due to faulting, most landforms have been shaped by long periods of weathering interspersed with episodes of broad tectonic uplift or doming. Erosion during and subsequent to uplift has resulted in stripping of some of the weathered mantle, exposing underlying Palaeozoic sedimentary and intrusive rocks, so that geology now provides a basic uniformity as well as variations across the uplands. There is a well-defined 'grain' or orientation of many topographical elements reflecting bedrock structures. The folded Palaeozoic sedimentary rocks occur in north-south strike bands and control the orientation of major ridges and valleys, while fracture systems in these rocks determine details of the drainage patterns.

Some granitic intrusions show bold slopes and higher plateaus with extensive outcrop of slabs and tor fields, such as at Mt Alexander, Mt Korong and Mt Kooyoora, while other granitic rocks at Carapooee and Tarnagulla have weathered to form low or undulating relief with little outcrop. The basin at Murmungee in the Ovens Valley is a deeply weathered intrusion concealed beneath alluvium.

Palaeozoic sediments metamorphosed by the heat of the intrusions form high arcuate ridges around parts of the granitic intrusions, such as the Big Hill Range near Bendigo, at Mt Ararat, and the northern rim of the Murmungee 'basin'.

Several prominent northern outliers of the uplands occur as ridges or isolated hills. These are typically erosional residuals of small granitic plutons, such as at Mt Terrick Terrick near Pyramid Hill and the Warby Range west of Wangaratta, in part due to faulting.

Most of the study area lies north of the Great Divide with drainage to the Murray Basin through the Ovens, Broken, Goulburn, Campaspe, Loddon, Avoca, and Wimmera rivers. A small part of the study area in the south-west lies south of the Divide and drains into the swampy headwaters of the Hopkins River. Near Ararat, lakes and swamps along the Great Divide are caused by the shallow slope of the Divide together with the effects of drainage disruption by young lava flows.

Lengthy periods of weathering and erosion in the uplands, uninterrupted by marine transgression or major tectonic movement, have allowed the accumulation of ancient weathering profiles, including the deep clay beds around Bendigo and Heathcote. Around the Harcourt batholith many metres of decomposed rock is exposed in road cuttings, with fresh granite tors and domes at the same or higher levels in the landscape. Deep kaolinitic profiles are preserved in places on both granitic and sedimentary rocks. Tertiary gravel and sand deposits include layers hardened by iron and silica to form ferricrete and silcrete. In places the strongly cemented siliceous gravels form ridge cappings and rounded hill tops.

Along broad highland valleys, younger gravel river deposits and lava flows provide local landform variations. Even younger alluvial and colluvial deposits have youthful soils and often include a surface deposit of alluvium resulting from European land use over the last 150 years.

## The Murray Basin Plains (Riverine Plain)

The major landform unit north of the uplands in Victoria is the Murray Basin Plains. In the study area, the principal landform sub-unit is the Riverine Plain, a surface built of and on Pleistocene and Holocene sediments. It is mapped as unit 4.2 on Map E. The sediments originated as

floodplain and river channel deposits, and also formed in shallow lakes and as wind-blown dunes. The deposits extend from upland valleys such as the Loddon and Ovens and coalesce to form an almost continuous mantle across the study area. They are known as the Shepparton Formation.

The landforms of the Riverine Plain may be grouped into four types: Prior Streams, Ancestral Rivers, Modern Streams, Lakes and Lunettes.

#### Prior Streams

These are the traces of the oldest rivers and appear as low ridges of silt and sand — former natural levee banks — that lie adjacent to shallow, meandering depressions that are the former river channels. Often these channels are perched or built higher than the level of the plain. They do not now normally carry surface water and both channels and levees are discontinuous as they have been partly eroded by later events. The prior streams often split into fans and distributaries and many are long distances from and unrelated to the present rivers.

#### Ancestral Channels

These are old, abandoned channels that lack levee banks and are incised into the surface of the plain and partly filled with alluvium. They are associated with and often crossed by the modern rivers and may act as floodways during high river discharge. As many of these channels are wider, include coarse sand and gravels, and have meander amplitude much greater than that of the present rivers, it appears they were formed at times of much greater river discharge.

#### Modern Streams

These are the channels and swamps of the present river system and in places they follow the paths of ancestral channels. They have narrow channels with well-defined banks and flood plains, some, such as the Campaspe, with alluvial terraces. On the flood plains are lakes and swamps that lie in cut-off meanders or avulsion channels, which are long reaches of channel abandoned during flood.

#### Lakes and Lunettes

Lakes on the Riverine Plain have formed from three causes:

- cut-off meanders and abandoned channels

- deflation (wind-eroded) hollows
- tectonic depressions.

Many lakes are composite and are fed by ground water rather than surface runoff.

Lunettes are unusual landforms of considerable scientific interest. They are broad crescent-shaped ridges composed of clay, silt and fine sand lying on the eastern sides of shallow lakes. They have a complex history and reflect episodes of lake level changes. Some lunette sediments formed as dunes from lake shore beaches but much of the material is clay blown from the lake floor during episodes when the lake dried.

A number of the Riverine Plain landforms can be dated and are of considerable significance in determining Late Quaternary climatic history and processes in this region.

## SITES OF GEOLOGICAL AND GEOMORPHOLOGICAL SIGNIFICANCE

Localities that display geological or landform features of interest to earth scientists and others for education, research, reference sites or for conservation may be rated according to a defined scale of significance. The size and nature of such features varies widely and includes natural outcrops as well as exposures in road and rail cuttings, quarries or other excavated sites. Geological sites generally display features developed in earlier times, such as an outcrop with fossils, but some geomorphological sites are important for displaying active land forming processes, such as slope movement or stream erosion and deposition.



*Exposed anticlinal fold in Ordovician sediments at Castlemaine.*

Three overlapping methodologies may be used when selecting and assessing the level of significance of features. These may be termed the *representative*, *outstanding* and *rarity* methods. In all methodologies, some geographical boundary must be specified for the significance comparisons, for example a local government area, a state or national boundary or some natural region such as a geological, climatic or ecological province. *Representative* sites are examples of features typical of a region; *outstanding* sites are excellent examples of a feature, either in the region or on a wider scale; and *rarity* is based on the degree of replication of a feature, the extreme case being a feature that is unique. These ratings may be used in combination, for example a representative feature for a region may also be an outstanding or rare example on a State or national level. Significance ratings contain a degree of subjectivity for they are in part determined by the existing data about the site as well as the level of knowledge of the assessors of similar sites elsewhere.

In this report, features are assessed on all three methodologies and given an overall significance rating of either regional significance in the Box-Ironbark investigation area (33 sites), or of State (9), national (1) or international (5) significance. They are shown on Map C and listed in Appendix IV.

Significant geological features in the region include rock units and structures visible as natural outcrops and in exposures created by mining and quarrying operations and road and railway cuttings. Weathered and faulted Cambrian and Ordovician rocks at Mt Major south of Dookie are some of the oldest rocks in Victoria and a *rare* example of the earliest geological events in south-eastern Australia. A number of road and rail cuttings in and on the flanks of the Pyrenees Range provide excellent *representative* sections showing structures in Cambrian–Ordovician sedimentary and metamorphic rocks. The most extensive natural rock exposures in the study area are of granitic bodies, such as at Mt Kooyoora and Mt Korong. A variety of *outstanding* structural and weathering forms are displayed on the broad slabs, domes and boulders of these mountains. At several localities in the Heathcote district and near Springhurst are *representative* exposures of Permian glacial sediments, comprising part of a complex rated of international significance.

## SOILS

### Inland hills

These soils vary mainly in relation to topography and parent material, because of limited climatic differences across the region. Soil-topographical associations are most pronounced on hilly lands with a repetition of soil types in the same slope position. On the crests and upper slopes of steep ridges soils are usually shallow and stony regardless of rock type. On mid to lower slopes on granitic, sedimentary and metamorphic rocks where there is deep weathering and accumulation of colluvium, soil profiles are deeper. Drainage lines and terraces of modern streams usually have deeper soils, derived from a variety of alluvial and colluvial parent materials.

Some soils show features developed under the influence of earlier rather than present climates, for example, the Tertiary development of lateritic profiles.

### Northern plains

The distribution of soils in this region is closely related to fluvial and aeolian landforms, and soils often form complex patterns. Lunettes and other dunes associated with lakes, channels and levees of former river systems have sand-dominated soils. The flat riverine plains have developed a range of soils on alluvial parent material.

### Soil types

To characterise the wide range of soil types found in the Box-Ironbark study area, the broad soil group and sub-group names of Gibbons and Rowan (1993) are used. They are easily linked to the geological information above, the land systems and geomorphic units outlined in Chapter 6, the hazards discussed in Chapter 20, and soil descriptions in detailed land studies covering several river basins in the area. Certain soil types are associated with geomorphic units corresponding to the Box-Ironbark area, although they are not exclusive to this area. Table 5 outlines the main soil types occurring.

### Bleached duplex soils

These are found over about 1 million ha in the study area. In common, the various bleached duplex soils have dark greyish-brown hard-setting loam topsoil, and conspicuously bleached A2-horizon usually containing

ironstone nodules/gravel, overlying a sodic, greyish-yellow, brown or red dispersible clay B-horizon. The A2 horizons are subject to waterlogging above B-horizon clays, causing their bleached feature. When dry, the A2 is cemented and nearly impenetrable to plant roots.

Sub-groups are hard red bleached duplex soils and hard yellow bleached duplex soils on lower slopes and valleys of the uplands; hard brown bleached duplex soils on the riverine plains in areas with over 600 mm average annual rainfall; and sandy yellow bleached duplex soils on lateritic tableland remnants. Mottled yellow bleached duplex soils are formed on some granitic parent material.

Yellow gum is common on these soils, within occurrences of Box-Ironbark Forest, Heathy Woodland and Low Rises Grassy Woodland Ecological Vegetation Classes (EVCs — see Chapter 7).

**Table 5: Common soil groups found in geomorphic units occurring in the Box-Ironbark study area**

Geomorphic Units <i>Location</i>	Soils Groups <i>(in order of occurrence)</i>
Riverine Plain <i>Northern plains</i>	Red duplex soils Bleached duplex soils Deep red and orange sands Very fertile loams Salty soils
West Victorian Uplands — prominent ridges <i>Crests and ridges of the inland hills west of Heathcote</i>	Shallow soils Poor loams and earths Fertile loams and earths
West Victorian Uplands — dissected uplands <i>Low hills and slopes of the inland hills west of Heathcote</i>	Bleached duplex soils Red duplex soils Fertile loams and earths Poor loams and earths Shallow soils Salty soils
<i>Dissected lateritic plateau over Palaeozoic sediments — north-west margins of the inland hills</i>	Bleached duplex soils Poor loams and earths
East Victorian Uplands <i>Inland hills east from Tooborac-Heathcote elevation above 300 m</i>	Fertile loams and earths Shallow soils Bleached duplex soils Red duplex soils Poor loams and earths Very fertile loams

**Red duplex soils**

About 1 million ha in the Box-Ironbark study area has the various soils in this group. The most common

subgroup — red-brown earths — occur equally across the northern plains and on the slopes of the West Victorian Uplands. They have hard-setting brown loamy topsoils with a paler A2 layer overlying reddish-brown blocky-structured sodic B horizons. Topsoils have poor structure; the surfaces crust after rain, but have moderate available water storage; they are acidic with low exchange capacity and low nitrogen and phosphorus levels. B-horizons may be dispersible, and alkaline in deep subsoils.

Extensive areas originally carried grassy woodlands with white box and grey box. Some Box-Ironbark Forests occur on these soils.

**Shallow soils**

Covering about 500 000 ha, the key feature of these soils is their depth of less than 60 cm. The texture of the profile is very variable — most are stony and gravelly, although on granitic parent material some are sandy. Shallow loams are found extensively in the study area, on prominent ridges. Commonly they support Heathy Dry Forest and Grassy Dry Forest with red box, long-leaf box, and red stringybark, with more grasses and taller trees where underlying rock is fractured and on sheltered aspects.

Shallow soils over laterite are formed from shallow deposits on a laterite layer. Gravelly-sediment Mallee grows on these soils.

**Poor loams and earths**

Two types of poor loams and earths occur over about 300 000 ha in the study area. These have low available nutrient levels, and low water holding capacity, although they are not poorly drained. Massive earths have formed at the junction of prominent ridges with slopes on Palaeozoic rocks. They have a major horizon that is massive in structure. Chemical limitations — low available nutrient level, resulting from sandy and acidic parent material — and low available water storage limit plant growth. Heathy Dry Forests and Grassy Dry Forests occur with long-leaf box, red stringybark, red box and heaths, shrubs and grasses.

Gravelly duplex soils with ironstone or silica hardpans occur on remnants of Tertiary laterite or Tertiary sands and gravels on mid-slope benches of the uplands Palaeozoic rocks. These soils have low available water storage and low available nutrient levels, for example in the Campaspe

catchment, among the lowest of any soils. They often carry Box-Ironbark Forests.

### Very fertile loams

Deep duplex soils with dark brown friable topsoil overlying coloured clay B-horizons occur in the wetter, eastern parts of the northern plains, on about 100 000 ha. They originally carried grey box and white box grassy woodlands. These soils have high infiltration rate and permeability, with good drainage through deep profiles, and hence few limitations for plant growth. Most have been cleared for grazing, cropping and irrigated horticulture.

### Deep red and orange sands

Deep non-calcareous red and orange sands are located as levees along the line of prior streams, and as low dunes, on the northern plains. They cover less than 100 000 ha.



*Permian glacial pavement at Kellams Rock, Lake Eppalock — international significance.*

### Salty soils

Natural salty soils occur outside the study area. Some box-ironbark soils display induced seepage-salting. This has been caused by alterations to the natural vegetation of the surrounding landscape through grazing, cropping and clearing, resulting in less water use, or excessive irrigation water application. Groundwater rising to levels near the surface dissolves salts that are concentrated by evaporation or transpiration. Most salty soils are on undulating areas with red duplex soils and hard yellow bleached duplex soils. Chemical limitations include subsoil horizons with more than 0.3 per cent sodium chloride, or topsoils with more than 0.1 per cent sodium chloride. Profiles are sodic and alkaline.

### Non box-ironbark soils

Certain distinctive soil types are found in adjoining land but not within box-ironbark areas. Soils occurring outside the study area boundary include:

- the black cracking clays of the Wimmera clay plains, some volcanic plains and certain riverine floodplains;
- the fertile loams and earths of the East Victorian Uplands;
- the red calcareous earths found in the swales of the Mallee dunefields;
- the deep white sands of the Mallee siliceous dunes;
- the very poorly drained soils around wetlands and some floodplains.

## 5. CLIMATE AND WATER RESOURCES

### CLIMATE

Climate, particularly rainfall, is one of the key variables determining the occurrence of box-ironbark vegetation (see Chapter 7 for more details). Climate is relatively uniform across the study area, and can be distinctly different from other parts of the investigation area (or indeed, other parts of Victoria) that do not support box-ironbark vegetation. The Grampians and the Wombat and Strathbogie Ranges, for example, receive more rainfall than box-ironbark areas and consequently support different vegetation types. The uniformity of climate in the Box-Ironbark study area is reflected in the Bureau of Meteorology's climatic districts — nearly all of the study area is contained in two districts, the Lower and Upper North.

As with most of Victoria, weather systems move across the study area from west to east, generally producing a cycle of alternating warmer and cooler periods, each lasting for approximately five to seven days. As would be expected from this movement of weather patterns, the predominant winds in the study area are from the north-west and south-west. In spring, weather systems are more mobile and winds are stronger.

At the most general level, the climate of the study area is temperate, that is, dry and warm to hot in summer and cooler and wetter in winter. The main broad determinants of climate in the study area are topography, altitude, and distance from the coast.

The following sections describe the climate of the study area in more detail, emphasising those aspects which most influence the occurrence of box-ironbark vegetation. Bureau of Meteorology data from four weather stations — St Arnaud, Castlemaine, Kyabram and Benalla — have been used to illustrate key points (Figure 4).

### Precipitation

Snow rarely falls in the study area, so nearly all precipitation occurs as rainfall, with some moisture being provided by dew. Rainfall is a major determinant of vegetation types in the investigation area. It varies from about 360 mm per year (average) near Kerang to over

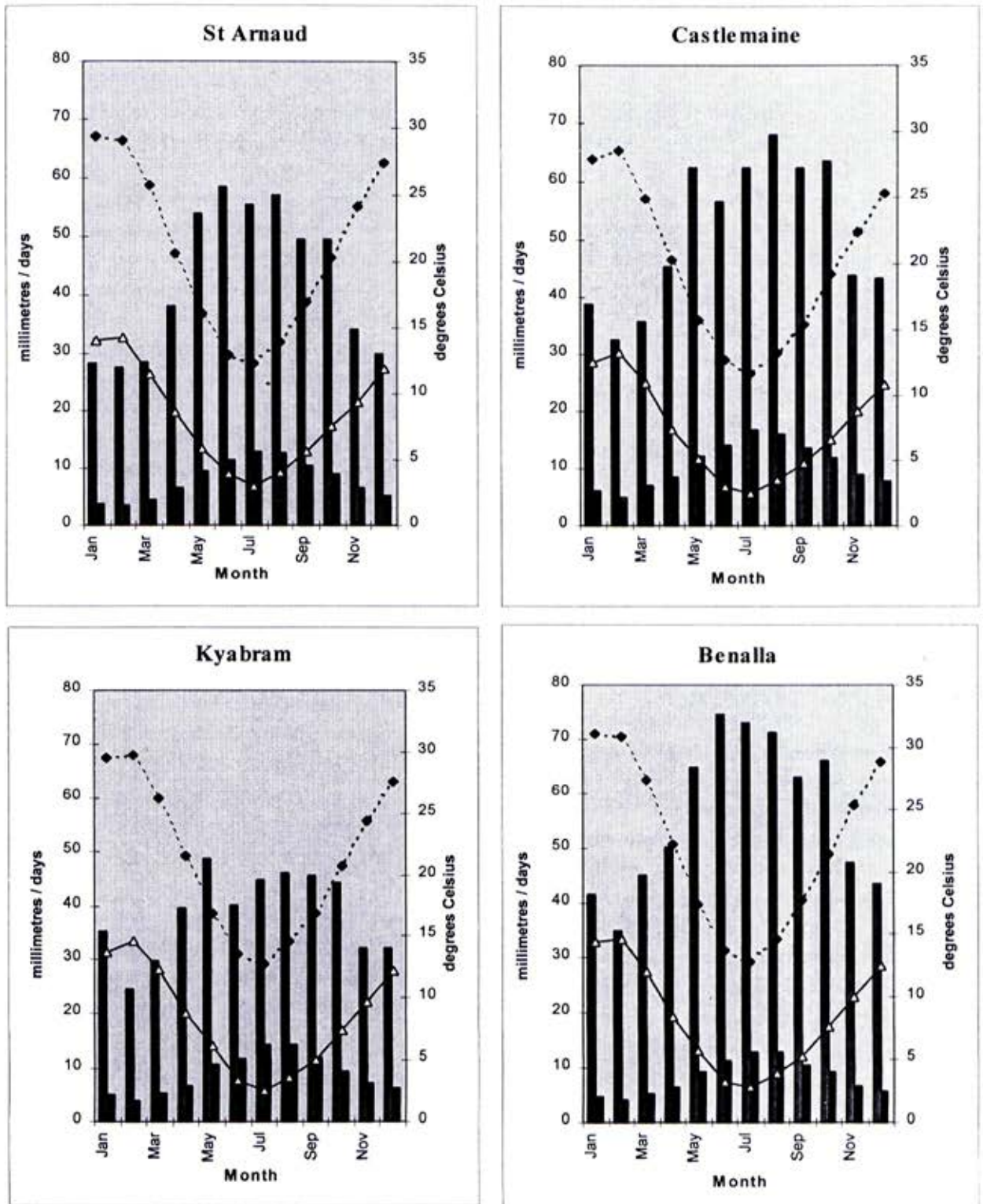
1000 mm per year (average) in many higher elevation areas — the Grampians, the Wombat and Strathbogie Ranges, and throughout much of the more elevated ranges along the south-eastern boundary of the investigation area (Map 9). Within this range, box-ironbark forests and woodlands occur predominantly within the 400–700 mm average annual rainfall band. Below about 400 mm, trees become sparser and grasslands more common, and in some areas sandy soils support mallee vegetation. Above 700 mm, box-ironbark forests and woodlands are replaced by wetter foothill forests, typically dominated by trees such as narrow-leaved peppermint and messmate.

Most rain falls in winter and spring: May to October are the wettest months in most parts of the study area, often being conspicuously wetter than the immediately adjacent months of April and November (Figure 4). Although rain typically falls more often in late winter or spring, June is the wettest month at most weather stations. The wettest month is likely to be later in the winter–spring in more southerly districts, reflecting their proximity to moisture-laden winds from the Southern Ocean in the windy months of spring.

Rainfall in the study area is primarily a function of topography: typically, rain-bearing weather systems move east across the study area, retaining most of their moisture while crossing the low elevation plains until the hills of the Dividing Range force the clouds to rise and release rain. The influence of topography is also apparent at a finer scale, that is even relatively minor topographic features can generate differences in rainfall. For example, low ranges induce higher rainfall and consequent rainshadows to the immediate east.

This association between rainfall and topography is moderated slightly in the eastern half of the study area, which is generally wetter than the western half. For example, inland hills in the Warby Ranges receive more rain than inland hills of comparable elevation in the hills around St Arnaud. The western half of the study area is closer to inland Australia, and therefore more prone to north-westerly winds and other drying influences from the arid zone.

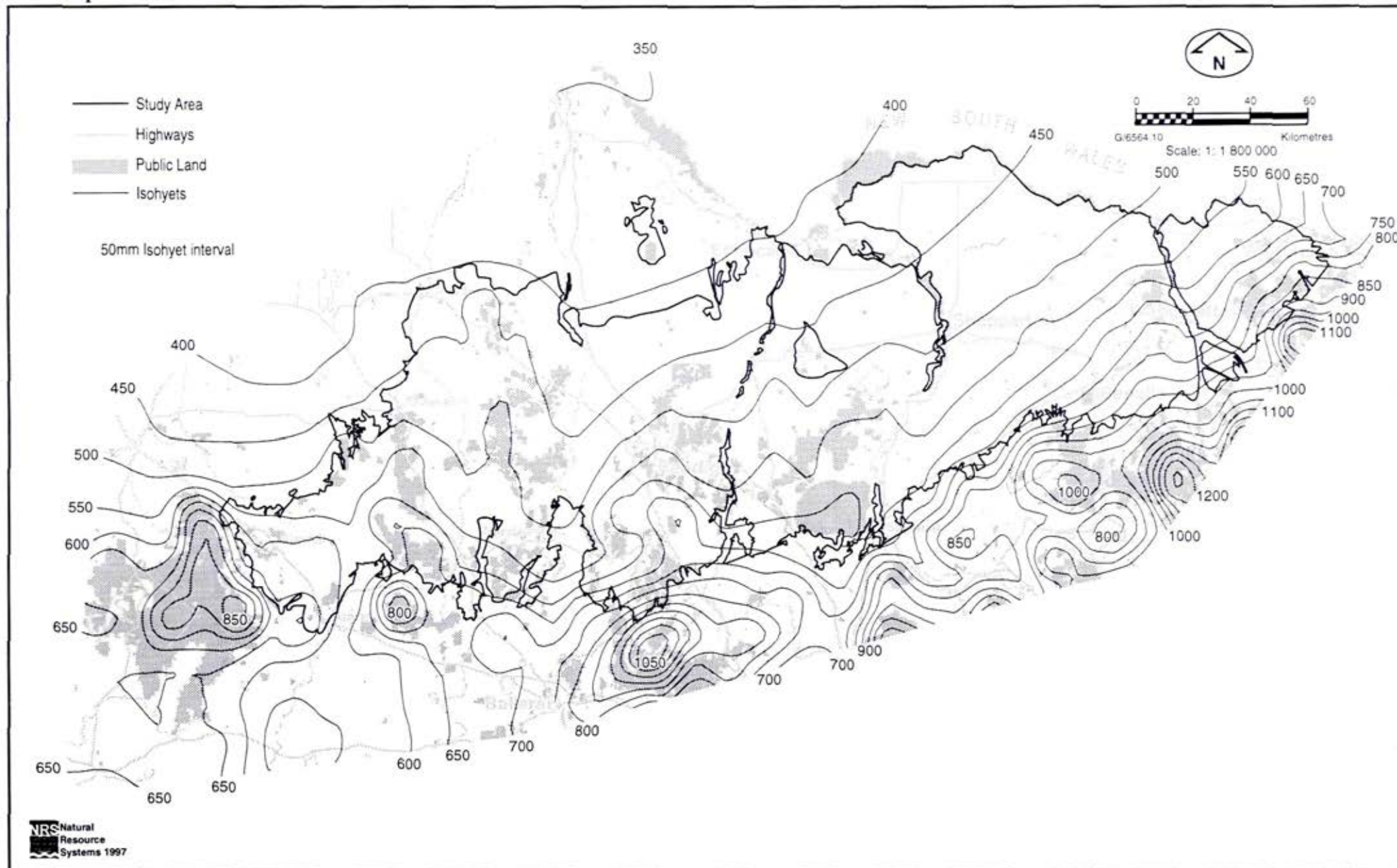
Figure 4: Climate characteristics of four representative towns – St Arnaud, Castlemaine, Kyabram and Benalla



Legend:

- █ Average Monthly Rainfall (mm)
- ...◆... Average Daily Maximum Temperature (oC)
- █ Average No. Raindays
- △— Average Daily Minimum Temperature (oC)

Map 9: Rainfall.



## Temperature

July is the coldest month in the study area, and January and February are the warmest (Figure 4). Temperature varies with topography and latitude: more elevated and southerly districts generally experience cooler weather at all times. Hence, the average daily maximum in January for Kyabram is 29.5° C, while that for Castlemaine is 27.9° C. High temperatures between October and March are typically the result of north-westerly air streams bringing very hot air from the centre of the continent. Such patterns can lead to daily maxima in excess of 35° C for several consecutive days. A subsequent cold front usually brings a thundery change to south-westerly air streams and dramatically cooler temperatures, but rain is less likely to accompany such changes in the study area than is the case in southern Victoria. This pattern of summer weather is a major influence on the natural environment in the study area, being closely related to such phenomena as fire and the vigour of plant growth.

## Drought

There are many definitions of drought, but the recurring theme is that drought is a relative concept. It is often defined by the degree to which rainfall is below the average, regardless of whether the average is relatively high or low — that is, it is closely related to the reliability of rainfall. The Bureau of Meteorology considers an area to be in drought when, after at least three consecutive months, rainfall is within the lowest 10 per cent of all previous totals for the same period of the year. Of course severe droughts can last for several years. Rainfall in the study area is highly variable and droughts occur approximately every one in five to one in ten years. They can occur at any time of the year but, although their effects are most apparent in summer, the most severe droughts are characterised by substantially reduced rainfall in the preceding winter and spring.

It is likely that drought is a major influence on the distribution and occurrence of many indigenous plant and animal species; species which are not well-adapted to drought are unlikely to be able to establish permanent populations in many parts of the study area.

Similarly, drought limits the forms of agricultural production that can be profitable in the study area, although the effects of annual shortages of effective rainfall (see

below) and minor droughts have been substantially ameliorated by the harnessing of water from the major rivers which flow through the study area. The most conspicuous example of this situation is the large Goulburn–Murray Irrigation District.

Some amelioration in other areas may be possible with increased predictability of droughts. Recent advances in the analysis of global weather patterns have established a relationship between changes in surface water temperatures and other parameters in the Pacific Ocean (ENSO — the El Niño Southern Oscillation) and the occurrence of drought in eastern Australia.

Shortage of water also affects plant growth outside drought periods. 'Effective rainfall' is the amount of rainfall that is available to plants after evaporation. Throughout the Box-Ironbark study area, lack of effective rainfall restricts growth of many plants (particularly non-indigenous species) for substantial periods — mostly summer and autumn — in most years.

## Fire

Very little is known about fire in box-ironbark forests and woodlands prior to European settlement. Evidence from many sites across Australia — predominantly accounts from early explorers, and anthropological and ecological studies — strongly suggests that fire was generally more widespread and frequent than it has been since European settlement (except perhaps for a short period immediately after the arrival of Europeans). This is mostly because of deliberate burning by Aboriginal people ('fire-stick farming'), the presence of large tracts of contiguous fire-prone indigenous vegetation, and the lack of impediments to, or control over, large-scale wildfires. There have also been, particularly in recent times, considerable resources directed at fire control measures such as the construction of roads through forest areas, and the development and use of technology to detect and extinguish fires as rapidly as possible.

While fire was formerly more widespread in Australia generally, as with many places, there is little evidence to demonstrate that fire was more widespread and frequent in box-ironbark forests and woodlands specifically. References to fire around the time of first settlement tend to be either very general, or when specific very limited in their wider applicability. Some specific fires are mentioned

by Curr (1965), for example, who resided near Tongala in the 1840s. It is difficult, however, to be confident of the implications of these accounts for fire regimes (the intensity, frequency, seasonality and spatial pattern of fire) in specific vegetation types or sites. Similarly, ecological disturbance associated with 150 years of European settlement and land use has been so severe and widespread that it is probably not possible to deduce pre-European fire regimes with any confidence or precision.

In contrast, there is little doubt that for most of this century, and probably since soon after the first goldrushes, fire has played a relatively minor role in shaping the natural environment and human affairs in the Box-Ironbark study area. Unplanned fires in the study area are typically much less extensive, much cooler and possibly less frequent than fires in adjoining major regions such as the mallee and south-eastern highlands. For example, of more than 800 wildfires on public land across the Box-Ironbark region over the period 1980/81 to 1995/96, almost 80 per cent were less than 5 ha in size. Only about 15 fires exceeded 100 ha, the largest being near Maryborough in 1985.

The use of fire as a management tool in prescribed burning to reduce forest fuel loads, may conflict with its potential use as an environmental management tool. In the latter case it can be used to control weeds, for example, as happens in many other vegetation types.

Fire is potentially a major threat to human life and property. It is, however, generally a less significant determinant of native vegetation and fauna habitat, and a less serious threat to human life and property (per capita) in the study area, than in the mallee and south-eastern highlands.

## Fire ecology

Fire may well have been frequent and widespread for many thousands of years prior to European settlement. There are numerous examples from other vegetation types where inappropriate fire regimes have significantly diminished biological diversity. It seems reasonable to suggest, therefore, that fire regime is an important ecological factor in box-ironbark forests and woodlands, at least at specific localities if not more generally.

It has been tentatively suggested that fire promotes reproduction by seed (as opposed to coppice) in box-ironbark eucalypts, and that the current general scarcity

of seedlings and saplings in box-ironbark forests and woodlands may be a consequence of the artificially reduced occurrence of fire since European settlement. Similarly, most box-ironbark eucalypts are vigorous post-fire epicormic resprouters — with the notable exception of the thinner-barked yellow gum which is more easily killed by fire but will resprout to some degree from the ligno-tuber (underground stem) — suggesting that these eucalypts have become adapted to frequent fire events. Again, however, the intensity, seasonality and frequency of these events are unknown. Similarly, many shrubs have specific fire frequency requirements for seed germination that relate to the time taken to produce a viable seed-fall and the persistence (life) of the seed.

Conversely, fire can have an adverse effect on plant and animal populations. For example, in isolated vegetation remnants fire may cause the local extinction of particular species.

As fire affects the structure and floristics of vegetation, it also has an impact on the abundance of important fauna habitat features, such as fallen timber, leaf litter, dead trees and hollow-bearing trees, and thus in turn affects the status and distribution of fauna.

## Fire suppression and protection

Section 62(2) of the *Forests Act 1958* requires the Department of Natural Resources and Environment to 'carry out proper and sufficient work for the prevention and suppression of fire in every State forest, national park and on all protected public land'. Responsibility for fire prevention and suppression on private land in rural Victoria rests with the Country Fire Authority.

The quantity of fuel in forests directly affects fire behaviour, particularly its intensity and forward rate of spread. Overall fuel hazard levels in box-ironbark forests are generally low, though if stringybark species are present, the levels can be very high (due to bark hazard).

Low-intensity prescribed or planned fuel-reduction burns in box-ironbark forests and woodlands are conducted in zones, or narrow strategic strips, and until recently, by spot-burning concentrations of eucalypt 'tops' left after timber and firewood harvesting (see Chapter 16). Only a few hundred hectares of public land in the study area, however, are deliberately fuel reduced in any year, and broad-scale burning is not widespread.

When large unplanned fires occur, they are generally fanned by strong northerly winds (e.g. Maryborough fires 1985, and Heathcote fires 1987), and are not greatly retarded by fuel-reduction burning, although the previously burnt strategic strips will experience a lower intensity fire, thereby making attempts at suppression of the wildfire safer and more effective.

Chapter 21 lists some of the potential, localised impacts of fire suppression and protection.

## Frost

The frequency and severity of frost in the study area is dependent on many factors: temperature, humidity, wind, cloud cover, vegetation cover, and landform. The last two factors are highly site-specific, so the frequency and severity of frosts can vary greatly within a small area. None the less, the conditions for frost are frequently met in winter and spring, and the study area includes some of the most frost-prone areas in the State (particularly in the north-east). In general, distance from the coast and the shelter provided by the Great Dividing Range lead to still, clear conditions. The elevation of the study area leads to low overnight temperatures, and the topography provides many hollows and valleys, which are the most frost-prone landforms. Sites which display these conditions (Castlemaine, for example) average 35–40 severe frosts per year, whereas sites on the plains have only 3–7 severe frosts a year on average. Severe frost is generally defined by a screen temperature of 0° C or less. Screen temperature is the conventional measure of ambient temperature; it refers to a bulb located 1.3 metres from the ground behind a 'Stephenson screen' — essentially a box with louvred sides to moderate the effects of wind. A severe frost may cause severe damage to vegetation on the ground, where the temperature can be significantly lower than the temperature one metre higher, where there may be significantly less frost damage.

Many plants and some animals are susceptible to severe frost. It is a significant limitation to agricultural production and to the distribution of some wild plants (indigenous and exotic) in the study area. Flower buds and green fruit of many orchard crops, particularly apricots and grapes, are most susceptible to frost, which can cause several million dollars damage to commercial crops in a single night. Similarly, large scale mortality of young lambs can result from severe frosts. On the other hand, frosts at certain times of the year are necessary for the setting of some fruits.

## Climate change

Palaeoclimatic studies indicate that cyclical changes in global climate have been a recurrent feature of the Earth's history. However, analysis of long term trends in global climate indicate that the Earth's climate is presently warming at a rate comparable to the most rapid increases in the palaeoclimatic record. Within the scientific community there is little debate about the general direction of this change, but the extent to which the activities of humans contribute to global warming is keenly contested. However, the international scientific majority view is that the balance of evidence suggests some discernible human influence on global climate.

The mechanism of human influence on global climate change is known as the enhanced greenhouse effect. In short, it entails the generation of a number of substances — 'greenhouse gases', such as carbon dioxide and methane — which enhance the natural retention of heat within the atmosphere.

No work has been published on climate change and the enhanced greenhouse effect in the context of the Box-Ironbark study area or even northern Victoria in general. However, it is possible to interpret some of the findings of nation-wide and state-wide studies in the light of information on pertinent characteristics of box-ironbark forests and woodlands. This approach forms the basis of the following discussion.

### Climate change and nature conservation

Since climate is a major determinant of the distribution and occurrence of plant and animal species and communities, and particularly so for box-ironbark forests and woodlands, it is axiomatic that climate change will alter the biogeography of parts of the study area in relation to other major vegetation types. Although climate change has been a perpetual feature in the evolution of box-ironbark ecosystems, there are two reasons for particular concern about the impacts of climate change on biodiversity in the next 20–50 years:

- *Depletion of vegetation types* — this problem is likely to be particularly acute in box-ironbark forests and woodlands where the extent of indigenous vegetation on public land is below the average for the rest of Victoria and highly fragmented in its distribution, especially on the northern plains (see Chapter 11 for more details).

- *Rate of climate change* — many models of climate change predict an accelerating rate of change. That is, even if biota are pre-adapted to climate change, they may not be adapted or able to adapt to a rate of change that is higher than has occurred previously.

By modelling the effects of a series of climate change scenarios on selected Victorian fauna (mostly threatened fauna), Bennett *et al.* (1991) were able to provide specific examples of some of the types of problems that are likely to eventuate. Their analysis included three box-ironbark species — the malleefowl, swift parrot and regent honeyeater. For all of these species, the size of both the overall geographic range and the geographic range within conservation reserves was predicted to decrease under most climate change scenarios. The malleefowl was predicted to be most severely affected, with its range contracting to the south and east — that is, from the mallee into what is currently the box-ironbark forests and woodlands of central Victoria. The inability of the malleefowl to persist in many of the now small and fragmented remnants of its formerly extensive habitat within the Box-Ironbark study area (see Chapter 9) raises serious doubts about its future in Victoria if the core of its distribution were to shift into such areas.

#### Climate change and primary production

Some analysts have suggested that the effects of climate change on agricultural productivity in Victoria are likely to be less significant than the effects of existing shorter term market forces. According to the Office of the Commissioner for the Environment (1991), productivity and competitiveness would be less likely to be diminished if primary industry planned for climate change. This is true regardless of whether climate change leads to increased or reduced primary productivity.

Climate change could also affect agricultural productivity indirectly. For example, increased rainfall would lead to increased groundwater recharge. Such an increase is likely to lead to further increases in dryland salting.

## WATER RESOURCES

This section describes the characteristics, distribution and condition of water resources in the study area. The use and production of water in the study area is integrated with a much larger system of production and use which extends

well beyond the investigation area. This system is discussed in Chapter 18.

The direct relevance of water resources to box-ironbark vegetation is limited by the occurrence of waterways in gullies and valleys — river and creek flats which usually support wetlands and riverine forests that are not central to the Box-Ironbark investigation. However, one box-ironbark Ecological Vegetation Class (EVC: see Chapter 7 for further explanation) — Creekline Grassy Woodland — is restricted to these riparian environments, albeit to the generally ephemeral upper reaches. In addition, box-ironbark vegetation plays an important role in the catchments of the study area which supply these waterways. Channels, storages and other infrastructure associated with water production and use often occur in box-ironbark areas away from drainage lines, but these features are more appropriately discussed in Chapter 18.

### River basins

Water resources are often discussed in terms of river basins. Of the 29 river basins identified in Victoria, eight overlap with the Box-Ironbark study area (Map 4). The Hopkins River basin is the only one in the South East Coast Drainage Division — it drains directly to the sea. The Avoca, Loddon, Campaspe, Goulburn, Broken, and Ovens river basins are in the Murray Darling Drainage Division and drain to the Murray River. The Wimmera-Avon rivers basin is also in the Murray Darling Drainage Division but the major rivers of this basin terminate in lakes — the Avon in Lake Buloke, and the Wimmera in lakes Albacutya and Hindmarsh and the Outlet Creek system.

The proportion of box-ironbark vegetation compared to other indigenous vegetation types varies greatly between river basins. In the Hopkins River basin, only a small area north of Ararat overlaps with the Box-Ironbark study area, whereas box-ironbark is the dominant indigenous vegetation type in all but the upper reaches of the Broken River basin.

### Streamflow volumes

Table 6 indicates the average total annual streamflow for each of the river basins in the study area, from measurements at numerous points in each basin. The river basins with the largest flow volumes are those with the largest tracts of mountainous country — the Ovens and Goulburn

River basins, for example. In many basins, particularly in the west of the study area, there is little or no runoff across extensive areas of the northern plains.

The regulation of water for human uses has caused major reductions in volume and significantly altered timing of streamflows in nearly all major waterways in the study area. Reductions in volume vary greatly across the study area, but can be as high as around 80 per cent. Typically, streamflows have decreased in winter and spring when rain falls and reduces the demand for water which accumulates in storages. In a typical year, most water is released from storage in summer, especially in January, February and March, and the increase from the pre-regulation flow volume can be very large — as much as 1200 per cent in March on the Campaspe downstream of Lake Eppalock. These changes have resulted in widespread and often severe impacts on both instream and floodplain ecology. However, with the possible exception of some areas of Creekline Grassy Woodland EVC, box-ironbark vegetation is not directly affected by these changes.

**Table 6: Average annual streamflow by river basin**

Basin	Annual Average Streamflow (ML)
Ovens River	1 620 000
Broken River	325 000
Goulburn River	3 040 000
Campaspe River	280 000
Loddon River	250 000
Avoca River	85 000
Wimmera-Avon rivers	210 000
Hopkins River	400 000

The data are total streamflow volumes calculated from measurements at numerous points in each basin — water diverted for human uses is not included in the totals.

Source: Department of Water Resources Victoria (1989)

## Surface water quality

An exhaustive discussion of water quality in the study area would require a large body of data on many parameters and from a large number of sites. Given that waterways and many riparian areas are outside the immediate scope of the Investigation, only a brief summary of data for relevant waterways is presented in Table 7. More detailed data and analyses have been provided by the Department of Water Resources Victoria (1989) and Office of the Commissioner for the Environment (1988).

Two major broad trends are apparent in water quality:

1. *Water quality decreases from east to west*, mostly because groundwater in the study area becomes more saline further west.
2. *Water quality decreases from the inland hills to the northern plains* because (a) human activities which both generate pollutants and consume (and hence dilute) clean water are generally more prevalent on the northern plains, (b) higher rainfall and lower evapotranspiration in the hills dilutes pollutants in both surface waters and groundwater, and remnant indigenous vegetation is generally more widespread and less degraded in the inland hills, leading to less dryland salinity and higher quality runoff — this factor is particularly important in riparian areas and along drainage lines where the integrity of remnant indigenous vegetation is the major determinant of water quality.

The latter trend is apparent from Table 7 in that, within river basins, water quality is usually lower in tributaries that are further downstream. This trend is also apparent from the more detailed Department of Water Resources Victoria (1989) data for each waterway. That is, when water quality varies within a waterway — turbidity in the Broken Creek, for example, varies from moderate to poor — the inferior quality readings usually originate from sampling points in the downstream reaches of that waterway. Typically, exceptions to this trend involve major point-sources of pollution and urban areas — the Bendigo Creek at Bendigo, for example — where some parameters improve downstream of the point-sources or urban areas.

While relative categories such as those used in Table 7 are useful for general comparisons across and between river basins, absolute criteria are required when formulating standards against which to assess water quality for particular purposes. Water quality standards vary according to application. For example, the World Health Organisation (1993) has developed widely accepted standards for drinking water, whereas other standards, such as those reviewed and proposed by the Office of the Commissioner for the Environment (1988), are required for various biological or ecological 'uses' of water.

Water quality standards and monitoring in Victoria have been significantly reorganised in the last eight years

Table 7: Summary of water quality in waterways flowing predominantly through the study area

Basin	Waterway	Water quality parameters <sup>1</sup>			
		Salinity	Nutrients and Dissolved Oxygen	Turbidity	Colour and Bacteria
Ovens River	Reedy	good	moderate	good	good
	Fifteen Mile	good	good	good	good
	Ovens	good	moderate-good	good	moderate-good
Broken River	Ryans	good	moderate	good	—
	Broken Creek	good	moderate-poor	moderate-poor	—
	Broken River	good	moderate	good	—
Goulburn River	Majors	good	good	—	moderate
	Castle, Seven, and Honeysuckle	good	moderate	—	moderate
	Goulburn	good	good-poor	good-moderate	good-moderate
Campaspe River	Coliban	good-moderate	good-moderate	good	moderate
	Axe	poor	poor	moderate	—
	Mt Pleasant	poor	moderate	poor	—
	Campaspe	moderate-poor	good-moderate	good-moderate	moderate
Loddon River	Bet Bet	poor	poor	moderate	—
	Bendigo	poor	moderate-poor	moderate-poor	—
	Loddon	moderate-poor	moderate	good-moderate	—
Avoca River	Avoca	poor	moderate	—	—
Wimmera–Avon rivers	Richardson	good	moderate	poor	—
	Avon	poor	moderate	moderate	—
	Mt William	moderate	good	good-moderate	—
	Wimmera	poor	moderate	good-moderate	poor

1 Explanations of the units of measurement for each parameter, and of the relative categories ('good', 'moderate', and 'poor') are provided by Department of Water Resources Victoria (1989).

2 Dashes (—) indicate no data available.

Source: Department of Water Resources Victoria (1989)

(see Rhodes *et al.* 1994, for example) as part of wider water industry restructure. While it is difficult to summarise recent data on water quality, it is clear that while the physical and chemical characteristics of drinking water in rural Victoria are generally satisfactory, concerns about the bacteriological quality of this water remain valid. The Working Group on Drinking Water Quality (1994) found that 68 per cent of rural Victorian consumers receive water that does not meet bacteriological guidelines similar to those of the World Health Organisation. Within the study area, this problem is perhaps less acute but still significant — 44 per cent of the 87 supply zones within the study area did not meet the guidelines of the Working Group.

## Groundwater

To varying degrees, soil and rocks are permeable; that is, they contain spaces through which water can move or, if the movement of water is impeded, they result in the soil or rock becoming saturated. Rocks that are more than about 2000 metres below the surface (less in many cases) are generally compacted and almost impermeable, and consequently impede the movement of water that is drawn from the surface by gravity. Water that is held in the resultant saturated zone is known as groundwater. The upper margin of the saturated zone, known as the watertable, is rarely more than 30 metres below the surface, and can reach

the surface in lakes and streams. Within the saturated zone, water generally moves with gravity, typically from elevated areas to the ocean or an inland basin. The gradient of groundwater movement in the Box-Ironbark study area is from east-south-east to west-north-west. The infiltration of water into the saturated zone is known as recharge, and the flow of water from the saturated zone to the ocean or low elevation inland sites is known as discharge.

As a result of variations in subsurface geology, several permeable units, known as aquifers, are typically present within the saturated zone. Aquifers that occur more than about 100 metres below the surface are considered deep aquifers and are generally confined — that is, adjacent less permeable layers severely restrict the movement of water beyond the aquifer. Shallow aquifers are generally unconfined or semi-confined — that is, the movement of water at the upper margin is not restricted. Consequently, the watertable can move vertically so that its distance from the surface at a given place can vary over time (as much as several metres in the course of a year). The movement of the watertable is closely monitored in areas that are prone to the discharge of saline groundwater, which has severe adverse effects on land use (see Chapter 20). Regional watertable levels are also important in the functioning of natural systems such as wetlands and springs.

In most parts of the study area, groundwater tables have risen since European settlement. The principal cause of the rises has been increased recharge, either through the introduction of irrigation or the clearing of native vegetation. In particular, the clearing of box-ironbark vegetation has turned many hills and slopes into recharge sites and major sources of groundwater recharge. Prior to clearing, relatively little groundwater originated from these sites. Much of this extra groundwater discharges in valleys immediately downslope from the cleared areas.

In parts of the Box-Ironbark study area, groundwater is an important source of water for homes, industry and agriculture (see Chapter 18). Four characteristics are important in the utilisation of groundwater:

1. *Quality.* Salinity is usually the only significant constraint on groundwater quality. Generally, salinity increases with the direction of groundwater flow — towards the west in the aquifers in the study area.
2. *Substrate type.* More permeable substrates allow water to flow more rapidly and hence deliver higher yields. In

the study area, there are two types of aquifers that are suitable for groundwater extraction: consolidated Palaeozoic rocks, such as granite, in which groundwater movement is mainly through fractures; and layers of unconsolidated Cainozoic sediments, such as sands and gravels, in which groundwater movement is mostly through inter-connected spaces between the grains. Aquifers in unconsolidated sediments generally have higher yields.

3. *Rate of recharge.* If the average rate of recharge of an aquifer is not comparable to the average rate of extraction, the resource will be depleted and become uneconomic.
4. *Depth.* Because of the cost of sinking bores, deeper aquifers are more expensive to harvest.

Groundwater basins or provinces are the natural hydrogeological units used for the description of groundwater. Two groundwater provinces underlie the study area:

1. *The Murray Basin* lies under the Riverine or Murray Basin Plain component of the study area (see 'Geomorphology' in Chapter 4). The Murray Basin is characterised by several shallow aquifers, among which the Shepparton Formation dominates, and the deeper (70–130 metre) Calivil/Renmark Aquifer. Both types are Cainozoic sand aquifers, with salinities generally increasing from east to west. The shallow aquifers occur across the basin, and exhibit a wide range of salinities and yields, although salinities are generally moderate and the yields generally low. The Calivil/Renmark Aquifer generally occurs in belts corresponding to buried ancient valleys of the existing rivers, which fan out into the basin as they move downstream. Salinity is generally low to moderate and bore yields are high (up to 125 L/second have been recorded).
2. *The Highlands Basin* lies under the West and East Victorian Uplands component of the study area (see 'Geomorphology' in Chapter 4). This basin is characterised by shallow unconfined aquifers in fractured Palaeozoic rocks, which yield relatively little groundwater (bores generally yield less than 3 L/second). Discharge from these aquifers into stream beds sustains summer and autumn flows in many upland streams. These aquifers have low salinities which increase from east to west.

## 6. LAND SYSTEMS

### INTRODUCTION

To assess what land is capable of producing or otherwise being used for, what limitations it has, and what land management is needed, requires a comprehensive knowledge of land characteristics. Land systems provide a method of analysing these characteristics.

Land system mapping uses an ecological approach integrating geology, landform, climate, soils and indigenous vegetation. It gives a useful general-purpose method of land characterisation for use at scales from 1:100 000 to 1:500 000.

Each land system is a complex mapping unit, containing a predictable and repeating pattern of land components. Land components each have a narrow range of biophysical characteristics. These are relatively uniform and can be mapped at larger scales of 1:100 000 to 1:25 000, depending on the complexity of the landscape. The land component is often regarded as the basic unit of management for broad-scale land uses such as dryland farming or forestry.

### LAND SYSTEMS OF VICTORIA

Geomorphological divisions, identified by Jenkin and Rowan (1987) have been mapped across Victoria into 29 geomorphic units. These are considered to contain areas in which common geomorphic processes operate. The State-scale geomorphic units can, in turn, be divided into regional-scale land systems, which may be further divided into local-scale land components.

Detailed land systems studies supported by field work and laboratory soil analysis exist for about half the State. Most of these describe, but do not map, the components of each land system. Much of the rest of Victoria has been described in less detail, using preliminary identification of broad units from aerial photographs and other base data, supported by limited field checking and some soil analyses. The LCC commissioned several such maps for its study areas. To complete other areas for State-wide coverage, Rowan (1990) interpreted geological maps and used local knowledge.

The Land Systems of Victoria database and report combine all land systems identified in these various studies at comparable scales and with consistent labels. Rowan combined the 850 land systems into their appropriate geomorphic units and produced 1:500 000 and 1:250 000 scale geomorphic unit and land system mapsets for the State.

### Detailed studies in northern Victoria

Comprehensive land systems studies have been carried out for the Avoca River catchment to below Charlton, Loddon River catchment to Fernihurst and Campaspe River catchment to Rochester, and parts of the Broken and Ovens River catchments upstream from Benalla and Whorouly respectively. Reconnaissance surveys were carried out for the LCC's North Central and Murray Valley Areas, and part of the North-eastern Area.

### GEOMORPHIC UNITS IN THE STUDY AREA

Table 8 lists the geomorphic units in and adjoining the Box-Ironbark study area. Parts of several of these — **2.1 West Victorian Uplands, dissected uplands**, **1.1 East Victorian Uplands, dissected uplands**, and **4.2 Riverine Plain, older alluvial plain** — effectively define the study area. This is indicated by the location of the study area boundary on Map E which depicts the geomorphic units (see 'Geomorphology' in Chapter 4).

Geomorphic unit **2.1 West Victorian Uplands** continues to the south outside the study area to higher rainfall areas in the Wombat and Mt Cole Forests along the Divide that do not carry box-ironbark vegetation.

North-west of a line approximately between Echuca and Charlton, unit **4.2 Riverine plain, older alluvial plain** continues outside the study area, predominantly carrying grasslands, the original scarcity of trees reflecting lower annual rainfall.

The *East Victorian Uplands, dissected uplands* unit **1.1** extends into higher elevation, higher rainfall areas over much of eastern Victoria, constituting the Alpine and

**Table 8: Geomorphic units in and adjoining the Box-Ironbark study area**

Geomorphic unit			Map symbol
Central Victorian Uplands	East Victorian Uplands	Dissected uplands	1.1
	West Victorian Uplands	Dissected uplands (Midlands)	2.1
	West Victorian Uplands	Prominent ridges (Grampians)	2.2
Murray Basin Plains	Riverine Plain	Present floodplain (Murray Valley)	4.1
	Riverine Plain	Older alluvial plain (Shepparton)	4.2
	Mallee Dunefields	Low calcareous dunes (Ouyen)	5.1
	Wimmera Plains	Clay plains (Nhill)	6.1
West Victorian Volcanic Plains		Undulating plains (Western District)	7.1
		Stony undulating plains (Western District)	7.2

**Table 9: Key to land systems**

<b>Landform</b>	
G	gentle to moderate hill
S	steep mountain and hill
P	plain above flood level
<b>Rock type and other soil parent material</b>	
c	coarsely textured unconsolidated deposits (sand and gravel)
f	finely textured unconsolidated deposits (silt and clay)
g	granites and gneisses
s	sedimentary rocks
v	volcanic rocks (e.g. Cambrian volcanics, Mt Camel Range and Mt Major)
<b>Climate (mean annual rainfall)</b>	
3	300–400 mm
4	400–500 mm
5	500–600 mm
6	600–700 mm
7	More than 700 mm; temperate
<b>Decimal number (last digit)</b>	
These distinguish land systems with similar landform, rock type and climate, but different soils and vegetation.	
<b>Note:</b> Only symbols relevant to the Box-Ironbark investigation area are included.	

adjoining areas, and carrying a range of non-box-ironbark vegetation including wetter foothill and mountain forests.

Unit 4.1 *Riverine plain — present floodplain* lies outside the Box-Ironbark study area and comprises the present floodplains consisting of Recent alluvium, most notably along the Murray River, and the Ovens, Goulburn, Campaspe and Loddon rivers. It forms the northern boundary of the study area, east from Echuca, and follows the north-flowing river floodplains upstream until they narrow.

The commencement of the extensive non box-ironbark *West Victorian volcanic plains — 7.1 undulating plains* and *7.2 stony undulating plains* — delineates parts of the southern boundary of the study area west of Seymour. Of interest are the narrow volcanic bands intruding into the Box-Ironbark area along former courses of the Campaspe and Loddon Rivers, and Tullaroop, Back and Bet Bet Creeks.



*Plains land system 2.1/Pf6.6 under vines, and forested steep sedimentary hills of 2.1/Ss7.1, Pyrenees.*

**Table 10: Land systems, occurrences, land degradation hazards and EVCs**

- For the geomorphic units and key to the land system codes, see Tables 8 and 9.

Geomorphic units	Land systems	Occurrences	Land degradation hazards	Ecological Vegetation Classes
1.1	Gs4.1	Waranga; south of Rushworth	Wa,C,S	Box-Ironbark Forests
1.1	Gs4.2	Rushworth	Wa,C,S	Gravelly-sediment Mallee
1.1	Gs5.1	Chiltern, Indigo, Boweya, Whroo, Costerfield	Wa,C,S	Box-Ironbark Forests
1.1	Gs6.1	Puckapunyal	Wa,C	Box-Ironbark Forests
1.1	Gs6.2 part	Mt Pilot	Wa,C,S	Heathy Dry Forests
1.1	Gs6.2 part	Chiltern	Wa,C,S	Grassy Dry Forests
1.1	Sg6.4 part	Barambogie, Pilot Range	L,Wa	Granitic Hills Woodland
1.1	Sg6.4 part	Barambogie, Pilot Range	L,Wa	Rocky Outcrop Mosaic
1.1	Sg7.2 part	Mt Pilot	L,Wa	Grassy Dry Forests
2.1	Gg3	Mt Terrick Terrick	Wa,L	Terrick Terrick Cypress-pine Grassy Woodland
2.1	Gg4	Mt Kooyoora	Wa,S	Granitic Hills Herb-rich Woodland
2.1	Gs4.1 part	Wedderburn	Wa,L	Gravelly-sediment Mallee
2.1	Gs4.1 part	Wedderburn	Wa,L	Sandstone-rise Broombush
2.1	Gs4.2 part	Tarnagulla, Wehla, Kamarooka	Wa,S,C	Box-Ironbark Forests
2.1	Gs4.2 part	Logan, Dunolly	Wa,S,C	Heathy Woodland
2.1	Gs4.2 part	Kamarooka	Wa,S,C	Low Rises Grassy Woodland
2.1	Gs4.3 part	Inglewood	Wa,C,L,S	Gravelly-sediment Mallee
2.1	Gs4.3 part	Inglewood, Bendigo	Wa,C,L,S	Sandstone-rise Broombush
2.1	Gs4.6	Fosterville	Wa,S,C	Box-Ironbark Forests
2.1	Gs5.3	St Arnaud Range, Pyrenees, Concongella	Wa,C,S	Box-Ironbark Forests
2.1	Gs5.4	Castlemaine, Maldon, Clydesdale	Wa,C,S	Box-Ironbark Forests
2.1	Gs5.5	Bendigo, Wellsford	Wa,C,S	Box-Ironbark Forests
2.1	Gs6.4	Caralulup	Wa,C,S	Box-Ironbark Forests
2.1	Pf4.8	Tottington	C	Low Rises Grassy Woodland with Alluvial Terraces Herb-rich Woodland
2.1	Pf4.17 part	South of Glenalbyn	C,Wa,L	Low Rises Grassy Woodland
2.1	Pf4.17 part	South of Glenalbyn	C,Wa,L	Heathy Woodland
2.1	Pf5.2 part	Deep Lead, Illawarra	C,L	Sedge-rich Woodland
2.1	Pf5.2 part	Tottington	C,L	Low Rises Grassy Woodland with Alluvial Terraces Herb-rich Woodland
2.1	Sg4.1 part	Mt Kooyoora, Mt Egbert, Yowang Hill	Wa,M,L	Metamorphic Slopes Shrubby Woodland
2.1	Sg4.1 part	Mt Kooyoora, Mt Egbert, Yowang Hill	Wa,M,L Wa,S	Granitic Hills Herb-rich Woodland
2.1	Ss4.2	Bealiba, Mt Hooghly	Wa,L,C	Heathy Dry Forests
2.1	Ss4.3 part	Rheola, Ravens Hill	Wa,L,C	Heathy Dry Forests
2.1	Ss4.3 part	Wedderburn, Mt Moliagul, Mt Brenanah	Wa,L,C	Hillcrest Herb-rich Woodland
2.1	Ss5.2	North St Arnaud Range	Wa,L,M,C	Grassy Dry Forests
2.1	Ss5.4	Mt Tarrengower	Wa,L,C	Hillcrest Herb-rich Woodland
2.1	Ss6.1 part	South St Arnaud Range, Pyrenees (exposed aspects)	Wa,L,C,M	Heathy Dry Forests
2.1	Ss6.1 part	Pyrenees, south St Arnaud Range (sheltered aspects)	Wa,L,C,M	Grassy Dry Forests
2.1	Ss6.4 part	Fryerstown, Taradale, Barfold	Wa,L,C,S	Heathy Dry Forests
2.1	Ss6.4 part	North Fryers Range, in valleys	Wa,L,C,S	Valley Grassy Forest
2.1	Ss7.6 part	South Fryers Range	Wa,C,L	Heathy Dry Forests

Geomorphic units	Land systems	Occurrences	Land degradation hazards	Ecological vegetation classes
2.1	Ss7.6 part	South Fryers Range, in valleys	Wa,C,L	Valley Grassy Forest
2.1	various	Drainage lines in various land systems	Wa,S	Creekline Grassy Woodland
2.1	various	Terraces in several land systems in south St Arnaud Range	Wa,C,L	Alluvial Terraces Herb-rich Woodland
2.1	Gg3	Mt Terrick Terrick	Wa,L	Terrick Terrick Cypress-pine Grassy Woodland
2.1	Gg4 Pf4.18	Wedderburn Junction Glenalbyn	Wa,S, C, Wa	West Riverine Grey Box Shrubby Woodland
4.2	Pf4.9	Borong	C	West Riverine Grey Box Grassy Woodland
4.2	Pf5.2, Pf5.1	Pranjip Dookie	C,Wg C,Wa,S	Central Riverine Grey Box Grassy Woodland
4.2	Pf5.3 Pf5.4	Tungamah Boorhaman	C,Wg	East Riverine Grassland
4.2	Pf6.1	Locksley	C,Wg	Eastern Low Rises Grassy Woodland

**Forms of land degradation hazards (listed in order of prevalence)**

- |  |   |
|--|---|
| C compaction — physical decline through surface pressure | S salting — salt seep                               |
| L leaching of nutrients — chemical decline               | Wa water erosion — sheet, gully, tunnel, deposition |
| M mass movement — landslides                             | Wg waterlogging                                     |

## LAND SYSTEMS IN THE STUDY AREA

Table 9 is the key to land system labels based on landform, rock type and climate, under the Land Systems of Victoria approach. These land system labels are used in Appendix V, and in Table 10, which summarises major land systems occurring in the three main geomorphic units in the study area, and their locations. These are not all the land systems in the study area. Map E locates the more extensive land systems.

## USES OF LAND SYSTEMS

Land Conservation Council recommendations for reference areas, and selection of the majority of the area of national and State parks, were based on land systems representation. Areas of public land recommended by the LCC to be alienated for agriculture were assessed as to whether their land systems were suited to that use. Some particular recent uses follow.

### Map of pre-1750 broad vegetation types

To assist in the development of Commonwealth-State Regional Forest Agreements, an indication of the likely extent of different vegetation types in about the year 1750

was required. This enables an approximation of the relative depletion of each vegetation type since that time. The Land Systems of Victoria report, which lists indigenous vegetation, and the geomorphic unit and land systems digital mapset, were used to generate a map of broad vegetation types for these purposes.

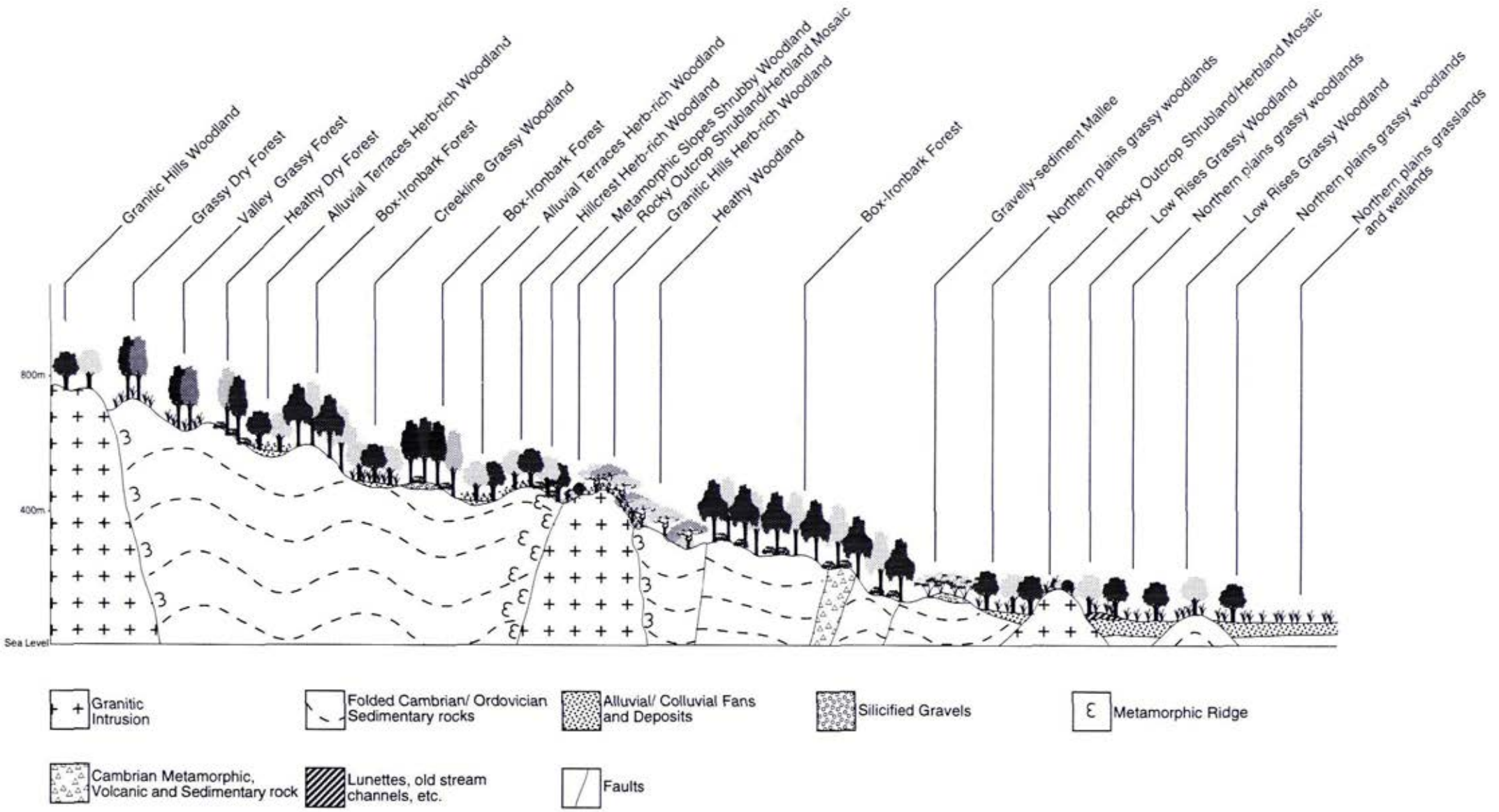
### Ecological Vegetation Classes

Floristic vegetation communities have been grouped into Ecological Vegetation Classes (EVCs) on the basis of vegetation structure, floristics, land systems, and other environmental information. More detail is provided in Chapters 7 and 8.

The EVCs occurring in certain land systems in the study area are also listed in Table 10. Note the following points:

- Box-Ironbark Forests are commonly found in several extensive 'Gs' land systems — on gentle to moderate hills on sedimentary rock, generally of Ordovician age — in areas within the range of mean annual rainfall from '4 to 6', that is, 400 to 700 mm;
- Heathy Dry Forests occur in some six 'Ss' land systems, having steeper landforms on sedimentary rock, and extending to areas with slightly higher rainfall than Box-Ironbark Forests;

Figure 5: Schematic south–north transect, showing relationship between geomorphology and vegetation type



- Grassy Dry Forests are found in some similar situations to Heathy Dry Forests, including land components with sheltered aspects within the same major land system;
- the suite of granitic EVCs occur on 'Sg' and 'Gg' land systems, with the rainfall increase from west to east across the study area reflected in the vegetation differences;
- Sedge-rich Woodland and Low Rises Grassy Woodland occur on plains or gentle slopes with fine-textured soils — 'Pf' land systems;
- several EVCs are located predominantly on one major land system;
- others, such as Creekline Grassy Woodland, occur on one component — the drainage lines — of more than one land system;
- Sandstone-rise Broombush is often found on ancient highly weathered soils with ironstone hardpans, in 'Gs4' land systems.

Appendix V lists the box-ironbark EVCs, their soil parent material, soil types and relevant land systems. Figure 5 illustrates the relationship between geology, landforms and EVCs.

## Biogeographic regionalisation

As part of the Commonwealth-State National Reserve System Program, Environment Australia has developed, in conjunction with the states, an interim biogeographic regionalisation of Australia. For Victoria, the 1:500 000 geomorphic units mapset was used as a basis. Biogeographic region boundaries generally follow geomorphic unit boundaries. These were simplified into 10 units for the national bioregionalisation (see Chapter 7 for more information).

## Land degradation

Various forms of degradation can affect the natural condition of the land and its soils, its ability to sustain indigenous vegetation, and its behaviour under various forms of modification and use.

A primary reason for identifying land systems is to locate land with similar limitations based on inherent characteristics and therefore comparable risk of particular forms of land degradation. Knowledge of a land system assists in predicting the behaviour of its components under land use, and identifying land management needs. Chapter 20 discusses the forms of land degradation common in the Box-Ironbark study area. Table 10 lists the expected degradation risks for major box-ironbark land systems.



*Forested Mt Korong slopes, land system 2.1/Gg4; mostly cleared plains, 2.1/Pf4.18; Mt Brenanah, near distance, 2.1/Ss4.3; Mt Kooyoora, far distance, 2.1/Sg4.1.*

## 7. BIOGEOGRAPHIC OVERVIEW

### BIOPHYSICAL SETTING

At the time of European settlement, northern Victoria's box-ironbark forests and woodlands covered approximately 3 million ha in a broad band across the gentle to moderate slopes on the inland fall of the Great Dividing Range and adjacent Riverina plains. This band is dissected at several points by:

- riverine forests dominated by river red gum or black box along the Campaspe, Goulburn and Ovens rivers, mostly in the north of the study area; and
- grasslands and grassy woodlands on basaltic soils derived from lava flows along the valleys of the Bet Bet and Tullaroop creeks and the Campaspe River, from the south of the study area.

The grasslands and grassy woodlands of these basalt plains show major floristic differences from the grasslands and grassy woodlands of the northern plains and, along with the riverine forests, are not included in the Box-Ironbark study area.

Box-ironbark vegetation is very closely associated with Silurian and Ordovician sedimentary formations (mudstones and shales) on the inland slopes, and Quaternary alluvial terraces above the present riverine floodplains. Other major formations are granitic intrusions such as Terrick Terrick, where small granitic hills rise above the surrounding grassland plain; contact metamorphic aureoles surrounding these intrusions; and Silurian and Ordovician sediments that have been regionally metamorphosed by folding. Chapter 4 has a more detailed description of the varied geology of the study area and Figure 5 provides a diagrammatic summary of changes in vegetation across the study area.

Topography is a major determinant of vegetation in northern Victoria, both directly and through its effect on climate (see below). The relief of the study area becomes gentler from south-east to north-west. Altitude varies from approximately 100 to 700 m above sea level. Below this altitude band, grasslands and riverine forests and wetlands are the dominant natural vegetation types, while above 700 m wetter mountainous vegetation types dominate. Within the box-ironbark band, most areas below 120 m

and above about 400 m support these other vegetation types. The main exceptions to the general pattern of relief in the study area are erosion resistant features, such as the Warby and Mt Camel Ranges and some very low rises on the plains, including those associated with existing or prior streams or lakes — see Chapter 4. The elevation at which the inland slopes give way to the plains is typically around 150 m, but varies from about 180 m in the south-east to around 120 m at the north-west.

The climate of the study area is discussed in detail in Chapter 5. In short, variation in rainfall reflects topography, with mean annual rainfall varying from 400 mm towards the inland to 700 mm in the south and south-east. Local exceptions to this rule may occur where higher rainfall is concentrated on minor ranges, with corresponding rainshadows immediately to the east.

Drought and frosts play a major role in determining the distribution of plant species and vegetation communities in the study area. Drought years occur with a frequency of between one in five and one in ten years. Even in an average year, however, it has been estimated that effective rainfall in the area is such that lack of rain will severely restrict plant growth for substantial periods. Late autumn, winter and spring frosts are a common occurrence throughout the study area, and may often be severe. Frost incidence increases with latitude and altitude, although incidence may also vary greatly with local conditions, for example slope and vegetative cover.

### ECOLOGICAL DEFINITION OF BOX-IRONBARK FORESTS AND WOODLANDS

The Department of Natural Resources and Environment is currently assigning and mapping all indigenous vegetation in Victoria into Ecological Vegetation Classes (EVCs). The box on the following page provides an explanation of vegetation classification systems, including the development of, and relationships between EVCs and Broad Vegetation Types (BVTs).

Description and mapping of EVCs has been completed for the inland hills component of the Box-Ironbark study area by Muir *et al.* (1995), and 16 inland hills EVCs have

been identified as appropriate for inclusion within box-ironbark forest and woodland areas as required by the Terms of Reference (see Chapter 1). Vegetation studies of the northern plains have not been finalised but Foreman (in prep.) has identified six 'floristic groups' — preliminary vegetation units — that are appropriate for inclusion in the Box-Ironbark Investigation. Further study may reveal overlap between some northern plains units and some inland hills units.

Thus, 22 vegetation units comprise box-ironbark forests and woodlands:

#### **Inland Hills Ecological Vegetation Classes (EVCs)**

Box-Ironbark Forest  
 Sandstone-rise Broombush  
 Gravelly-sediment Mallee  
 Heathy Woodland  
 Sedge-rich Woodland  
 Low Rises Grassy Woodland  
 Alluvial Terraces Herb-rich Woodland  
 Creekline Grassy Woodland  
 Heathy Dry Forest  
 Grassy Dry Forest  
 Valley Grassy Forest  
 Metamorphic Slopes Shrubby Woodland  
 Hillcrest Herb-rich Woodland  
 Granitic Hills Herb-rich Woodland  
 Granitic Hills Woodland  
 Rocky Outcrop Mosaic

#### **Northern Plains 'Floristic Groups'**

West Riverine Grey Box Grassy Woodland  
 West Riverine Grey Box Shrubby Woodland  
 Terrick Terrick Cypress-pine Grassy Woodland  
 Central Riverine Grey Box Grassy Woodland  
 East Riverine Grassland  
 Eastern Low Rises Grassy Woodland

Although not strictly EVCs, for convenience the northern plains floristic groups will be referred to in this report as such.

### **Vegetation classification systems**

A variety of systems has been developed in order to classify vegetation types, for a variety of purposes. In recent years, botanists with the Department of Natural Resources and Environment have used two basic vegetation classification systems to satisfy a number of purposes. The first system generates Broad Vegetation Types (BVTs), and the second generates Ecological Vegetation Classes (EVCs), vegetation communities and sub-communities. Table 11 provides a comparative summary of these systems.

BVTs provide an overview of forest and woodland types across the study area. They are based on land system units derived from broad information on climate, geology, topography, soils and broad vegetation structure (woodland, shrubland, forest, etc.). Refer to Chapter 6 for a discussion of land systems.

EVCs, communities and sub-communities are based on a finer resolution and a wider range of environmental parameters than BVTs (see Table 11), including vegetation structure, life forms (shrub, climber, annual grass, etc.), and floristics (the species that occur at a site). This system is hierarchical in that each sub-community occurs only in one community, and each community occurs only in one EVC.

The need for more than one vegetation classification system is well illustrated in the section of this Chapter entitled 'Patterns of vegetation change'.

Several box-ironbark EVCs fall loosely within each BVT (see Map B) because land system characteristics are common features of both classification systems. However some EVCs may occur in more than one BVT because many additional factors contribute to the delineation of EVCs.

Many of the 22 EVCs that occur in the Box-Ironbark investigation area also occur in other areas. For example, Muir *et al.* (1995) documented areas of both the Heathy Dry Forest and Box-Ironbark Forest EVCs in the Nillumbik Hills north-east of Melbourne, and elsewhere. Other occurrences of similar vegetation such as red ironbark forests are found near Anglesea, in the Brisbane Ranges and parts of Central and East Gippsland, and in dry box woodlands in the Upper Snowy Valley rainshadow.

**Table 11: Comparison of vegetation classification systems**

Vegetation Classification System	Units of Classification	Features of Each System
Strongly based on land systems and structure	Broad Vegetation Types (BVTs)	<ul style="list-style-type: none"> <li>BVTs are based on land systems information: climate, geology, topography and soils, and broad vegetation structure (woodland, forest etc.).</li> <li>Suitable for strategic statewide and broad regional planning; insufficient resolution for specific management; maximum map scale 1: 500 000.</li> <li>Provides a comparison between pre-1750 and present day forest cover.</li> </ul>
Based equally on land systems, structure and floristics	Ecological Vegetation Classes (EVCs)	<ul style="list-style-type: none"> <li>EVCs are based on vegetation structure and floristics (the species that occur at a site), land systems, other environmental information (aspect, slope, elevation, rainfall, fire frequency), and ecological responses to disturbance (e.g. modes of regeneration).</li> <li>EVCs provide a standard statewide system of classification that recognises that broadly similar vegetation types occur in different parts of the state because they exist under similar environmental regimes.</li> <li>Map scales 1: 100 000 to 1: 250 000 that is suitable for regional management planning.</li> <li>EVCs do not form part of a hierarchy with BVTs because they are derived from different information sources. As a result, any one EVC may occur in several BVTs.</li> <li>May be difficult to use to derive pre-1750 vegetation cover to compare with present day cover.</li> </ul>
Strongly based on floristics	Communities	<ul style="list-style-type: none"> <li>Communities are strongly based on floristic information collected in field survey which is analysed to determine groupings or associations of species. Vegetation structure and local environmental factors contribute to a lesser degree.</li> <li>Communities provide sufficient resolution for local management planning.</li> <li>They form a hierarchy with EVCs i.e. they are subsets of EVCs.</li> </ul>
	Sub-communities	<ul style="list-style-type: none"> <li>Sub-communities are strongly based on floristic information collected in field survey and analysed to determine close associations of species. Vegetation structure and local environmental factors contribute little although microenvironmental factors such as presence of a soak, fire history or proximity to adjacent vegetation will influence their delineation.</li> <li>Sub-communities reflect the variability of communities at the local scale.</li> <li>They form a hierarchy with communities i.e. they are subsets of communities.</li> </ul>

**Note:** Several EVCs fall loosely within each BVT (see Map B) because land system characteristics are common features of both classification systems. However, some EVCs may occur in more than one BVT because many additional factors contribute to the delineation of an EVC.

Several maps (Map 1, for example) show the approximate extent of box-ironbark vegetation in the investigation area — the study area. They show the collective distribution of the 22 component EVCs, with minor variations to simplify interpretation. For example, small areas of other vegetation types have not been excised from large public land blocks dominated by box-ironbark vegetation, and these areas are included in the Investigation. The study area, as described in Chapter 1, covers around 3.1 million ha. The distribution of each EVC is provided in Map B (at the end of this report), although some of the mapped information on the northern plains is preliminary and requires field checking.

Along with Table 12, Map B also indicates the relationship between Broad Vegetation Types and Ecological Vegetation Classes in the study area.

### Similar vegetation types outside the study area

Several areas having geographical or ecological affinities with the Box-Ironbark study area occur away from northern Victoria. They generally have different understorey vegetation characteristics, and share only some of the other characteristics of the study area; for example overstorey eucalypts, fauna, rainfall, or topography.

**Table 12: Relationships between Broad Vegetation Types (BVTs) and Ecological Vegetation Classes (EVCs) in the study area**

Broad Vegetation Type	Ecological Vegetation Class
Dry Foothill Forests	<ul style="list-style-type: none"> <li>• Heathy Dry Forest (Nth Foothills)</li> <li>• Grassy Dry Forest (Nth Foothills)</li> </ul>
Box-Ironbark Forests	<ul style="list-style-type: none"> <li>• Box-Ironbark Forest (Nth &amp; West Goldfields, Nth-east Hills)</li> <li>• Heathy Dry Forest (Nth &amp; West Goldfields, Nth-east Hills)</li> <li>• Grassy Dry Forest (Nth &amp; West Goldfields, Nth-east Hills)</li> <li>• Low Rises Grassy Woodland</li> <li>• Creekline Grassy Woodland</li> </ul>
Mallee	<ul style="list-style-type: none"> <li>• Gravelly-sediment Mallee</li> <li>• Sandstone-rise Broombush (Nth Goldfields)</li> </ul>
Inland Slopes Woodlands	<ul style="list-style-type: none"> <li>• Granitic Hills Woodland</li> <li>• Rocky Outcrop Mosaic</li> <li>• Heathy Woodland (West &amp; Nth Goldfields)</li> <li>• Metamorphic Slopes Shrubby Woodland</li> </ul>
Herb-rich Woodlands	<ul style="list-style-type: none"> <li>• Granitic Hills Herb-rich Woodland</li> <li>• Hillcrest Herb-rich Woodland</li> <li>• Alluvial Terraces Herb-rich Woodland</li> </ul>
Valley Grassy Forests	<ul style="list-style-type: none"> <li>• Valley Grassy Forest</li> </ul>
Plains Grassy Woodlands	<ul style="list-style-type: none"> <li>• West Riverine Grey Box Grassy Woodland</li> <li>• West Riverine Grey Box Shrubby Woodland</li> <li>• Terrick Terrick Cypress-pine Grassy Woodland</li> <li>• Central Riverine Grey Box Grassy Woodland</li> <li>• East Riverine Grassland</li> <li>• Eastern Low Rises Grassy Woodland</li> </ul>

**Note:** Some EVCs (Grassy Dry Forest, for example) occur in more than one BVT, so the relationship between the two classification systems is not hierarchical.

Examples of vegetation types broadly similar to inland hills box-ironbark forests and woodland areas can be found in the Brisbane Ranges, Long Forest Mallee, Central and East Gippsland (including the Upper Snowy Valley), Hurstbridge, South West Wimmera Plains and Anglesea areas. Examples that are broadly similar to northern plains box-ironbark can be found in the Mallee, Wimmera Clay Plains, and Melton areas.

In the south and east of the study area, box-ironbark forests merge with adjoining foothill forests of the Great Divide. Some vertebrates that depend on box-ironbark habitat for part of the year move into these foothill forests seasonally, often to breed in spring and summer — crimson rosellas and white-naped honeyeaters, for example. Generally, however, foothill forests and other higher rainfall areas over 400 m altitude are outside the scope of the investigation.

On the northern and western fringes of the study area, topographic and botanical boundaries are even more obscure, both naturally and as a result of the intensive agricultural use of this region. The Avoca River serves as a useful boundary between the grassy woodlands of the northern and western plains. West of the Avoca River, for example, black box is a more significant component of the grassy woodlands (Foreman in prep.). To the north, in the area around Dingee, grassy woodlands grade into grasslands, as tree cover becomes sparser and eventually disappears from some large areas.

## PATTERNS OF VEGETATION CHANGE

Mapping of the extent of vegetation types at the time of European settlement — referred to as the pre-1750 extent of vegetation types — is necessary to determine the level of

**Table 13: Changes in tree cover of Broad Vegetation Types in the study area**

- Percentages indicate what remains of the total pre-1750 extent of each vegetation type.

Broad Vegetation Type	Pre-1750 forest cover	Tree cover in 1993							
	Total area	Public land — reserves		Public land — other		Private land		Total	
	ha	ha	%	ha	%	ha	%	ha	%
Dry Foothill Forests	94 383	3 730	3.95	29 599	31.36	9 721	9.82	42 600	45.14
Box-Ironbark Forests	965 275	26 950	2.79	185 027	19.17	62 377	6.46	274 354	28.42
Mallee	66 435	7 808	11.75	10 613	15.98	7 936	11.95	26 357	39.67
Inland Slopes Woodlands	194 598	8 688	4.46	24 799	12.74	19 220	9.88	52 707	27.09
Herb-rich Woodlands	225 790	3 243	1.44	5 200	2.30	8 609	3.81	17 052	7.55
Valley Grassy Forests	9 229	0	0.00	667	7.23	280	3.03	947	10.26
Plains Grassy Woodlands	1 490 484	3 389	0.29	15 394	1.03	20 086	1.35	39 869	2.67



*The much greater loss of native vegetation types in flatter, more fertile areas (foreground) is evident throughout the study area.*

depletion of vegetation types since European settlement (see also Chapter 6). This is an important consideration when making public land use decisions, particularly decisions about the reservation of representative areas of particular vegetation types. By extrapolating from the distribution patterns of remnant vegetation and from the environmental parameters which determine these patterns, the pre-1750 extent of vegetation types can be 'reconstructed'. The pre-1750 extent of box-ironbark EVCs has not yet been modelled, and it is currently necessary to use BVTs to determine the level of depletion of vegetation types. Map D shows the depletion of BVTs since settlement.

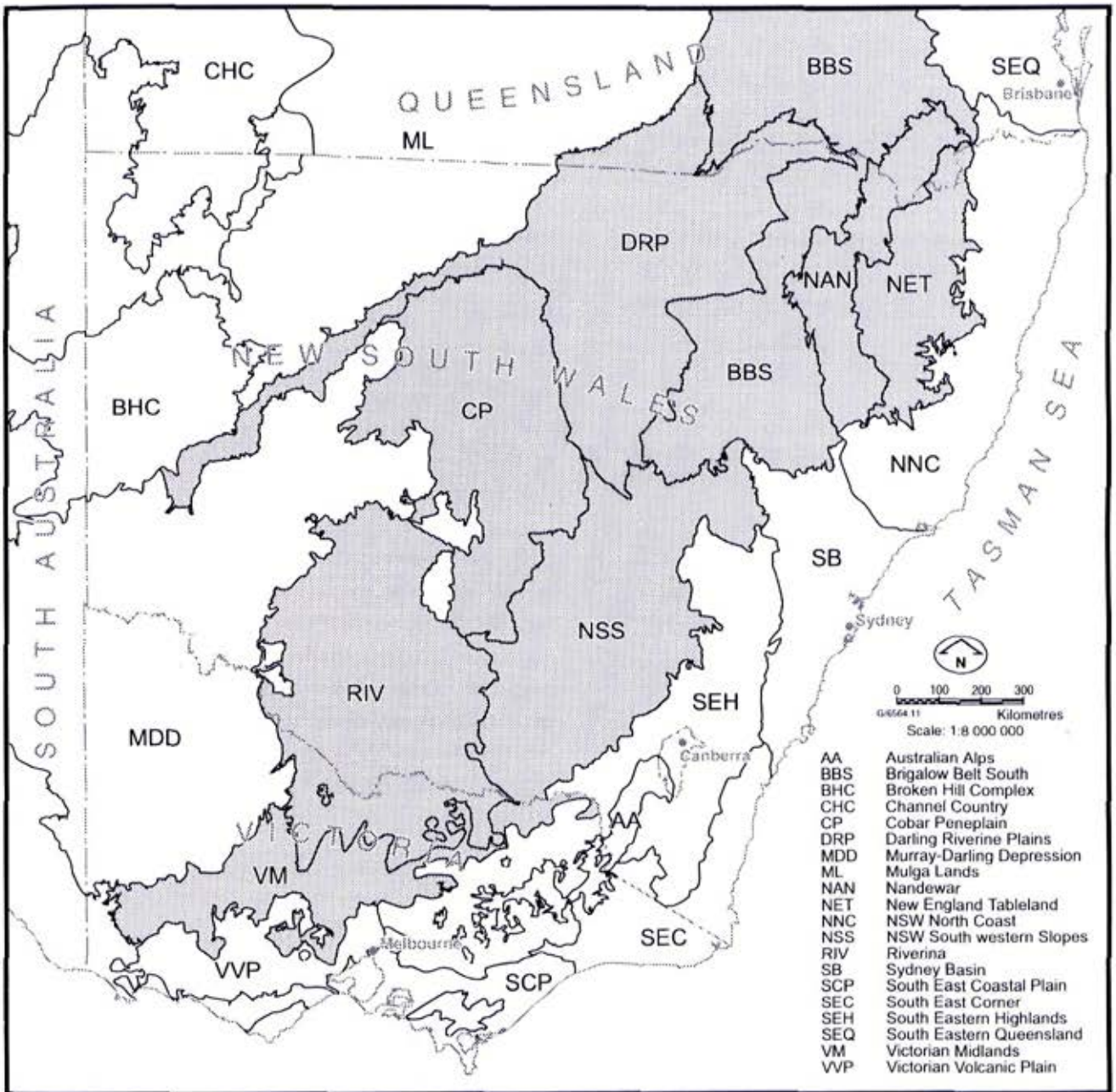
Comparing the remaining tree cover of each BVT (see Table 13) with its pre-1750 extent, indicates the degree to which each type has been depleted by vegetation clearance. It is apparent that BVTs such as Herb-rich Woodland and

Valley Grassy Forest were never of great extent and have been largely cleared within the study area. In comparison, Plains Grassy Woodland was originally the most widespread BVT but like the other grassy and herb-rich BVTs it has also been severely depleted. This pattern reflects the higher fertility and moisture availability of the grassy and herb-rich areas compared with the Inland Slopes Woodland, Mallee and Box-Ironbark Forest BVTs. Most of the fertile areas were cleared for agriculture whereas the other forests and woodlands were more marginal for this purpose and consequently less severely cleared. Forests on the less fertile areas were cut for high quality timber but were allowed to regenerate to provide for future timber needs, for mining, firewood, farm use and sleepers (refer to Chapter 3).

It should be recognised that nearly all remaining vegetation in the study area has been modified following European occupation of this region. The existence of forest cover does not necessarily indicate the presence of the same vegetation assemblage that occurred there pre-1750. For example forest remnants on private land often consist of overstorey trees with only introduced pasture grasses in the understorey.

Table 13 also provides some perspective on the current representation of remnant BVTs in parks and reserves. In most cases the remaining areas of BVTs are outside the public land conservation reserve system (national and regional parks, flora reserves, flora and fauna reserves and reference areas), occurring largely on public land committed to a variety of uses, or on private land.

Map 10: Interim biogeographic regions – ‘box-ironbark regions’ shaded.



Source: Thackway and Cresswell (1995).

## BIOGEOGRAPHIC PATTERNS

The band of box-ironbark vegetation that extends through central and northern Victoria is part of a much larger band of temperate woodlands and dry forests that occur at the interface between arid/semi-arid inland habitats (sometimes called the Eyrean zone by

biogeographers) and wetter southern coastal and mountainous habitats (the Bassian zone). Bands of these temperate woodlands occur in south-eastern and south-western Australia.

Biogeographers have recently developed an interim list of 80 terrestrial biogeographic regions across Australia (Thackway and Cresswell 1995). There are numerous plant

and animal distributions which conform to the regional boundaries, as well as many exceptions. In Victoria, box-ironbark forests and woodland areas occur in the Riverina, New South Wales South-western Slopes, and Victorian Midlands biogeographic regions (Map 10). The first two of these regions extend into New South Wales and are contiguous with a series of allied biogeographic regions: the Cobar Peneplain, Darling Riverine Plain, Brigalow Belt South, Nandewar, and New England Tablelands. The band of temperate woodlands continues through these regions and into Queensland, where temperate woodlands abut tropical woodlands and are often characterised by trees which do not occur or are rare in Victoria — e.g. poplar box, narrow-leaved red ironbark, brigalow and boree.

## Flora

The NSW South-western Slopes biogeographic region includes the inland slopes of southern New South Wales as well as the very north-eastern corner of Victoria. This reflects similarities in land systems and broad vegetation structure in these two areas.

The Victorian Midlands biogeographic region sweeps across the inland slopes and foothills of the Dividing Range through north-central Victoria to western Victoria. The vegetation structure across this region is also broadly uniform. Floristically there are gradational differences between the western extent of the Victorian Midlands and the central Victorian area. The floristic differences between central Victoria and north-eastern Victoria are of similar dimension, that is, the distinction between the Victorian Midlands and NSW South-western Slopes is not strong from a floristic point of view. Nonetheless, there are some species which reflect this distinction. For example, yellow gum is found throughout the Victorian Midlands but not in the NSW South western Slopes, while the reverse is true for black cypress-pine.

Across the Victorian Midlands and NSW South-western Slopes biogeographic regions various EVCs grade in and out from the west to the north-east. This is reflected in the variation of communities that fall within particular EVCs across the study area, for example the occurrence of different box-ironbark communities in the western goldfields, northern goldfields and north-eastern hills of Victoria.

In Victoria at least, the Riverina biogeographic region is fairly distinct from the NSW South-western Slopes and

Victorian Midlands because of the predominantly grassy vegetation types that occur on the alluvial plain. This disjunction is also apparent in the very low number of 'box-ironbark stronghold species' — plant species that have their Victorian stronghold in the Box-Ironbark study area — that occur in the Riverina and in one or both of the other two regions. Three wattles, the golden wattle, hedge wattle and gold-dust wattle are among the few exceptions. This absence of floristic affinity between the Riverina and the other two regions is mainly a consequence of the differences in soils between the inland slopes and the Riverina plain.

## Fauna

The division between the inland slopes and the plains is much less apparent in the fauna of the study area than it is in the vegetation. For example, in the fauna, around 10 'box-ironbark stronghold species' occur both on the inland slopes and on the plains. Some of the best known are the brush-tailed phascogale, squirrel glider, swift parrot, barking owl, white-bellied cuckoo-shrike, painted honeyeater, black-chinned honeyeater, and diamond fire-tail. That there are no reptiles or amphibians in this list is not surprising. Most reptiles and amphibians live close to the ground and for them, like plants, soil type is a more important habitat determinant than is generally the case for birds and mammals. Thus the distinction between the plains and the inland slopes is more strongly reflected in the distributions of reptiles and amphibians.

A pattern in the distribution of box-ironbark flora that is also apparent in the distribution of fauna is the rather weak distinction between the Victorian Midlands and New South Wales South-western Slopes bioregions — few if any animal species are characteristic of one but not the other.

The fauna of box-ironbark can be characterised by four major groups:

1. Eyrean species, with a predominantly inland distribution reaching the edge of their range in the study area, for example: budgerigar, rainbow bee-eater, Gould's sand goanna.
2. Bassian species, with a predominantly mountain or coastal distribution reaching the inland limit of their range in the study area, for example: sugar glider, crimson rosella, powerful owl.
3. 'Box-ironbark stronghold species' — species for which the study area provides a stronghold in Victoria — for

example: bush stone-curlew, swift parrot, grey-crowned babbler, fuscous honeyeater.

4. Widespread species which occur across the study area and in a range of other dissimilar habitats, for example: echidna, willie wagtail, Australian magpie.

An interesting phenomenon in this regard is the case of five species which were widespread at the time of European settlement, but have subsequently declined to become 'box-ironbark stronghold species' — the brush-tailed phascogale, bush stone-curlew, swift parrot, turquoise parrot, and regent honeyeater.

The co-occurrence of Eyrean and Bassian species is itself a distinctive characteristic of box-ironbark faunal assemblages, and also results in a particularly diverse fauna and many sites of high diversity. For example, over 220 bird species (including water birds) have been recorded in Chiltern Box-Ironbark National Park.

Ecologically mature trees play a conspicuous role in the functioning of box-ironbark ecosystems. The presence of roosting or nesting hollows is essential for approximately 25 per cent of resident mammal, bird and reptile species. These hollows are usually formed in mature trees when branches die back and fungus or termites enter the tree. Several other characteristics of ecologically mature trees are important for fauna. This importance is explored more fully in Chapter 9.

Another key feature of the ecology of box-ironbark forests and woodlands, which sets them apart from other vegetation types, is the prominent role of eucalypt nectar: several of the characteristic box-ironbark eucalypts (e.g. mugga ironbark, red ironbark, yellow gum, yellow box, white box, and grey box) are noted for the volume of nectar that they produce. The flowering of these eucalypts is typically seasonal (usually over one to two months each year) but the vigour of flowering can be highly variable between years and between locations. For example, nearly all trees of a particular species in an area may produce abundant blossom in one year but in the next year, or in the same year at another location, less than 10 per cent of trees might flower, and produce relatively little blossom per tree.

The abundance of food available when eucalypts are flowering prolifically in an area often attracts remarkable concentrations of animals (nocturnal and diurnal) to feed on both the nectar and on other animals that are attracted

to the area. Consequently, box-ironbark faunal assemblages include a larger proportion (around 25 per cent) of nectarivorous mammal and bird species compared to other Australian vegetation types which, in turn, are generally rich in nectarivores compared to comparable vegetation types on other continents. Wide-ranging nomadic and migratory nectarivorous birds, including several of the most characteristic box-ironbark species (for example swift parrot, regent honeyeater), are a particularly prominent component of the box-ironbark fauna. Invertebrates are often conspicuously abundant around prolifically flowering trees, suggesting that the invertebrate fauna of box-ironbark forests and woodlands is likely to parallel the vertebrate fauna in reflecting the ecological significance of nectar.



*Fuscous honeyeater.*

Probably as a result of this high degree of seasonal (or less predictable) variation in food availability, box-ironbark forests and woodland areas support a large number of species (mostly birds) that move throughout the study area on either a regular (migratory), sporadic (nomadic), or even daily basis. Many species also regularly move between the study area and adjacent habitat types, providing a reminder of the links that extend beyond boundaries. A good example of the latter phenomenon is the superb parrot, which breeds in colonies in large river red gums in Barmah forest and 'commutes' daily to feeding sites in remnant box woodlands several kilometres to the south of the breeding sites. The abundance and distribution of often small remnants of indigenous vegetation in predominantly cleared landscapes is a major factor in the ecology of species such as the superb parrot. This issue is often called landscape ecology, and is discussed further in Chapter 21 (under 'Reserve system design').

## 8. FLORA

The vegetation in the study area extends from dry forests and woodlands of the inland hills of the Dividing Range to grassy woodlands of the northern plains. The division between the inland hills and the northern plains, and the further division into 22 Ecological Vegetation Classes (EVCs) provides a useful framework for discussion of the vegetation. Where they exist, common names are used for plants throughout this chapter. Appendix VI lists the common and scientific names of all species mentioned.

### VEGETATION OF THE INLAND HILLS

Twenty-two floristic communities representing 16 EVCs have been described for the inland hills (Table 14), ranging from the widespread Box-Ironbark Forest to woodlands with grassy, heathy, sedge-rich and herb-rich understoreys, and mallee scrubs. Approximately 1300 vascular plant taxa have been recorded from this part of the study area, of which 75 per cent are native, 76 rare or threatened, three endemic, and two extinct. The most common families represented are the daisies, grasses, orchids, peas, lilies, eucalypts and tea-trees (Myrtaceae), and wattles.

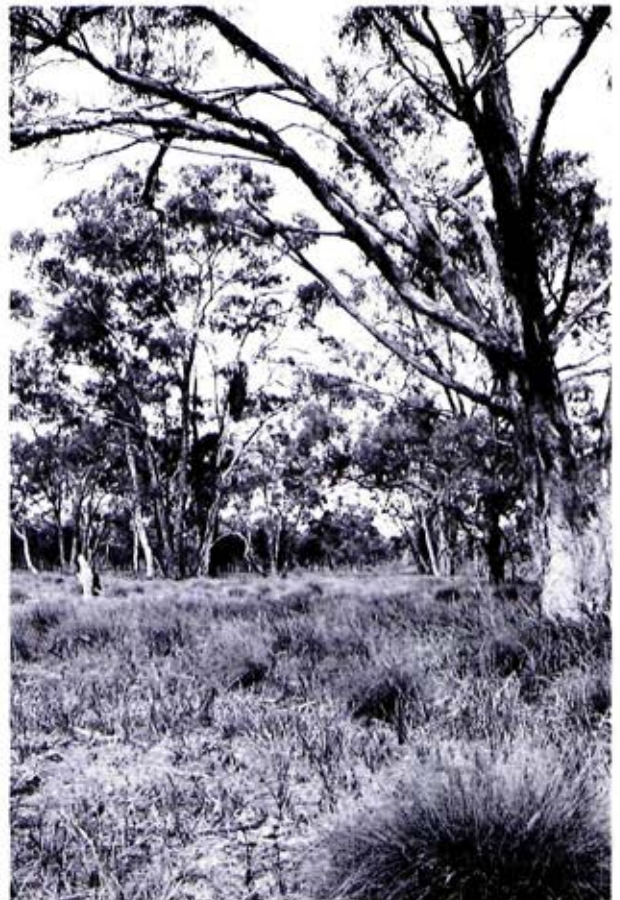
The inland hills are dominated by the Box-Ironbark Forest EVC, in which the most common trees are red ironbark, grey box, yellow gum and red box. These forests are found on the gently undulating rises and low hills that are a feature of this part of the study area. The soils, which are derived from Palaeozoic sediments, have low fertility and poor water-holding capacity (Box-Ironbark Forest in Table 14).

Mallee shrublands with a canopy of green mallee, blue mallee, bull mallee or broombush occur on the most skeletal soils of the sedimentary rises on the northern fringes of the hills (Gravelly-sediment Mallee and Sandstone-rise Broombush in Table 14).

Heathy woodlands occur as small patches associated with Box-Ironbark Forests. They are found on low fertility sands and gravels, mostly in the west of the study area. Some sites are seasonally wet. Overstorey trees are

commonly long-leaf box, yellow gum or red box (Heathy Woodland and Sedge-rich Woodland in Table 14).

The interfaces between the undulating sedimentary rises and the alluvial plains support woodlands with grassy or herb-rich understoreys. Soils are more fertile and have a better water availability than the adjacent Box-Ironbark Forest. Grey box, yellow box and river red gum are the dominant eucalypts. (Low Rises Grassy Woodland, Alluvial Terraces Herb-rich Woodland and Creekline Grassy Woodland in Table 14). More detailed assessment of vegetation at the inland hills — northern plains interface may lead to minor rearrangements of the currently identified EVCs — for example, some may be amalgamated with some of the northern plains EVCs listed below.



*Sedge-rich Woodland EVC, Deep Lead. The dominant trees are yellow gum and yellow box.*

Table 14: Vegetation communities of the inland hills

Structure	Canopy	Shrub and /or ground layer (typical species)	Rainfall (mm)	Mean altitude	Landform, geology and soils	Location
<b>Box-Ironbark Forest (Northern Goldfields)</b>						
open-forest	red ironbark grey box red box yellow gum	golden wattle twiggy bush-pea gold-dust wattle shiny everlasting drooping cassinia spiky guinea-flower wattle mat-rush black-anther flax-lily bristly wallaby-grass	400-600	220 m	Gently undulating rises to low hills. Shallow stony soils from Ordovician sediments.	Rushworth to Heathcote Puckapunyal Military Area Dunolly to Inglewood
<b>Box-Ironbark Forest (Western Goldfields)</b>						
open-forest	red box red ironbark grey box yellow gum	golden wattle gold-dust wattle drooping cassinia narrow-leaf bitter-pea spiky guinea-flower wattle mat-rush black-anther flax-lily bristly wallaby-grass slender rice-flower	450-650	270 m	Gently undulating rises to low hills. Shallow stony soils from Ordovician sediments.	Dunolly to S of Maryborough S of St Arnaud Stawell
<b>Box-Ironbark Forest (North-eastern Hills)</b>						
open-forest	mugga ironbark grey box	golden wattle gorse bitter-pea slender rice-flower grey guinea-flower shiny everlasting black-anther flax-lily silvertop wallaby-grass common wheat-grass rough spear-grass stinking pennywort	550-700	200 m	Gently undulating rises to low hills. Shallow stony soils from Ordovician sediments.	Euroa to Chiltern
<b>Heathy Dry Forest (Northern Goldfields)</b>						
open-forest	red stringybark red box	daphne heath cat's claws grevillea common rice-flower common hovea blue finger-flower silvertop wallaby-grass grey tussock-grass black's goodenia tall sundew	450-650	250 m	Upper slopes and ridgetops of undulating terrain and low hills. Shallow stony soils from Ordovician and Lower Devonian sediments.	S of Bendigo Rushworth to Heathcote N of Dunolly Vegetation mapping indicates that another distinct community probably occurs in the western goldfields but this has not yet been verified by field sampling.

Table 14: Vegetation communities of the inland hills (continued)

<b>Heathy Dry Forest (Northern Foothills)</b>						
open-forest	red stringybark red box long-leaf box	daphne heath gorse bitter-pea common rice-flower common hovea silvertop wallaby-grass grey tussock-grass stinking pennywort	500-700	370 m	Upper slopes and ridgetops. Shallow stony soils from Ordovician and Cambrian sediments.	Castlemaine S of St Arnaud Pyrenees Euroa to Chiltern
<b>Heathy Dry Forest (North-eastern Hills)</b>						
open-forest	red stringybark hill red gum red box	daphne heath grey guinea-flower silvertop wallaby-grass small poranthera stinking pennywort common woodrush	550-700	320 m	On ridgetops and plateaus. Soils derived from Granite or contact metamorphosed Ordovician sediments.	Warby Ranges to Chiltern
<b>Grassy Dry Forest (Northern Goldfields)</b>						
open-forest	red stringybark red box yellow box	grey tussock-grass blue finger-flower kangaroo grass common woodrush magenta stork's-bill short-hair plume-grass	450-650	295 m	On upper slopes and ridgetops of low hills. Often close to Heathy Dry Forest (Northern Goldfields). Shallow, stony soils from Ordovician and Lower Devonian sediments.	N of Heathcote NW of Dunolly Vegetation mapping indicates that two additional communi- ties probably occur in the west- ern goldfields and north-eastern hills, but this has not yet been verified by field sampling.
<b>Grassy Dry Forest (Northern Foothills)</b>						
open-forest	red stringybark yellow box red box long-leaf box	grey tussock-grass tall bluebell stinking pennywort small St John's wort green rock fern cotton fireweed magenta stork's-bill austral cranesbill common woodrush	550-700	440 m	Sheltered aspects on upper slopes and ridgetops of rolling hills and lower slopes of ranges. Shallow, stony soils derived from Ordovician and Cambrian sediments.	Pyrenees S end of St Arnaud Range
<b>Heathy Woodland (Northern Goldfields)</b>						
low woodland	red ironbark red box grey box	daphne heath common fringe-myrtle cat's claws grevillea cranberry heath shiny everlasting	450-550	200 m	Undulating plains, rises and low hills. Sandy or clay soils.	Bendigo Dunolly
<b>Heathy Woodland (Western Goldfields)</b>						
low woodland	long-leaf box yellow gum	daphne heath common fringe-myrtle brush heath flame heath wax-lip orchid scented sundew	450-650	220 m	Undulating plains, rises and low hills. Tertiary sands with thin cover- ing of clay, sandstone often altered to quartzite gravel.	Stawell SE and SW of St Arnaud

Structure	Canopy	Shrub and /or ground layer (typical species)	Rainfall (mm)	Mean altitude	Landform, geology and soils	Location
<b>Metamorphic Slopes Shrubby Woodland</b>						
woodland	grey box drooping sheoke	wallowa (a wattle) sticky hop-bush tall raspwort rough spear-grass	400–500	230 m	Rocky slopes of metamorphic aureoles adjacent to granitic plutons.	Dunolly Tarnagulla Inglewood
<b>Granitic Hills Woodland</b>						
woodland	hill red gum red box white cypress- pine	grey guinea-flower cat's claws grevillea nodding blue-lily tall raspwort common fringe-myrtle	500–700	290 m	Crests and slopes of granitic hills.	Warby Range Chesney Vale Hills
<b>Rocky Outcrop Shrubland/Herbland Mosaic</b>						
shrubland and herbland	no tree canopy	spur-wing wattle common fringe-myrtle nodding blue-lily rock isotome mosses, lichens annual herbs	500–700	270 m	Outcropping of flat sheets of granite. Coarse, sandy soils in pockets between rock slabs.	Warby Ranges Chesney Vale hills Terrick Terrick
<b>Sedge-rich Woodland</b>						
woodland	yellow gum	sticky sword-sedge black bristle-sedge slender sun-orchid yellow bulbine-lily	500–650	220 m	Flat or slightly undulating terrain with seasonally inundated depressions. Tertiary sands and sandstones, soils include clay-loams with ironstone gravel at surface	Deep Lead Stawell
<b>Low Rises Grassy Woodland</b>						
woodland	grey box white box	sticky hop-bush drooping cassinia feather spear-grass saloop saltbush fuzzy New Holland daisy blue burr-daisy lemon beauty-heads	400–500	160 m	Plains and gently undulating terrain. Soils derived from Ordovician sediments and alluvium.	Kamarooka Bendigo
<b>Creepline Grassy Woodland</b>						
woodland	river red gum yellow box	weeping grass common wheat-grass tall sedge rush species wirilda (a wattle) rough-barked honey- myrtle	450–650	190 m	Shallow or ephemeral drainage lines. Alluvial soils.	Across study area (tiny remnants)

Table 14: Vegetation communities of the inland hills (continued)

Structure	Canopy	Shrub and /or ground layer (typical species)	Rainfall (mm)	Mean altitude	Landform, geology and soils	Location
<b>Metamorphic Slopes Shrubby Woodland</b>						
woodland	grey box drooping sheoke	wallowa (a wattle) sticky hop-bush tall raspwort rough spear-grass	400-500	230 m	Rocky slopes of metamorphic aureoles adjacent to granitic plutons.	Dunolly Tarnagulla Inglewood
<b>Granitic Hills Woodland</b>						
woodland	hill red gum red box white cypress-pine	grey guinea-flower cat's claws grevillea nodding blue-lily tall raspwort common fringe-myrtle	500-700	290 m	Crests and slopes of granitic hills.	Warby Range Chesney Vale Hills
<b>Rocky Outcrop Shrubland/Herbland Mosaic</b>						
shrubland and herbland	no tree canopy	spur-wing wattle common fringe-myrtle nodding blue-lily rock isotome mosses, lichens annual herbs	500-700	270 m	Outcropping of flat sheets of granite. Coarse, sandy soils in pockets between rock slabs.	Warby Ranges Chesney Vale hills Terrick Terrick
<b>Sedge-rich Woodland</b>						
woodland	yellow gum	sticky sword-sedge black bristle-sedge slender sun-orchid yellow bulbine-lily	500-650	220 m	Flat or slightly undulating terrain with seasonally inundated depressions. Tertiary sands and sandstones, soils include clay-loams with ironstone gravel at surface	Deep Lead Stawell
<b>Low Rises Grassy Woodland</b>						
woodland	grey box white box	sticky hop-bush drooping cassinia feather spear-grass saloop saltbush fuzzy New Holland daisy blue burr-daisy lemon beauty-heads	400-500	160 m	Plains and gently undulating terrain. Soils derived from Ordovician sediments and alluvium.	Kamarooka Bendigo
<b>Creepline Grassy Woodland</b>						
woodland	river red gum yellow box	weeping grass common wheat-grass tall sedge rush species wirilda (a wattle) rough-barked honey-myrtle	450-650	190 m	Shallow or ephemeral drainage lines. Alluvial soils.	Across study area (tiny remnants)

Upslope of the Box–Ironbark Forests are dry forests dominated by red stringybark and red box. A heathy understorey develops on westerly or northerly aspects (Heathy Dry Forest in Table 14).

The southerly and easterly aspects of upper slopes and ridgetops and the sheltered valleys of these steeper hills support forests with grassy and herb-rich understoreys. The tree canopy usually includes red stringybark, red box or yellow box (Grassy Dry Forest and Valley Grassy Forest in Table 14).



*Central Riverine Grey Box Grassy Woodland EVC.*

Distinctive woodlands occur on ridges formed from contact metamorphosed rock. Shrubby woodlands with an overstorey of grey box occur on the slopes, and herb-rich woodlands with a canopy of yellow box on the broad hilltops (Metamorphic Slopes Shrubby Woodland and Hillcrest Herb-rich Woodland in Table 14).

Herb-rich woodlands dominated by hill red gum occur on granitic hills, including the rocky outcrops and outwash slopes (Granitic Hills Herb-rich Woodland, Granitic Hills Woodland and Rocky Outcrop Mosaic in Table 14).

## VEGETATION OF THE NORTHERN PLAINS

Six 'floristic groups' of grassy woodlands have been described for the northern plains by Foreman (in prep.). As explained in Chapter 7, these 'groups' will be treated as EVCs in this report, but further study is required to accurately identify their appropriate status. Sixty rare or threatened vascular plants have been recorded in the grassy woodlands of the northern plains, 21 of which also occur in the inland hills.

There are likely to be additional communities that have been so depleted and modified by land management that they have become extinct, or have not been sampled adequately and not recognised in vegetation surveys to date. This is particularly the case on the northern plains where much of the remnant vegetation is on private land.

The composition and distribution of grassy woodlands on the Northern Riverine Plain as a whole is related to the patterns of river systems running from the Dividing Range to the Murray River. Where regular flooding occurs, wetlands are present. Where there is no regular flooding, grasslands and grassy woodlands are the dominant vegetation types. Grasslands develop on the finer textured soils, and grassy woodlands — that part of the Northern Riverine Plain which is included in the study area — develop on the coarser sediments. Different floristic communities are linked to rainfall gradation from west to east. At the periphery of the Midlands and on outlying hills such as Terrick Terrick and Dookie, distinctive grassy woodlands occur. Because human disturbance to vegetation on the northern plains has been so pervasive since European settlement, some of the floristic groupings probably reflect common responses to this disturbance as much as natural phenomena. It may no longer be possible to unravel anthropogenic from natural determinants of vegetation formations on the northern plains.

Table 15: Vegetation communities of the northern plains

Structure	Canopy	Shrub and /or ground layer (typical species)	Rainfall (mm)	Mean altitude	Landform, geology and soils	Location	
<b>West Riverine Grey Box Grassy Woodland</b>							
open woodland	grey box	wallaby-grass species rough spear-grass spider grass wingless bluebush bottle bluebush variable sida grassland wood-sorrel	fuzzy New Holland daisy woolly New Holland daisy lemon beauty-heads pink bindweed dense crassula	< 400	125 m	riverine plain, soils with surface texture lighter than clay loam	between Mitiamo and Serpentine between Wedderburn and Charlton W of Boort
<b>West Riverine Grey Box Shrubby Woodland</b>							
open woodland	grey box	golden wattle mallee wattle sweet bursaria gold-dust wattle curved/silky rice-flower rough spear-grass feather spear-grass common wheat-grass wallaby-grass nodding chocolate-lily	chocolate-lily leek lily black-anther flax-lily scented mat-rush yellowish bluebell grassland wood-sorrel common everlasting fuzzy New Holland daisy lemon beauty-heads	400-500?	171 m	?Ordovician sediments, edge of riverine plain	Bendigo to Wedderburn (Calder Highway)
<b>Terrick Terrick Cypress-pine Grassy Woodland</b>							
open woodland	white cypress-pine grey box	rough spear-grass hill wallaby grass variable sida grassland wood-sorrel woolly New Holland daisy creamy candles common early nancy austral carrot small-leaf goodenia	common sunray hairy stylewort pygmy sunray spoon curdweed dense crassula hard-head daisy paper sunray nodding saltbush	< 400	120 m	lower slopes of granite hills	Terrick Terrick State Park nearby private land
<b>Central Riverine Grey Box Grassy Woodland</b>							
open woodland	grey box	curved/silky rice-flower common wheat-grass bristly wallaby-grass hill wallaby-grass common wallaby-grass rough spear-grass spurred spear-grass grassland wood-sorrel variable sida grassy bindweed	cut-leaf goodenia fuzzy New Holland daisy woolly New Holland daisy yellowish bluebell nodding chocolate-lily yellow bulbine-lily wingless bluebush dense crassula	400-500	142 m	riverine plain, soils with surface texture coarser than clay loam	Numurkah Nagambie N of Bendigo Mitiamo Charlton

Eastern Riverine Grassland							
closed grassland with scattered eucalypts, formerly open woodland	grey box yellow box white box	bristly wallaby-grass hill wallaby grass kangaroo grass rough spear-grass yellow bulbine-lily wattle mat-rush common bog-sedge chocolate-lily milkmaids black-anther flax-lily	common onion-orchid common early nancy yellow rush-lily small loosestrife tall sundew scaly buttons blue devil common raspwort common everlasting	> 500	165 m	riverine plain, soils with lighter texture and larger particle size than further to north and west	Wangaratta Chiltern adjacent to Warby Range N of Euroa
Eastern Low Rises Grassy Woodland							
open woodland	hill red gum red box white box lightwood	varnish wattle grey guinea-flower urn heath cane wire-grass weeping grass dense spear-grass kangaroo grass wattle mat-rush chocolate-lily black-anther flax-lily	many-flowered mat-rush common bog-sedge blue squill yellow rush-lily common raspwort small St. Johns wort tall sundew stinking pennywort austral cranesbill	500- 600	256 m	?outwash of granite and sedimentary hills	Seymour to Wangaratta ?Dookie hills

Structurally, the grassy woodlands of the northern plains vary from open woodland to virtually treeless grassland, although the absence of trees is an artefact of clearing rather than natural processes. Dominant overstorey species vary, but grey box is the most frequently occurring. In general the shrub layer has been removed by grazing, so that shrubs remain at a small number of very lightly grazed sites. The ground layer is characterised by a large range of grasses, most frequently wallaby-grasses and spear-grasses. Between the grass tussocks perennial native herbs are the most common component. Summary descriptions of the northern plains EVCs are provided in Table 15.

The distribution of all EVCs within the study area is presented in Map B. Figure 5 provides a simplified diagrammatic representation of the variation in vegetation across the study area in relation to geology — through the inland hills and across the northern plains.

## VEGETATION CLASSIFICATION

In Chapter 7, Broad Vegetation Types (BVTs), Ecological Vegetation Classes (EVCs), communities and sub-communities were introduced, and their relationships to each other were explained. The main application of BVTs in conservation planning is in providing a framework for broadscale assessment of conservation criteria, when more precise frameworks are not available. However, Ecological Vegetation Classes, communities and sub-communities provide the most appropriate vegetation classification system for assessing the adequacy of biodiversity conservation. EVCs are units that can be used to fulfil this assessment at the landscape scale whereas communities and sub-communities provide planning units at a more local scale (see Tables 14 and 15 for a description of communities in the study area).

Conservation planning should be based on the vegetation community or sub-community level where this information is available because at this resolution the full variation of a vegetation type across its geographic range can be considered. For example, adequate reservation of the Box-Ironbark Forest EVC will not be achieved by good reservation of the Box-Ironbark Forest (Western Goldfields) community alone. Box-Ironbark Forest (Northern Goldfields) and Box-Ironbark Forest (North-eastern Hills)

communities will also be integral to conservation of the EVC. Similarly, the Gravelly-sediment Mallee community comprises two sub-communities, one of which is particularly targeted for eucalyptus oil harvesting and is also poorly reserved.

## FACTORS AFFECTING FLORA CONSERVATION

All vegetation communities in the study area have been affected to varying degrees by a range of threatening processes. These include vegetation clearance and fragmentation, mining and quarrying, harvesting forest products, grazing and environmental weed invasion. Some vegetation communities have been more severely affected than others because of the particular physical or biological features with which they are associated — see Tables 16 and 17. Grassy woodlands of more fertile and moist soils are the most depleted and modified.



*Sandstone-rise Broombush EVC.*

### Vegetation clearance

The indigenous vegetation of the study area has been severely depleted (see Chapter 7). Native vegetation has been lost either permanently (average across all vegetation types of approximately 85 per cent of pre-European extent cleared, mostly for agriculture) or temporarily through activities such as mining, and eucalypt oil harvesting. Where native vegetation has regenerated, it is generally modified — the composition of the understorey flora almost certainly changed, and overstorey trees are much thinner and more densely spaced than those of the pre-European forests and woodlands. Table 16 provides information on the landform and soil characteristics of each EVC/community as a guide to understanding why

Table 16: Conservation status of vegetation communities in the inland hills

Ecological Vegetation Class	Landform and soil characteristics.	Threats (historical or current origin)	Condition of vegetation communities and reservation status
Box-Ironbark Forest (Northern Goldfields, Western Goldfields, North-eastern Hills)	<ul style="list-style-type: none"> <li>Gently undulating rises to low hills.</li> <li>Shallow stony soils from Ordovician sediments.</li> <li>Low fertility and moisture.</li> </ul>	<ul style="list-style-type: none"> <li>Vegetation clearance.</li> <li>Fragmentation of vegetation.</li> <li>Harvesting wood products.</li> <li>Mining and quarrying.</li> <li>Grazing.</li> <li>Environmental weed invasion.</li> </ul>	Depleted and modified. <i>Nth Goldfields</i> : 5 per cent in conservation reserves. Moderate representation in Whipstick SP, Costerfield FR. Patchy rep. in Mt Ida FR, Mt Black FR, One Tree Hill RP, Wychitella FFR. <i>West Goldfields</i> : 5 per cent in conservation reserves. Moderate representation in Paddys Range SP. Patchy rep. in Kara Kara SP. <i>Nth-east Hills</i> : Severely fragmented and poorly reserved. Rep. in Chiltern NP, Reef Hills RP, Killawarra RA, Boweya FFR.
Heathy Dry Forest (Northern Goldfields, Northern Foothills, North-eastern Hills)	<ul style="list-style-type: none"> <li>Upper slopes and ridgetops.</li> <li>Shallow stony soils from Ordovician, Lower Devonian and Cambrian sediments.</li> <li>Low fertility and moisture.</li> </ul>	<ul style="list-style-type: none"> <li>Vegetation clearance.</li> <li>Fragmentation of vegetation.</li> <li>Harvesting wood products.</li> <li>Mining and quarrying.</li> <li>Grazing.</li> <li>Disease.</li> </ul>	Depleted and modified. <i>Nth Goldfields</i> : High quality sites and good representation in Mt Black FR, One Tree Hill RP. Moderate rep. in Pilchers Bridge FFR, Mt Ida FR, Sandhurst RA. One of three sub-communities is threatened by cinnamon fungus. <i>Nth Foothills</i> : Good representation in Fryers Range FR, Kara Kara SP, Landsborough FFR, Ararat Hills RP, Tallarook FR, Reef Hills RP, Chiltern NP. <i>Nth-east Hills</i> : Good representation in Warby Range SP, Chiltern NP.
Grassy Dry Forest (Northern Goldfields, Northern Foothills)	<ul style="list-style-type: none"> <li>Upper slopes and ridgetops of rolling hills and lower slopes of ranges.</li> <li>Shallow, stony soils derived from Ordovician and Cambrian sediments</li> <li>Low fertility and moderate moisture availability.</li> </ul>	<ul style="list-style-type: none"> <li>Vegetation clearance.</li> <li>Fragmentation of vegetation.</li> <li>Harvesting wood products.</li> <li>Grazing.</li> </ul>	Depleted and modified. Not well developed in study area - merges into Heathy Dry Forest. <i>Nth Goldfields</i> : High quality sites in south of One Tree Hill RP. <i>Nth Foothills</i> : Represented in same reserves as Heathy Dry Forest (Nth Foothills).
Heathy Woodland (Northern Goldfields, Western Goldfields)	<ul style="list-style-type: none"> <li>Undulating plains, rises and low hills.</li> <li>Tertiary sands with thin covering of clay. Sandstone often altered to quartzite.</li> <li>Low fertility and variable moisture holding capacity.</li> </ul>	<ul style="list-style-type: none"> <li>Vegetation clearance.</li> <li>Fragmentation of vegetation.</li> <li>Harvesting wood products.</li> <li>Grazing.</li> <li>Mining and quarrying.</li> </ul>	Depleted and modified. <i>Nth Goldfields</i> : Not represented in a conservation reserve. <i>West Goldfields</i> : Moderate representation in Deep Lead FFR, Dalyenong FR, Morri Morri FR.
Metamorphic Slopes Shrubby Woodland	<ul style="list-style-type: none"> <li>Rocky slopes of metamorphic aureoles adjacent to granitic plutons.</li> <li>Low fertility and moisture.</li> </ul>	<ul style="list-style-type: none"> <li>Vegetation clearance.</li> <li>Fragmentation of vegetation.</li> <li>Harvesting wood products.</li> <li>Mining and quarrying.</li> <li>Grazing.</li> <li>Environmental weed invasion.</li> </ul>	Depleted and modified. Naturally uncommon in the study area. Patchy representation in Kooyoora SP, Inglewood FR, Wychitella FFR, Mt Black FR.

Table 16: Conservation status of vegetation communities in the inland hills (continued)

Ecological Vegetation Class	Landform and soil characteristics	Threats (historical or current origin)	Condition of vegetation communities and reservation status
Granitic Hills Woodland	<ul style="list-style-type: none"> <li>• Crests and slopes of granitic hills.</li> <li>• Moderate fertility and moisture.</li> </ul>	<ul style="list-style-type: none"> <li>• Vegetation clearance.</li> <li>• Fragmentation of vegetation.</li> <li>• Harvesting wood products.</li> <li>• Grazing.</li> <li>• Environmental weed invasion.</li> </ul>	Depleted and modified. Good representation in Warby Range SP and Mt Meg FR.
Rocky Outcrop Mosaic	<ul style="list-style-type: none"> <li>• Outcropping of flat sheets of granite.</li> <li>• Coarse, sandy soils in pockets between rock slabs.</li> <li>• Low fertility and moisture.</li> </ul>	<ul style="list-style-type: none"> <li>• Vegetation clearance.</li> <li>• Fragmentation of vegetation.</li> <li>• Grazing.</li> <li>• Construction of utility towers.</li> </ul>	Depleted and modified. Moderate representation in Warby Range SP and Mt Meg FR.
Sedge-rich Woodland	<ul style="list-style-type: none"> <li>• Seasonally inundated depressions.</li> <li>• Tertiary sands and sandstones, soils are clay-loams with ironstone gravel at surface.</li> <li>• Low fertility and variable moisture holding capacity.</li> </ul>	<ul style="list-style-type: none"> <li>• Vegetation clearance.</li> <li>• Fragmentation of vegetation.</li> <li>• Harvesting wood products.</li> <li>• Mining and quarrying.</li> </ul>	Depleted and modified. Naturally uncommon in the study area. Moderate representation in Deep Lead FFR.
Low Rises Grassy Woodland	<ul style="list-style-type: none"> <li>• Plains and gently undulating terrain.</li> <li>• Alluvial soils and soils derived from Ordovician sediments.</li> <li>• Moderate fertility and moisture.</li> </ul>	<ul style="list-style-type: none"> <li>• Vegetation clearance.</li> <li>• Fragmentation of vegetation.</li> <li>• Harvesting wood products.</li> <li>• Grazing.</li> <li>• Environmental weed invasion.</li> </ul>	Extremely depleted and modified. Good representation in Kamarooka SP. Patchy representation in Wychitella FFR, Runnymede FR.
Creepline Grassy Woodland	<ul style="list-style-type: none"> <li>• Shallow or ephemeral creeks.</li> <li>• Alluvial soils.</li> <li>• Moderate to high fertility and moisture.</li> </ul>	<ul style="list-style-type: none"> <li>• Vegetation clearance.</li> <li>• Fragmentation of vegetation.</li> <li>• Harvesting wood products.</li> <li>• Mining and quarrying.</li> <li>• Grazing.</li> <li>• Environ. weed invasion.</li> </ul>	Extremely depleted and modified. Given final recommendations for listing on Schedule 2 of the <i>Flora and Fauna Guarantee Act 1988</i> . Not represented in a conservation reserve. Only high quality site is on Commonwealth land (Puckapunyal Military Area).
Valley Grassy Forest	<ul style="list-style-type: none"> <li>• Along creek flats and gully heads in dissected hills.</li> <li>• Alluvial soils and soils derived from Ordovician and Cambrian sediments.</li> <li>• Moderate fertility and moisture.</li> </ul>	<ul style="list-style-type: none"> <li>• Vegetation clearance.</li> <li>• Fragmentation of vegetation.</li> <li>• Harvesting wood products.</li> <li>• Grazing.</li> <li>• Environmental weed invasion.</li> </ul>	Extremely depleted and modified. Patchy representation in Kara Kara SP and Warby Range SP.
Hillcrest Herb-rich Woodland	<ul style="list-style-type: none"> <li>• Broad ridgetops and upper slopes.</li> <li>• Soils from Ordovician and Cambrian sediments.</li> <li>• Moderate fertility and moisture.</li> </ul>	<ul style="list-style-type: none"> <li>• Vegetation clearance.</li> <li>• Fragmentation of vegetation.</li> <li>• Harvesting wood products.</li> <li>• Grazing.</li> <li>• Environmental weed invasion.</li> </ul>	Depleted and modified. Patchy representation in Mt Bolangum FFR, Wychitella FFR and Sandhurst RA.

Table 16: Conservation status of Vegetation Communities in the inland hills (continued)

Ecological Vegetation Class	Landform and soil characteristics	Threats (historical or current origin)	Condition of vegetation communities and reservation status
<b>Granitic Hills Herb-rich Woodland</b>	<ul style="list-style-type: none"> <li>• Crests and slopes of steep hills with granite or granodiorite outcropping.</li> <li>• Low to moderate fertility and moisture.</li> </ul>	<ul style="list-style-type: none"> <li>• Vegetation clearance.</li> <li>• Fragmentation of vegetation.</li> <li>• Harvesting wood products.</li> <li>• Grazing.</li> <li>• Environmental weed invasion.</li> </ul>	Depleted and modified. Good representation in Kooyoora SP. Patchy representation in Mt Ida FR, Mt Black FR, and Wehla FR.
<b>Alluvial Terraces Herb-rich Woodland</b>	<ul style="list-style-type: none"> <li>• Lower slopes, creeksides and outwash plains.</li> <li>• Sodic soils derived from Ordovician sediments or Tertiary alluvium.</li> <li>• Moderate fertility and moisture.</li> </ul>	<ul style="list-style-type: none"> <li>• Vegetation clearance.</li> <li>• Fragmentation of vegetation.</li> <li>• Harvesting wood products.</li> <li>• Grazing.</li> <li>• Environmental weed invasion.</li> </ul>	Extremely depleted and modified. Limited occurrences in Kara Kara SP, Bolangum FFR, Dalyenong FR, Landsborough FFR. These sites are small patches adjacent to cleared agricultural land.
<b>Gravelly-sediment Mallee</b>	<ul style="list-style-type: none"> <li>• Gentle rises.</li> <li>• Shallow, stony soils from Ordovician sediments.</li> <li>• Low fertility and moisture.</li> </ul>	<ul style="list-style-type: none"> <li>• Vegetation clearance.</li> <li>• Fragmentation of vegetation.</li> <li>• Harvesting eucalyptus oil and mulch.</li> <li>• Mining and quarrying.</li> </ul>	Depleted and extremely modified in some areas. Moderate rep. in Kamarooka SP, Wychitella FFR, Inglewood FR, Tarnagulla FR, Gobarup FR. One sub-community is esp. vulnerable to eucalyptus oil harvesting.
<b>Sandstone-rise Broombush (Northern Goldfields)</b>	<ul style="list-style-type: none"> <li>• Tops of gentle rises.</li> <li>• Soils from Ordovician sediments, form compacted surfaces, hard-pans and laterised rock.</li> <li>• Low fertility and moisture.</li> </ul>	<ul style="list-style-type: none"> <li>• Vegetation clearance.</li> <li>• Fragmentation of vegetation.</li> <li>• Mining and quarrying.</li> </ul>	Depleted and modified. Moderate representation in Kamarooka SP, Wychitella FFR, Inglewood FR.

Key: rep. = representation, RA = reference area, NP = national park, SP = State park, RP = regional park, FR = flora reserve, FFR = flora and fauna reserve.

particular threats have impacted on particular communities. For example, it indicates that Creepline Grassy Woodland has been intensively cleared and/or grazed. This reflects the high fertility and moisture availability of the alluvial soils of this community which make it highly favoured for agriculture. Current and historical threats, condition of vegetation and its representation in conservation reserves is sourced from Muir *et al.* (1995).

Degradation of habitat has led to the extinction in Victoria of two vascular plants that originally occurred in the inland hills. A further 76 taxa are regarded as rare or threatened in the State (Table 18). Sixty rare or threatened taxa are found in the grassy woodlands of the northern plains (Table 20). Table 18 indicates the degree of rarity or threat experienced by plant species in the inland hills. The reservation status provides some perspective on the security

of a species, i.e. a species that occurs in a national or State park, where nature conservation is a primary land use, is less vulnerable to management activities that may threaten its survival than one which occurs on public land utilised for a non-conservation purpose. However the size of the population of a particular species or its viability in the particular location(s) where it occurs cannot be derived from the information above. More detailed locality information is available in Muir *et al.* (1995) and Berwick (1996). Locations with high botanical value have been identified by NRE Flora Section and are currently being documented. These sites are based on a range of criteria including protection of all rare or threatened species in the study area.

Table 19 illustrates the representation of Victorian Rare or Threatened plants (VROT) in the inland hills vegetation communities. Four communities stand out as supporting

**Table 17: Conservation status of northern plains grassy woodlands (collectively)**

Vegetation Class	Landform and soil characteristics	Threats (historical or current origin)	Condition of vegetation communities and reservation status
northern plains grassy woodlands	<ul style="list-style-type: none"> <li>• Higher level riverine plain not subject to inundation.</li> <li>• Loam soils.</li> <li>• Moderate fertility and moisture.</li> </ul>	<ul style="list-style-type: none"> <li>• Vegetation clearance.</li> <li>• Fragmentation of vegetation.</li> <li>• Harvesting wood products.</li> <li>• Grazing.</li> <li>• Environmental weed invasion.</li> </ul>	Extremely depleted and modified. Moderate representation of one atypical EVC in Terrick Terrick State Park. 'Grey Box-Buloke Grassy Woodland Community' is one of several buloke grassy woodland communities that have been identified recently and have received preliminary recommendation for listing on Schedule 2 of the <i>Flora and Fauna Guarantee Act 1988</i> . This community is a major component of Box-Ironbark vegetation on the northern plains.

relatively large numbers of VROTs: Box-Ironbark Forest (Northern Goldfields), Alluvial Terraces Herb-rich Woodland, Low Rises Grassy Woodland and Gravelly Sediment-Mallee. This reflects either the particularly intense impact of threatening processes on these communities (whether through depletion or modification), or the clustering of naturally rare species in some communities. Detailed information is not available on the abundance of many VROTS for the northern plains. It is likely that all these communities support a large number of VROTS given the level of depletion and disturbance on the northern plains. Clearing vegetation has also resulted in increased soil erosion and forest litter loss in many areas. This has removed habitat for plants and for micro-organisms involved in recycling of nutrients in the system. Accelerated soil erosion has caused stream sedimentation, affecting aquatic plants. Clearing vegetation in recharge areas has resulted in salinity problems in lower-lying areas, causing the death of vegetation.

Most vegetation clearance has occurred on private land. Some vegetation communities have been cleared more extensively than others. For example, the grassy and herb-rich communities Low Rises Grassy Woodland, Creekline Grassy Woodland, Alluvial Terraces Herb-rich Woodland and Valley Grassy Forest, have been selectively cleared for agriculture, and only four per cent of the original extent of the grassy woodlands of the northern plains is estimated to remain (Foreman 1996). This reflects the relatively high fertility and moisture holding capacity of their soils when compared with communities such as Box-Ironbark Forest or Heathy Dry Forest. Fertile

forests and woodlands often have the greatest number of species so a large suite of plants is affected by vegetation clearance. Vegetation reserved on public land is usually associated with poorer soils and consequently protects a selected and possibly less diverse range of plant communities and species.

### Fragmentation of forests and woodlands

Fragmentation refers to the patchwork pattern of vegetation clearance that has resulted in patches of forest and woodland, and the plants within them, being isolated from each other. The remnant patches are exposed to edge effects such as weed invasion from surrounding cleared land or increased pressure from rabbit grazing. Where a plant species becomes locally extinct in a particular remnant due to drought, fire or disease, it may be impossible for that species to recolonise from other remnants because the distance is too great for seed dispersal or other reproductive processes to be effective.

Vegetated linkages between remnant patches can provide a corridor for recolonisation of plant species but the narrowness of many linkages make them susceptible to extreme weather effects, weed invasion and tree dieback. Dieback is possibly influenced by the use of fertilisers on surrounding agricultural land (see 'Fertilisers' below) as well as the presence of noisy miners which prefer these edge habitats and drive out other bird species. The aggressive habits of the miners prevent other birds preying on and controlling leaf-eating insects responsible for dieback.

Table 18: Rare or threatened vascular plants of the inland hills

Scientific name	Common name	Status				
		ESP Act <sup>1</sup>	Aust. <sup>2</sup>	FFG Act <sup>3</sup>	Vict. <sup>4</sup>	Res <sup>5</sup>
<i>Acacia ausfeldii</i>	Ausfeld's wattle	-	R	-	v	1,2,Pb,Pv
<i>Acacia deanei</i> ssp. <i>deanei</i>	Deane's wattle	-	-	n	e	2
<i>Acacia decora</i>	western silver wattle	-	-	-	v	1
<i>Acacia lineata</i>	streaked wattle	-	-	-	r	2,Pb
<i>Acacia osswaldii</i>	umbrella wattle	-	-	-	d	1
<i>Acacia triptera</i>	spur-wing wattle	-	-	-	r	1,2
<i>Acacia williamsonii</i>	Williamson's wattle	-	R	-	r	1,2,Pb,Pv
<i>Allocasuarina luehmannii</i>	buloke	-	-	l	d	1,2,Pb,Pv
<i>Amyema linophyllum</i> ssp. <i>orientale</i>	buloke mistletoe	-	-	-	v	2,Pv
<i>Brachyscome chrysoglossa</i>	yellow-tongue daisy	-	-	-	v	1
<i>Brachyscome debilis</i>	weak daisy	-	-	-	v	1,Pb
<i>Brachyscome gracilis</i> ssp. <i>gracilis</i>	Dookie daisy	-	-	n	v	1,2,Pb,Pv
<i>Bulbine glauca</i>	bluish bulbine-lily	-	-	-	r	1
<i>Caladenia audasii</i> <sup>6</sup>	Audas' spider-orchid	L	E	l	e	2,Pb,Pv
<i>Caladenia concolor</i>	maroon spider-orchid	-	V	l	v	2,Pb
<i>Caladenia fulva</i>	spider-orchid	L	E	l	e	2,Pb
<i>Caladenia magnifica</i> <sup>6</sup>	spider-orchid	-	K	l	k	2
<i>Caladenia reticulata</i>	veined caladenia	-	-	-	v	2,Pb
<i>Caladenia</i> sp. aff. <i>patersonii</i> <sup>7</sup>	spider-orchid	-	-	-	-	Pb
<i>Caladenia versicolor</i>	Grampians spider-orchid	L	V	-	v	Pb
<i>Caladenia xanthochila</i>	spider-orchid	-	E	l	e	Pb
<i>Callitris glaucophylla</i>	white cypress-pine	-	-	-	d	1,2,Pb,Pv
<i>Calochilus richiae</i> <sup>6</sup>	bald-tip beard-orchid	L	E	l	e	Pb
<i>Comesperma polygaloides</i>	small milkwort	-	-	l	v	1
<i>Cryptandra amara</i> var. <i>longiflora</i>	bitter cryptandra	-	-	-	r	Pb
<i>Dampiera dysantha</i>	shrubby dampiera	-	-	-	r	1,2,Pb
<i>Daviesia genistifolia</i>	broom bitter-pea	-	-	-	r	2,Pb
<i>Desmodium varians</i>	slender tick-trefoil	-	-	-	r	2,Pv
<i>Dipodium hamiltonianum</i>	yellow hyacinth orchid	-	-	l	e	2,Pv
<i>Diuris palustris</i>	swamp diuris	-	-	n	v	Pb
<i>Diuris punctata</i>	purple diuris	-	-	l	v	2,Pb,Pv
<i>Dodonaea boroniifolia</i>	hairy hop-bush	-	-	-	r	2
<i>Eremophila deserti</i>	turkey-bush	-	-	-	d	1
<i>Eriostemon difformis</i> ssp. <i>difformis</i>	small-leaf wax-flower	-	-	-	r	1,2,Pb
<i>Eucalyptus froggattii</i>	Kamarooka mallee	-	R	l	r	1,2,Pb,Pv
<i>Eutaxia diffusa</i>	spreading eutaxia	-	-	-	r	1,2,Pb
<i>Glycine latrobeana</i>	clover glycine	L	V	l	v	2,Pb,Pv
<i>Goodenia macbarronii</i>	narrow goodenia	L	V	l	v	2,Pb,Pv
<i>Goodia medicaginea</i>	western golden-tip	-	-	-	r	Pb
<i>Hibbertia humifusa</i> ssp. <i>erigens</i>	Euroa guinea-flower	-	-	l	v	Pb
<i>Hibbertia humifusa</i> ssp. <i>humifusa</i>	rising star guinea-flower	-	R	-	r	2,Pb,Pv
<i>Indigofera adesmiifolia</i>	tick indigo	-	-	-	v	2
<i>Isolepis congrua</i>	slender club-sedge	-	-	n	v	1,2
<i>Lepidium pseudopapillosum</i>	erect pepper-cress	L	V	l	e	1
<i>Leptorhynchos elongatus</i>	lanky buttons	-	-	-	r	2,Pb
<i>Maireana humillima</i>	dwarf bluebush	-	-	-	r	1
<i>Maireana rohrlachii</i>	Rohrlach's bluebush	-	-	-	r	1,2
<i>Myoporum montanum</i>	waterbush	-	-	-	r	Pb
<i>Olearia pannosa</i> ssp. <i>cardiophylla</i>	velvet daisy-bush	-	R	l	v	2,Pb,Pv
<i>Phebalium obcordatum</i>	dainty phebalium	-	R	n	v	1,2,Pb
<i>Phebalium obcordatum</i>	dainty phebalium	-	R	n	v	1,2,Pb
<i>Pomaderris paniculosa</i> ssp. <i>paniculosa</i>	inland pomaderris	-	-	-	d	1,2

Table 18: Rare or threatened vascular plants of the inland hills (continued)

Scientific name	Common name	Status				
		ESP Act <sup>1</sup>	Aust. <sup>2</sup>	FFG Act <sup>3</sup>	Vict. <sup>4</sup>	Res <sup>5</sup>
<i>Prasophyllum campestre</i>	plains leek-orchid	-	R	-	e	2
<i>Prasophyllum fitzgeraldii</i>	Fitzgerald's leek-orchid	-	-	n	e	2,Pb
<i>Prasophyllum frenchii</i>	slaty leek-orchid	L	V	n	e	Pb
<i>Prasophyllum lindleyanum</i>	green leek-orchid	-	-	-	v	1,2
<i>Prasophyllum subbisectum</i>	Pomonal leek-orchid	L	E	l	e	2,Pb
<i>Prasophyllum</i> sp. aff. <i>validum</i> <sup>7</sup>	leek-orchid	-	-	-	-	2,Pb
<i>Prostanthera decussata</i>	dense mint-bush	-	-	-	r	1
<i>Pterostylis aciculiformis</i>	needle greenhood	-	-	-	r	1,Pb,Pv
<i>Pterostylis boormanii</i>	Boorman's greenhood	-	-	-	r	1,2,Pb
<i>Pterostylis despectans</i>	lowly greenhood	L	E	l	e	Pv
<i>Pterostylis hamata</i>	scaly greenhood	-	-	-	r	1,2
<i>Pterostylis setifera</i>	bristly greenhood	-	-	-	r	1,2,Pb
<i>Pterostylis woolsii</i>	long-tail greenhood	-	R	l	e	Pb
<i>Pultenaea graveolens</i>	scented bush-pea	-	-	l	v	2,Pb
<i>Quinetia urvillei</i>	quinetia	-	-	-	r	2
<i>Santalum acuminatum</i>	sweet quandong	-	-	-	d	1,2,Pb
<i>Santalum lanceolatum</i>	northern sandalwood	-	-	l	e	1
<i>Senecio macrocarpus</i>	large-fruit groundsel	L	V	l	e	2
<i>Stipa breviglumis</i>	cane spear-grass	-	R	-	r	1,2,Pb,Pv
<i>Stipa hemipogon</i>	half-bearded spear-grass	-	-	-	r	2,Pb
<i>Stipa setacea</i>	corkscrew spear-grass	-	-	-	r	2,Pb
<i>Swainsona recta</i>	mountain swainson-pea	L	E	l	e	Pb
<i>Templetonia stenophylla</i>	leafy templetonia	-	-	l	d	1,2,Pb
<i>Westringia crassifolia</i>	Whipstick westringia	L	E	l	e	Pb
<i>Zieria aspalathoides</i>	whorled zieria	-	-	n	v	1,Pb

**Legend:**

- 1 L = Listed as threatened under the Commonwealth *Endangered Species Protection Act 1992*
- 2 E = Endangered; V = Vulnerable; R = Rare; K = Poorly known - in Australia (Briggs and Leigh 1996)
- 3 l = listed as threatened under the Victorian *Flora and Fauna Guarantee Act 1988*; n = nominated but not currently listed
- 4 e = endangered; v = vulnerable; d = depleted; r = rare; k = poorly known - in Victoria (CNR 1994 and updates)
- 5 Reservation status: 1 = protected in class one reserve (national park, State park, reference area), 2 = protected in class two reserve (regional park, flora and fauna reserve), Pb = occurs on other public land, Pv = occurs on private land.
- 6 Endemic to the Box-Ironbark study area.
- 7 The taxonomic status of this taxon is uncertain but it is almost certainly a VROT.

All vegetation communities have been affected by fragmentation but those most extensively cleared are now very small remnants often extremely isolated from each other. For example Creekline Grassy Woodland would have originally occurred continuously along shallow or ephemeral drainage lines in the study area. Today this EVC is represented by tiny fragments widely scattered across the landscape because its soils have been highly favoured for agriculture.

**Mining and quarrying**

Gold mining and accompanying activities — timber harvesting, and stone extraction — have been closely associated with the study area since the middle of the 19th century (see Chapter 3 for further details). Current and potential mining activities are summarised in Chapter 17.

Gold mining has had a profound effect on the vegetation of the inland hills in particular. As a result of historical mining and associated activities, the forests today comprise relatively young trees and it is likely that some plant species have been lost as a result of the high levels of soil disturbance. Typical modern open-cut and alluvial mining operations involve the removal of all vegetation in the affected area and may cause significant changes to drainage patterns.

Substantive rehabilitation of mining sites in box-ironbark forests and woodlands has begun only in the last few years and at very few sites. Consequently, the extent to which rehabilitation can lead to the re-establishment of the biodiversity existing prior to mining remains to be demonstrated, and there are many potential problems.

Table 19: Occurrence of VROTS in vegetation communities of the inland hills

Scientific name	Common name	Communities in which species occurs
<i>Acacia ausfeldii</i>	Ausfeld's wattle	BIF-NG, BIF-NEH, GSM, HW-NG, CGW, LRGW, HDF-NG, ATHW
<i>Acacia deanei</i> ssp. <i>deanei</i>	Deane's wattle	LRGW, ATHW
<i>Acacia decora</i>	western silver wattle	transition from granitic hills to plains
<i>Acacia lineata</i>	streaked wattle	SRB, BIF-NG
<i>Acacia osswaldii</i>	umbrella wattle	LRGW
<i>Acacia triptera</i>	spur-wing wattle	ROM
<i>Acacia williamsonii</i>	Williamson's wattle	BIF-NG, GSM, SRB, LRGW,
<i>Allocasuarina luehmannii</i>	buloke	ATHW, LRGW, HW-WG
<i>Amyema linophyllum</i> ssp. <i>orientale</i>	buloke mistletoe	ATHW, LRGW
<i>Brachyscome chrysoglossa</i>	yellow-tongue daisy	LRGW
<i>Brachyscome debilis</i>	weak daisy	ATHW
<i>Brachyscome gracilis</i> ssp. <i>gracilis</i>	Dookie daisy	BIF-NG/LRGW, HDF-NEH, HDF-NG, GHW, LRGW, ATHW/VGF, GSM
<i>Bulbine glauca</i>	bluish bulbine-lily	ROM
<i>Caladenia audasii</i>	Audas' spider-orchid	GDF-NG, BIF-NG, BIF-WG
<i>Caladenia concolor</i>	maroon spider-orchid	HW-WG, HW-NG, HDF-NE, VGF
<i>Caladenia fulva</i>	spider-orchid	BIF-WG, BIF-WG/ATHW
<i>Caladenia magnifica</i>	spider-orchid	HW-WG,
<i>Caladenia reticulata</i>	veined caladenia	SRW, HW-WG
<i>Caladenia</i> sp. aff. <i>patersonii</i>	spider-orchid	GDF-NG
<i>Caladenia versicolor</i>	Grampians spider-orchid	yellow box woodland, herb- and sedge- rich
<i>Caladenia xanthochila</i>	spider-orchid	HW-WG/ATHW
<i>Callitris glaucophylla</i>	white cypress-pine	ROM, GHW
<i>Calochilus richiae</i> <sup>6</sup>	bald-tip beard-orchid	HDF-NG/BIF-NG
<i>Comesperma polygaloides</i>	small milkwort	SRW
<i>Cryptandra amara</i> var. <i>longiflora</i>	bitter cryptandra	ATHW, VGF
<i>Dampiera dysantha</i>	shrubby dampiera	SRB, GSM, BIF-NG, HW-NG
<i>Daviesia genistifolia</i>	broom bitter-pea	BIF-NG, BIF-NEH
<i>Desmodium varians</i>	slender tick-trefoil	VGF, ATHW
<i>Dipodium hamiltonianum</i>	yellow hyacinth orchid	HDF-NEH
<i>Diuris palustris</i>	swamp diuris	SRW
<i>Diuris punctata</i>	purple diuris	grassy woodland
<i>Dodonaea boroniifolia</i>	hairy hop-bush	GHHW, GHW
<i>Eremophila deserti</i>	turkey-bush	LRGW
<i>Eriostemon difformis</i> ssp. <i>difformis</i>	small-leaf wax-flower	GSM
<i>Eucalyptus froggattii</i>	Kamarooka mallee	GSM, LRGW,
<i>Eutaxia diffusa</i>	spreading eutaxia	BIF-NG, BIF-WG, LRGW
<i>Glycine latrobeana</i>	clover glycine	ATHW
<i>Goodenia macbarronii</i>	narrow goodenia	spring soak herbland
<i>Goodia medicaginea</i>	western golden-tip	GHW
<i>Hibbertia humifusa</i> ssp. <i>erigens</i>	Euroa guinea-flower	heathy/herb-rich woodland
<i>Hibbertia humifusa</i> ssp. <i>humifusa</i>	rising star guinea-flower	HDF-NG, BIF-NG, HW-NG/HDF-NG, HW-WG, ATHW, GSM, SRW
<i>Indigofera adesmiifolia</i>	tick indigo	grassy dry forest
<i>Isolepis congrua</i>	slender club-sedge	SRW
<i>Lepidium pseudopapillosum</i>	erect pepper-cress	LRGW
<i>Leptorhynchus elongatus</i>	lanky buttons	GDF-NG
<i>Maireana humillima</i>	dwarf bluebush	LRGW
<i>Maireana rohrlachii</i>	Rohrlach's bluebush	LRGW
<i>Myoporum montanum</i>	waterbush	LRGW
<i>Olearia pannosa</i> ssp. <i>cardiophylla</i>	velvet daisy-bush	BIF-NG, GSM
<i>Phebalium obcordatum</i>	dainty phebalium	BIF-NG, HW-NG/GSM, SRB, GSM, HW-NG
<i>Pomaderris paniculosa</i> ssp. <i>paniculosa</i>	inland pomaderris	GSM

Scientific name	Common name	Communities in which species occurs
<i>Prasophyllum campestre</i>	plains leek-orchid	wetland complex / grassy grey box woodland
<i>Prasophyllum fitzgeraldii</i>	Fitzgerald's leek-orchid	HW-WG,
<i>Prasophyllum frenchii</i>	slaty leek-orchid	no habitat information available
<i>Prasophyllum lindleyanum</i>	green leek-orchid	HW-WG
<i>Prasophyllum subbisectum</i>	Pomonal leek-orchid	HW-WG, BIF-WG
<i>Prasophyllum</i> sp. aff. <i>validum</i>	leek-orchid	BIF-WG
<i>Prostanthera decussata</i>	dense mint-bush	GHW
<i>Pterostylis aciculiformis</i>	needle greenhood	GSM/BIF-NG, GSM
<i>Pterostylis boormanii</i>	Boorman's greenhood	GSM
<i>Pterostylis despectans</i>	lowly greenhood	BIF-WG
<i>Pterostylis hamata</i>	scaly greenhood	GHW
<i>Pterostylis setifera</i>	bristly greenhood	GSM, BIF-NG,
<i>Pterostylis woolsii</i>	long-tail greenhood	BIF-NG/GSM, GSM
<i>Pultenaea graveolens</i>	scented bush-pea	BIF-NG, BIF-WG, HDF-NG
<i>Quinetia urvillei</i>	quinetia	grassy grey box woodland
<i>Santalum acuminatum</i>	sweet quandong	HW-NG
<i>Santalum lanceolatum</i>	northern sandalwood	LRGW
<i>Senecio macrocarpus</i>	large-fruit groundsel	SRW
<i>Stipa breviglumis</i>	cane spear-grass	GSM, LRGW, BIF-NG
<i>Stipa hemipogon</i>	half-bearded spear-grass	ATHW, LRGW
<i>Stipa setacea</i>	corkscrew spear-grass	LRGW, ATHW
<i>Swainsona recta</i>	mountain Swainson-pea	transition from granitic hills to plains
<i>Templetonia stenophylla</i>	leafy templetonia	SRW, LRGW, BIF-WG, BIF-NEH
<i>Westringia crassifolia</i>	Whipstick westringia	GSM, LRGW, BIF-NG, SRB
<i>Zieria aspalathoides</i>	whorled zieria	GHW, GHHW

Some VROT's cannot be readily ascribed to vegetation communities because their habitat has been highly modified or insufficiently described. In these cases a general written description has been provided.

#### Key to vegetation community abbreviations:

Vegetation community	Abbreviation	Number of VROT's ascribed to each community
Box-Ironbark Forest (Northern Goldfields)	BIF-NG	18
Box-Ironbark Forest (Western Goldfields)	BIF-WG	8
Box-Ironbark Forest (North-eastern Hills)	BIF-NEH	3
Heathy Dry Forest (Northern Goldfields)	HDF-NG	5
Heathy Dry Forest (North-eastern Hills)	HDF-NEH	1
Heathy Dry Forest (Northern Foothills)	HDF-NF	1
Grassy Dry Forest (Northern Goldfields)	GDF-NG	3
Grassy Dry Forest (Northern Foothills)	GDF-NF	0
Heathy Woodland (Northern Goldfields)	HW-NG	6
Heathy Woodland (Western Goldfields)	HW-WG	9
Metamorphic Slopes Shrubby Woodland	MSSW	0
Granitic Hills Woodland	GHW	7
Rocky Outcrop Mosaic	ROM	3
Sedge-rich Woodland	SRW	7
Low Rises Grassy Woodland	LRGW	21
Creekline Grassy Woodland	CGW	1
Valley Grassy Forest	VGW	4
Hillcrest Herb-rich Woodland	HCHW	0
Granitic-Hills Herb-rich Woodland	GHHW	2
Alluvial Terraces Herb-rich Woodland	ATHW	14
Gravelly-sediment Mallee	GSM	16
Sandstone-rise Broombush (Nth Goldfields)	SRB	5

Table 20: Rare or threatened vascular plants of the northern plains

Scientific name	Common name	Status				
		ESP Act <sup>1</sup>	Aust. <sup>2</sup>	FFG Act <sup>3</sup>	Vict. <sup>4</sup>	Res <sup>5</sup>
<i>Acacia ausfeldii</i>	Ausfeld's wattle	-	R	-	v	
<i>Acacia lineata</i>	streaked wattle	-	-	-	r	
<i>Acacia melvillei</i>	myall	-	-	-	v	
<i>Acacia notabilis</i>	mallee golden wattle	-	-	-	v	
<i>Acacia oswaldii</i>	umbrella wattle	-	-	-	d	
<i>Acacia pendula</i>	weeping myall	-	-	l	e	
<i>Acacia trineura</i>	three-nerve wattle	-	-	-	v	
<i>Alectryon oleifolius</i> ssp. <i>canescens</i>	cattle-bush	-	-	-	d	
<i>Allocasuarina luehmannii</i>	buloke	-	-	l	d	
<i>Amyema linophyllum</i>	buloke mistletoe	-	-	-	v	
<i>Aristida jerochensis</i> var. <i>subspinulifera</i>	Jericho Wire-grass	-	-	-	r	
<i>Brachyscome gracilis</i> (Kings Billabong)	Dookie daisy (Kings Billabong)	-	n	v		
<i>Brachyscome muelloroides</i>	Mueller daisy	-	V	l	e	
<i>Brachyscome readeri</i>	Reader's daisy	-	-	-	r	
<i>Callitris glaucophylla</i>	white cypress-pine	-	-	-	d	
<i>Cheilanthes lasiophylla</i>	wooly cloak-fern	-	-	-	r	
<i>Cymbonotus lawsonianus</i>	bear's-ears	-	-	-	r	
<i>Daviesia genistifolia</i>	broom bitter-pea	-	-	-	r	
<i>Digitaria ammobila</i>	silky umbrella-grass	-	-	-	v	
<i>Digitaria coenicola</i>	finger panic grass	-	-	-	v	
<i>Diuris punctata</i>	purple diuris	-	-	l	v	
<i>Eragrostis molybdea</i>	granite love-grass	-	-	-	r	
<i>Eragrostis tenellula</i>	delicate love-grass	-	-	-	r	
<i>Eremophila deserti</i>	turkey-bush	-	-	-	d	
<i>Eremophila maculata</i>	spotted emu-bush	-	-	-	r	
<i>Eremophila oppositifolia</i>	twin-leaf emu-bush	-	-	-	v	
<i>Eremophila sturtii</i>	narrow-leaf emu-bush	-	-	l	e	
<i>Eucalyptus odorata</i>	peppermint box	-	-	-	v	
<i>Eutaxia diffusa</i>	spreading eutaxia	-	-	-	r	
<i>Goodenia macbarronii</i>	narrow goodenia	L	V	l	v	
<i>Hakea leucoptera</i>	silver needlewood	-	-	-	d	
<i>Hakea tephrosperma</i>	hooked needlewood	-	-	-	d	
<i>Ixiolaena tomentosa</i>	wooly plover-daisy	-	-	-	v	
<i>Lepidium monoplocoides</i>	winged pepper-cress	-	E	l	e	
<i>Lepidium phlebopetalum</i>	veined pepper-cress	-	-	-	v	
<i>Maireana excavata</i>	bottle bluebush	-	-	-	v	
<i>Maireana humillima</i>	dwarf bluebush	-	-	-	r	
<i>Maireana rohrlachii</i>	Rohrlach's bluebush	-	-	-	r	
<i>Minuria intergerrima</i>	smooth minuria	-	-	-	r	
<i>Myoporum montanum</i>	waterbush	-	-	-	r	
<i>Poa lowanensis</i>	mallee tussock-grass	-	R	-	r	
<i>Podolepis canescens</i>	grey podolepis	-	-	-	r	
<i>Pomaderris paniculosa</i> ssp. <i>paniculosa</i>	inland pomaderris	-	-	-	d	
<i>Prasophyllum campestre</i>	plains leek-orchid	-	R	-	e	
<i>Ptilotus erubescens</i>	hairy-tails	-	-	l	e	
<i>Rhodanthe stricta</i>	slender sunray	-	-	l	e	
<i>Rytidosperma richardsonii</i>	straw wallaby-grass	-	-	-	v	
<i>Santalum acuminatum</i>	sweet quandong	-	-	-	d	
<i>Santalum lanceolatum</i>	northern sandalwood	-	-	l	e	
<i>Sclerolaena birchii</i>	galvanised burr	-	-	-	r	
<i>Sclerolaena napiformis</i>	turnip bassia	-	V	n	e	
<i>Stipa gibbosa</i>	spurred spear-grass	-	-	-	r	

Table 20: Rare or threatened vascular plants of the northern plains (continued)

Scientific name	Common name	Status				
		ESP Act <sup>1</sup>	Aust. <sup>2</sup>	FFG Act <sup>3</sup>	Vict. <sup>4</sup>	Res <sup>5</sup>
<i>Stipa setacea</i>	corkscrew spear-grass	-	-	-	r	
<i>Swainsona murrayana</i>	Murray Swainson-pea	-	V	l	e	
<i>Swainsona recta</i>	mountain Swainson-pea	L	E	l	e	
<i>Swainsona swainsonioides</i>	downy Swainson-pea	-	-	-	e	
<i>Templetonia stenophylla</i>	leafy templetonia	-	-	l	d	
<i>Tripogon loliformis</i>	rye beetle-grass	-	-	-	r	
<i>Vittadinia condyloides</i>	club-hair New Holland daisy	-	-	-	r	
<i>Vittadinia pterochaeta</i>	winged New Holland daisy	-	-	-	e	

**Legend:**

- 1 L = Listed as threatened under the Commonwealth *Endangered Species Protection Act 1993*
- 2 E = Endangered; V = Vulnerable; R = Rare; K = Poorly known - in Australia (Briggs and Leigh 1996)
- 3 l = listed as threatened under the Victorian *Flora and Fauna Guarantee Act 1988*; n = nominated but not currently listed
- 4 e = endangered; v = vulnerable; d = depleted; r = rare; k = poorly known - in Victoria (CNR 1994 and updates)
- 5 Reservation status: 1 = protected in class one reserve (national park, State park, reference area), 2 = protected in class two reserve (regional park, flora and fauna reserve), Pb = occurs on other public land, Pv = occurs on private land.

For example, soil microorganisms and fungi that assist in nutrient cycling or uptake by plants often diminish in the topsoil when it is stockpiled. These problems compound pre-existing problems of soil loss and disturbance in areas that have been mined in the past.

Gold is mined in many vegetation communities in the study area (see Table 16). The extremely depleted community, Creekline Grassy Woodland, is commonly targeted for mining operations. In Box-Ironbark Forest, the lower slopes dominated by grey box and yellow gum are also more heavily targeted for gold-mining because of the presence of alluvial gold. This places particular pressure on the flora of these more fertile sites and their very fertility puts them at greater risk of weed invasion. Any site in the study area that has been historically affected by mining or other soil disturbance activities is particularly vulnerable to further impacts from current mining.

Stone, gravel and sand for various purposes is extracted from many locations across the study area. The extraction process for gravel involves stripping the understorey vegetation from a site, stockpiling topsoil if it is present, removing two metres or more depth of material, and then replacing topsoil on the exposed hard base. Apart from loss of the original vegetation, this practice modifies the soil and substrate structure and thus can limit the success of rehabilitation. Sand extraction results in similar disturbance to sites.

Most quarrying activities occur on public land. Box-Ironbark Forest (North-east Hills), Heathy Dry Forest (Northern Goldfields) and Heathy Woodland (Western and Northern Goldfields) are the communities most affected by gravel extraction. The latter two communities are also affected by sand extraction.

### Harvesting forest products

The history of forest production is documented in Chapter 3, Chapter 15 details current harvesting for apiculture, and Chapter 16 for other products.



Heathy Woodland EVC.

#### Wood products

Widespread, virtually uncontrolled harvesting of wood products in the past has led to the relatively dense stands of

smaller coppice trees that exist today. The structure of these remaining forests and woodlands is very different from the pre-European forests of larger, ecologically mature, more widely-spaced trees. Almost all the trees are now regenerating from coppicing stumps, which have an unknown lifespan and may suppress the growth of some other plants. Smaller trees shed less bark and branches than old trees, limiting the amount of litter on the ground. This is exacerbated by firewood collection. Logs, branches and bark provide humus and protect seedling plants from grazing animals, as well as reducing soil erosion, which is fairly extensive in the study area as a result of past gold mining. Recruitment of eucalypt seedlings is infrequent in box-ironbark forests and woodlands and appears to be dependent on a range of factors including the presence of large canopy openings, fire events, good rainfall conditions and a good cover of grasses or other low vegetation.

All vegetation communities have been affected by harvesting of wood products. The dense and highly durable timber of the ironbarks, yellow gum and many of the box species has made them popular for a wide range of uses from sleepers and fence posts to firewood. Unregulated harvesting of firewood from remnants on private land is having an adverse effect on grassy woodlands of the northern plains. The mallee and broombush communities have not provided these wood products but mallee has been extensively harvested for other products (see below).

#### Eucalyptus oil and mulch

Severe erosion of topsoil and changes in microclimatic conditions caused by the removal of the mallee eucalypt canopy for eucalyptus oil and mulch are very likely to affect the diversity and abundance of understorey species. Land adjacent to oil harvesting areas can also be affected by sheet erosion. The mallee eucalypts themselves are unable to attain a mature tree structure because of frequent cutting, and the lifespan of the underground stem from which they regenerate is unknown. Harvesting the mallee eucalypts also reduces the nutrient cycling back into the ecosystem.

The vegetation community affected by eucalyptus oil harvesting is Gravelly-sediment Mallee. This community is one of the few mallee scrubs in Australia to have developed on clay and rocky soils rather than on sandy soils, making it quite distinctive. Both sub-communities that fall within this community are subject to oil harvesting, but that which occurs midslope on gentle

rises is the most vulnerable to its effects. Vegetation dominated by blue mallee is most affected because it is a preferred species for oil production.

#### Honey

The impact that the honey bee (feral and otherwise) has on indigenous pollinators such as native bees and honey-eaters, and on pollination mechanisms in native plants, is not well understood. Studies in other states have indicated that seed production in some native plants was reduced when honey bees were frequent visitors to flowers, while for other plants seed production was enhanced.

Tree species favoured by apiarists include grey box, yellow box and summer flowering red ironbark.

#### Grazing

Grazing by introduced herbivores — mostly cattle, sheep and rabbits — has been an important historical disturbance factor in the study area since the 1830s. Although it is being gradually phased out, sheep grazing still continues on some public land under licence or leasehold arrangements. It also has an impact on vegetated remnants on private land. The detrimental effects of stock and rabbit grazing on native vegetation are well recognised. Grazing causes a change in the relative abundance of native plant species due to selective grazing of palatable species. This may lead to the loss of species from certain areas. Where grazing prevents the regeneration of trees there is a permanent loss of the overstorey as established trees mature and die. Shrub regeneration is also suppressed.

Grazing by introduced herbivores also contributes to the invasion of environmental weeds, which are spread in droppings and carried in wool and hoofs. The establishment of weeds is favoured by the increase in soil fertility and reduction in cover of native species caused by domestic stock. The hard hoofs of domestic stock also lead to soil compaction, which impedes the growth of indigenous plants.

Outside the cleared country, grazing by introduced herbivores has had greatest impact on the most fertile vegetation communities, grassy woodlands of the northern plains, Low Rises Grassy Woodland, Creekline Grassy Woodland, Valley Grassy Forest, Hillcrest Herb-rich Woodland and Alluvial Terraces Herb-rich Woodland. Vegetation in granitic communities has been particularly

affected by rabbits, which can readily establish burrows in the coarse soils. Box-Ironbark Forest, Heathy Dry Forest, Grassy Dry Forest and Heathy Woodland communities have also been grazed.

Grazing pressure from eastern grey kangaroos and black wallabies appears to have increased in some areas due to an increase in the number of fire dams and water troughs. However the specific effects of this grazing on the vegetation are unknown.

### Environmental weeds

Weeds that have invaded native vegetation are known as environmental weeds, as opposed to agricultural and noxious weeds. They include pasture grasses, pasture weeds and other introduced species, as well as native plants that do not occur naturally in box-ironbark forests and woodlands. Environmental weeds pose one of the most serious threats to flora conservation, and are one of the largest and most difficult management problems in the study area.

The worst weed invasions occur in fertile areas, in areas where soil has been highly disturbed and in forests which have a large boundary with agricultural pasture land. Soil fertility can be increased by the manure from livestock and the spread of fertilisers (see below). Soil and vegetation disturbances that favour weeds include grazing, mining, rabbit activity, fire protection works, road construction, timber harvesting, firewood collection and some recreational activities. Severe weed invasions are often closely correlated with areas that have had a long history of sheep grazing (see above under 'Grazing'). Vehicles can gain easy off-track access to many areas of gentle terrain and open forest/woodland in the study area, contributing to the introduction of weeds and creating suitably disturbed environments for their establishment. Because of the fragmented nature of the forests and woodlands in the study area, many of the remnants are close to rural pastures which are the source of most weed invasions.

All vegetation communities are affected by weed invasion but those on the most fertile soils are more vulnerable, for example grassy woodlands of the northern plains, Low Rises Grassy Woodland, Creekline Grassy Woodland, Alluvial Terraces Herb-rich Woodland, Valley Grassy Forest (see Table 17 for further details). Granitic communities are also quite susceptible to weed invasion with St John's wort having a severe effect in the Warby

Ranges and Beechworth areas, and just beginning to invade similar areas such as Mt Kooyoora. Drainage lines in many parts of the study area have been severely affected by Toowoomba canary-grass because the seed washes down from sown pasture on surrounding slopes. See Chapter 20 for tables of the most widespread and invasive weeds and additional information.



*Granitic Hills Herb-rich Woodland EVC with hill red gum, Kooyoora State Park.*

### Disease

Cinnamon fungus has had a serious effect in some areas. In the Warby Ranges of north-eastern Victoria its effects have been widespread, eliminating austral grass-trees and daphne heath in many areas, and possibly affecting the health of red stringybarks. This fungus has also been detected in the Bailieston area where daphne heath has been affected. At Mt Black Flora Reserve adjacent to Rushworth State Forest, the fungus has had a minor effect to date, causing the decline of austral grass-trees and daphne heath in some areas. Although the origin of the fungal attack in

each area is not known, it is probable that road and fire-break machinery, vehicles (cars and trail bikes), and human and animal traffic have assisted its spread or manifestation through these areas, as has been documented in studies of other areas where cinnamon fungus outbreaks have occurred.

## Fertilisers

The use of fertilisers and the presence of livestock manure has increased the amount of soil nutrients and possibly modified the soil chemistry in many areas, including areas beyond the sites of direct application through dispersal of nutrients by wind and runoff water. Higher nutrient levels provide ideal conditions for environmental weeds to invade, but it is not known how native plants, soil animals and microorganisms are directly affected by such change. There are some indications that the high nutrient levels associated with the presence of livestock may be a key factor contributing to the abundance, size and rapid growth of defoliating insects, and hence to their impact on eucalypts. This manifests as dieback, which can sometimes result in tree death. Some indigenous plants are susceptible to direct poisoning by high nutrient concentrations.

## Fire

In Australia, fire is almost universally one of the most important determinants of natural vegetation ecology, and there is no reason to believe that box-ironbark is an exception to the rule. Consequently, ecological fire management — managing fire to conserve biodiversity — is an important component of the overall management for biodiversity conservation. However, as discussed in Chapter 5, very little is known about appropriate fire regimes for broadscale application. None the less, research is likely to be able to provide information that will be useful in specific contexts — the appropriate regime for a particular rare species, or a particular site, for instance.

## Potentially threatening processes operating on flora in the study area

The following items have been listed on Schedule 2 of the *Flora and Fauna Guarantee Act 1988* as potentially threatening processes:

- Degradation of native riparian vegetation along Victorian rivers and streams.

- Increase in sediment input into Victorian rivers and streams due to human activities.
- Loss of hollow-bearing trees in Victorian native forests.
- The invasion of native vegetation by 'environmental weeds'.

## LOCATIONS WITH HIGH BOTANICAL VALUE

### Inland hills

A number of locations with high botanical value were identified during EVC and threatened flora survey work in the inland hills. Some examples on public land are Deep Lead Flora and Fauna Reserve, Kooyoorra State Park, One Tree Hill Regional Park, Runnymede Flora Reserve, Puckapunyal Military Area, VCAH Dookie Timber Reserve and Chiltern Box-Ironbark National Park. In assessing the value of sites, criteria such as the importance of an area for rare or threatened flora or vegetation types, the richness or diversity of indigenous flora, the viability of the site in terms of intactness and size, or a site's importance in demonstrating a range of vegetation types, are taken into account.

### Old-growth forest

The presence of old-growth forest in the study area is particularly noteworthy because almost the entire area has been cut over or highly modified since European occupation. Old-growth forest in the inland hills is currently being assessed as part of the Commonwealth/State Regional Forest Agreement process. In the initial assessment, only one small patch of Heathy Woodland (Western Goldfields) in Dalyenong Flora and Fauna Reserve met the criteria of old-growth forest, which is defined as having significant amounts of senescing trees and negligible effects of disturbance. However, assessments are ongoing and, in addition, other patches of old trees that fall outside this definition have been identified and described by Soderquist and Rowley (1996).

No systematic old-growth or similar survey has been conducted for the northern plains, but information collected by the ECC indicates that patches of remnant vegetation on the northern plains generally contain a higher proportion of older trees than remnant vegetation in the inland hills. Water frontages along the Broken, Boosey and

Nine Mile creeks in particular, support relatively large areas of grassy woodlands where large, old grey box trees are comparatively abundant.

## Northern plains

Formal assessment of sites of botanical significance against explicit criteria has not been finalised, but preliminary assessments have identified a number of sites of high botanical value. Examples of these sites on public land are Terrick Terrick State Park, Katamatite Bushland Reserve, Wunghnu Bushland Reserve, Inglewood-Charlton Rail Reserve, Doctors Swamp Wildlife Reserve and Glenrowan Rail Reserve.

## NON-VASCULAR PLANTS

### Bryophytes and lichens

Bryophytes (mosses and liverworts) and lichens are a common component of box-ironbark vegetation, particularly where rock outcrops are common. They can be terrestrial, lithophytic (growing on rock), epiphytic (growing on other plants) or aquatic, and can be found in all habitats, from the wettest to the driest.

Bryophytes and lichens have not been assessed in botanical surveys in box-ironbark forests, and our knowledge of their presence, distribution and abundance is derived entirely from herbarium collections and from a handful of bryological surveys undertaken in a limited number of box-ironbark areas. The relationship between EVCs and the non-vascular flora in the study area cannot be determined from the scant data available, and thus a discussion of biogeographic patterns is inappropriate. A representative reserve system for EVCs that caters adequately for vascular plants might also cater adequately for non-vascular species. However it is likely that there are sites that are not notable in a vascular sense (and might therefore not be reserved) that support significant communities of non-vascular species. This is the case in alpine areas, where rock shelters or other local phenomena provide habitat for species which are otherwise known only from wet forest or rainforest.

The following description is therefore general and limited. Lichen taxonomy is particularly difficult so they are largely described here at genus level only. Aquatic

habitats do not appear to have been sampled in box-ironbark forest, and thus are not included in this description.

In box-ironbark forests, liverworts are less abundant than in other forest types, due largely to the drier conditions. Few lichen species are recorded but their abundance can be significant in some areas. Mosses are more numerous than liverworts, since they are better able to survive desiccation. They often form large swathes on the ground, and are usually abundant on rocks, especially granite.

### Terrestrial species

Terrestrial bryophytes and lichens are well-known colonisers of disturbed areas, forming turfs, wefts or open colonies that reduce erosion by binding soils and reducing the impact of rainfall on the soil surface. However, only a few species are able to occupy such habitat. Most species survive only in undisturbed habitat where their need for a particular and constant microclimate can be satisfied.

Terrestrial bryophytes and lichens are easily damaged by disturbance, particularly trampling and fire. The damage is more likely to be severe during drier periods when these plants are dry and brittle. Anecdotal evidence from other forests, where cattle grazing continually disturbs the soil, is that bryophyte and lichen diversity is greatly reduced, often close to nil.

Common terrestrial species include the mosses *Archidium stellatum*, *Bryum billardierei*, *Campylopus bicolor*, *Campylopus clavatus*, *Campylopus introflexus*, *Ceratodon purpureus*, *Eccremidium arcuatum*, *Eccremidium pulchellum*, *Entosthodon subnudus* var. *gracilis*, *Hypnum cupressiforme*, *Polytrichum commune*, *Tortella calycina* and *Triquetrella papillata*; the liverworts *Asterella drummondii*, *Cephaloziella exiliflora*, *Fossombronina* spp., *Lethocolea squamata* and *Lophocolea semiteres*; and the lichens *Cladia aggregata*, *Cladia retipora*, *Cladia sullivanii* and *Cladonia* spp.

Two bryophytes are notable colonisers of recently burnt soils: the moss *Funaria hygrometrica* and the liverwort *Marchantia berteriana*. Both arise around 12 months after fire, and survive for several years before the fire-generated nutrients they require are no longer available in sufficient quantities. The liverwort *Lunularia cruciata* is a common coloniser of bare damp soils.

## Lithophytes

Bryophytes and lichens are the major occupiers of bare rock habitat. They collect soil on rock surfaces, thus providing a suitable substratum for vascular plant growth; they reduce the rate of water flow across rock surfaces; they collect water and release it slowly; they provide habitat for invertebrates; and some species assist soil formation by tearing away from rock faces and accumulating as organic debris at the base of rocks. Some invertebrates, such as dragonflies, rely on the cryptic camouflage provided by the patchy colours of lithophytic bryophytes and lichens.

Lithophytes are particularly susceptible to damage from abrasion. The damage caused by a single footprint in a rock moss bed can be considerable, since it may alter the water regime over a wide area below the damage site, resulting in the death of large patches of moss.

Common lithophytes include the mosses *Breutelia affinis*, *Bryum argenteum*, *Campylopus bicolor*, *Grimmia laevigata*, *Grimmia pulvinata*, *Grimmia tricophylla*, *Hedwigia ciliata*, *Hedwigia integrifolia* and *Leptodontium paradoxum*; the liverworts *Frullania probosciphora* and *Lophocolea semiteres*; and the lichens *Cladonia squamulosa*, *Heterodia* spp., *Parmelia* spp., *Siphula* spp., *Thysanospecium* spp. and *Usnea* spp.

## Epiphytes

Epiphytic bryophytes and lichens provide an important habitat for small invertebrates, and lichens in particular play a role in the decomposition of woody matter. Epiphytic bryophytes occur mainly on *Acacia*

species and other smaller trees and shrubs. They are very rarely present on eucalypts, and never on ironbarks, probably because the eucalypt exudates are toxic to them.

Bryophytes and lichens occupy well-defined niches on trees and shrubs, and do not survive if the microclimate is altered (as by tree-fall or a change in microclimatic factors). They are susceptible to fire, abrasion, and mechanical disturbance to the trees and shrubs.

Common epiphytes include the mosses *Hypnum cupressi forme* and *Tortula papillosa*, the liverworts *Cephaloziella exiliflora* (on burnt tree trunks), *Frullania probosciphora* and *Lophocolea semiteres*, and the lichen *Usnea confusa*.

## Rare species

The conservation status of bryophytes and lichens is largely unknown. However, a list of rare mosses and liverworts has been published as Appendices 3.3 and 3.4 of the *Flora and Fauna Guarantee Procedures Manual*. Many of these species occupy habitats that occur in box-ironbark forests and woodlands, and it seems likely that a number of rare species could be recorded if systematic surveys were to be undertaken.

## Weed species

Two weed mosses might be present in box-ironbark forest, although they have not been recorded to date. *Brachythecium albicans* is a weedy moss of grassy areas, and *Pseudoscleropodium purum* is a fast-spreading weedy moss that grows in shady areas in woodlands and forests. Both originated in Europe and have the potential to displace native moss species.

## 9. FAUNA

### INTRODUCTION

The forests and woodlands of the Box-Ironbark study area support a fauna markedly different from that of the higher rainfall forests to the south or the floodplain and arid woodlands and grasslands to the north. About 85 per cent of box-ironbark forests and woodlands that existed at the time of European settlement has now been cleared and much of the remaining 15 per cent has been modified by various activities. Not surprisingly, this loss and continuing degradation of habitat has had a devastating effect on the fauna, causing marked changes in the distribution and abundance of hundreds of species, including the disappearance of many.

In recent years major studies by the Department of Natural Resources and Environment (NRE), tertiary institutions, fauna conservation groups and local naturalists have yielded much new information on the fauna of box-ironbark forests and woodlands. None the less, there are substantial gaps, and much remains to be learnt about the invertebrate fauna in particular. Indeed, the paucity of information on the invertebrate fauna is such that the nature of existing information is quite different from that available for the vertebrate fauna. Consequently, the two groups are considered separately in the main body of this chapter.

For vertebrates, this chapter documents the terrestrial taxa (mammals, birds, reptiles and amphibians) that are known to occur in the study area, including those that have become extinct in historical times. In addition, it documents the habitat types utilised by the fauna, highlights significant taxa and discusses processes affecting their long-term conservation status. Habitats are considered in the context of the 22 Ecological Vegetation Classes that comprise the study area.

A total of 324 terrestrial vertebrate species is known from the study area, consisting of 54 mammal, 213 bird, 43 reptile, and 14 amphibian species. Although major waterways are excluded from the study area, brief mention is made of 15 freshwater fish species. The composition of the terrestrial fauna reflects the climatic gradient from the temperate, colder and wetter, south-east of the study area to the arid, hotter and drier, north-west. Two species, the

eastern hare-wallaby and the white-footed rabbit-rat, are now extinct. Four others, the eastern quoll, rufous bettong, bridled nailtail wallaby and southern purple-spotted gudgeon, are extinct in the study area, but survive elsewhere in Victoria or Australia; and one more, the dingo in its 'pure' form, is extinct in the study area, although hybrids with feral dogs may still occur there. A further 43 taxa are regarded as threatened in Victoria and in many cases throughout Australia, and still other taxa are known to have declined within the study area but are not yet considered threatened in Victoria or Australia. It is likely that further species have declined or disappeared but due to a lack of historical faunal inventories, it is now impossible to identify them.

The relatively small amount of information available on invertebrates in the Box-Ironbark study area indicates a very rich and diverse fauna, and although only 550 species from 39 invertebrate Orders have been collected to date, the final number of species can be expected to be at least one to two orders of magnitude greater. The dominant groups are ants and wasps, spiders, mites, crickets and grasshoppers, bugs, thrips, beetles and flies. Biogeographically the region is significant because it contains elements of both the semi-arid mallee area of north-western Victoria and the wetter regions of southern Victoria.

It is noteworthy that, of the eight threatened invertebrates recorded in box-ironbark forests and woodlands to date, seven are among the 182 known species of butterflies or moths. This may be an indication of the threats faced by the invertebrate fauna, because the level of knowledge available for other invertebrate groups is far short of that available for butterflies.

### VERTEBRATE FAUNA

#### Changes to the vertebrate fauna

Before European settlement, several Aboriginal groups occupied the study area (see Chapter 2) and were likely to have played a significant role in determining the character of the then extensive box-ironbark forests and woodlands and, consequently, the composition, abundance and distribution of the fauna, especially through their use of fire.

With European settlement, extensive clearance of native vegetation combined with heavy cutting of timber for mines, railways and firewood had a profound effect on the fauna but, again, very limited information is available on the fauna for that period (e.g. Campbell 1902). In Australia generally, mammals have fared worst in terms of extinctions, whereas birds, reptiles and amphibians have not yet been similarly affected.

While the immediate effects of European settlement have had a major impact on the fauna of the region, changes to the region's biodiversity are still continuing. According to Bennett (1993) three groups of species have been identified as particularly threatened within the study area, and it is probable that most species in each group have declined since European settlement:

- **hollow-dependent woodland species** — threatened by habitat clearance including the reduction in size of remnant blocks of vegetation and by decreasing numbers of already scarce hollow-bearing old trees;
- **mobile species that utilise resources in different localities** — threatened by clearing of vegetation, including loss and isolation of important habitats;
- **forest-dependent ground-dwelling species** — threatened by habitat clearance, degradation of soils and ground vegetation, and introduced predators.

### Changes to the mammal fauna

Six species (eastern quoll, rufous bettong, eastern hare-wallaby, bridled nailtail wallaby, white-footed rabbit-rat and the 'pure' form of dingo) are now extinct across the study area. These extinctions represent 14 per cent of the 43 native mammal species known from the study area. Other species, including the spot-tailed quoll, brush-tailed phascogale, common wombat and squirrel glider, have disappeared from or declined in some parts of the study area and at least one species, the black wallaby, has expanded its range. In addition, ten mammal species have been introduced in historical times (see Appendix VII), and one of them, the cat, may have arrived much earlier.

Historical records from the Black Dog Creek area, east of Rutherglen, indicate that the spot-tailed quoll disappeared about 1895 and the eastern quoll disappeared about 1907–8. In the Dookie area, the spot-tailed quoll persisted until the early 1970s. Another mammal, the 'rat kangaroo' (probably the rufous bettong) also



*White-winged chough.*

disappeared about 1895. In the Heathcote area, the first and last record of the white-footed rabbit-rat from within the study area was of one caught by a cat, east of Pyalong, in 1839. Not long after, the white-footed rabbit-rat apparently disappeared from Victoria; the last reliable record being from Portland Bay in 1845.

### Changes to the avifauna

Several species, such as the emu, malleefowl, bush stone-curlew, superb parrot, blue bonnet, regent honeyeater and grey-crowned babbler, have all declined markedly and their population sizes are now only a fraction of what they once were. Others, such as the powerful owl and barking owl, are also likely to have declined following the loss of habitat, especially old trees with suitably large hollows. Conversely, some species that inhabit open country, such as the crested pigeon, galah, eastern rosella, Richard's pipit and Australian magpie, have increased in abundance in or near the cleared areas. The Australian bustard *Ardeotis australis* is now extinct in the study area.

In the Chiltern area, five species are now locally extinct (emu, grey goshawk, yellow-tailed black-cockatoo, chestnut-rumped thornbill and crested bellbird), a further ten are known to have declined and three others have increased in abundance.

In the Bendigo area, three species are now extinct (emu, malleefowl and blue bonnet); eleven have declined, and at least three have increased in abundance.

In the northern plains there has been a long-term decline and major loss of many woodland birds in farmland, especially intensively-managed irrigation areas.



*Grey-crowned babbler.*

## Changes to the reptile and amphibian fauna

No species of reptile or amphibian is known to have become extinct in the study area, but some declines have been detected including the carpet python, the four-toed skink, and the bandy bandy.

In the northern plains there have been widespread and continuing declines, leading to probable local extinctions. For instance, as shown by Brown and Bennett (1995), few or no reptile species were found during recent censuses in open farmland, suggesting that reptiles have largely been eliminated from extensive areas as a result of land clearance.

In the Rutherglen area in the 1960s, the eastern tiger snake and an unspecified species of goanna were reported to have been more common previously. In the Puckapunyal Military Area, the growling grass frog was known from across the northern section in the early 1960s, but was only recorded once during a recent survey (Kinhill

Engineers 1996). This species has experienced significant range contractions and local declines in other parts of south-eastern Australia.

## THE VERTEBRATE FAUNA

### Mammals

Fifty-four mammal taxa have been recorded from the study area, comprising 44 that are native and ten that are introduced (Appendix VII). Of the 38 native taxa that still occur in the area, two are monotremes, 19 are marsupials and 17 are placental mammals.

Bats form the largest group with 15 species, of which 13 are small insectivores and two are larger fruit-eaters that only occasionally visit the study area. Many of the insectivorous bats are relatively common and widespread throughout the study area. They consume vast quantities of invertebrates and may be important in maintaining the health of farm trees and woodlands in rural environments, and reducing insect numbers that affect croplands. Due to their mobility, bats are able to utilise roosting and foraging areas in different localities.

The largely tree-dwelling mammals (yellow-footed antechinus, brush-tailed phascogale, koala, common brushtail possum, eastern pygmy-possum, yellow-bellied glider, sugar glider, squirrel glider, common ringtail possum and feathertail glider) form another distinctive group in the study area. Most of them are hollow-dependent and consequently are restricted to those localities that contain suitable hollows. The study area is of critical importance to three of these species. The distribution of the squirrel glider in Victoria is almost entirely confined to the study area, and more than 50 per cent of the Victorian populations of the brush-tailed phascogale and the yellow-footed antechinus, also occur there.

Several ground-dwelling native mammals disappeared soon after European settlement. Of those that survived, the short-beaked echidna, eastern grey kangaroo and black wallaby have robust populations in areas of remaining native vegetation. The black wallaby formerly reached the inland limit of its distribution in the study area, but in recent decades has extended its range into drier areas in the north and west of the state. The common wombat and long-nosed bandicoot (more typical of the Bassian biogeographic region — see Chapter 7) are known only from

the eastern and south-eastern margin of the study area close to the forested ranges (e.g. Wangaratta, Rutherglen). The southern brown bandicoot is common in the Grampians and extends into the study area around Great Western, where there is an isolated population along the Concongella Creek.



*Squirrel glider.*

The fat-tailed dunnart is one of the few native species found in cleared farmland, although most records are from unimproved pastures and native grasslands. It is also found in open box-ironbark woodlands and mallee shrublands. The common dunnart, paradoxically, is rare throughout much of the study area. Recent work in the Puckapunyal Military Area revealed that this species is widespread but in relatively low numbers there.

Two aquatic species, the water rat and the platypus, occur in the study area. The water rat is not strictly confined to waterways and can use adjacent terrestrial habitats. The platypus is largely associated with the major river systems outside the study area but occurs along some of the minor permanent streams, such as Barkers Creek, that run through box-ironbark forests and woodlands.

Ten introduced species (house mouse, brown rat, black rat, feral dog, red fox, cat, goat, pig, brown hare and European rabbit) have established themselves to varying degrees in the study area and their populations fluctuate with time and the efficacy of control measures. The extent to which the feral dog or hybrids have replaced the dingo in the study area is unclear given continued debate over the definitions and, consequently, identifications of feral dogs, hybrids and dingoes.

## Birds

Two hundred and fourteen (213) bird species are known from the study area, comprising 205 that are native and eight that are introduced (Appendix VII). Over 85 per cent (180 species) of these are known to have bred within the study area. Some additional species within the broad boundary of the study area will not be considered here because they are restricted primarily to wetlands (for example, most waterfowl and shorebirds) or grassland (for example plains-wanderer).

The native avifauna is rich and varied, and consists of:

- characteristic woodland species, all of which occur to a greater extent in the study area than elsewhere in Victoria — for example bush stone-curlew, swift parrot, turquoise parrot, speckled warbler, regent honeyeater, fuscous honeyeater, black-chinned honeyeater, painted honeyeater, and grey-crowned babbler;
- forest species from the south and south-east of the study area — for example crimson rosella, superb fairy-wren, white-browed scrubwren, striated thornbill, eastern spinebill and scarlet robin;
- mallee species such as malleefowl, yellow-rumped pardalote, shy heathwren, purple-gaped honeyeater, yellow-plumed honeyeater and southern scrub-robin;
- inland species from north and north-west of the study area — for example black falcon, cockatiel, budgerigar, black honeyeater and ground cuckoo-shrike; and
- many generalist species which are widespread throughout Victoria — black-faced cuckoo-shrike, willie wagtail, grey shrike-thrush, Australian magpie and Australian raven, for example.

Several groups of species that are prominent in this study area include:

- **nectar-feeders**, such as many of the honeyeaters (over 20 species), lorikeets (four species) and the swift parrot;
- **hollow-dependents**, such as the owls (five species), parrots (13 taxa), cockatoos (nine species), kingfishers (four species) and treecreepers (two species);
- **foliage-gleaners**, such as the pardalotes (three taxa), thornbills (seven species), gerygones (two species) and weebill;
- **mistletoe specialists** — the painted honeyeater and mistletoebird; and

- **ground-dwellers**, such as the malleefowl, spotted quail-thrush, southern whiteface, diamond firetail and heathwrens (two species).

Movements of birds resulting in changes in the local composition of bird communities is a notable feature of the avifauna of the Box-Ironbark study area. Several types of movement pattern can be recognised.

First, some species undertake movements in response to sporadic events, such as droughts, floods or wildfire. Second, a large proportion of land birds make regular seasonal movements across the boundaries of the study area, resulting in seasonal fluctuations in the avifauna. The two main seasonal patterns of migration are spring/summer and autumn/winter.

Third, there are many irregular movements of birds both daily and weekly between habitats and locations in response to variation in food resources. Of particular importance in this region is the movement of nectar-feeding birds in response to the flowering patterns of eucalypts. A large suite of nectarivorous birds, including the musk, little, and purple-crowned lorikeets, swift parrot, red wattlebird, noisy friarbird, regent honeyeater, fuscous, painted and New Holland honeyeaters, is a characteristic feature of this region.

Fifteen of the bird species that are resident or regularly occur in the study area have declined in status to the point of being considered threatened at a Victorian, national or even global level. These include the square-tailed kite, bush stone-curlew, superb parrot, swift parrot, powerful owl, barking owl, regent honeyeater and grey-crowned babbler.

## Reptiles and Amphibians

Forty-three species of reptile and 14 frog species are known from the study area (Appendix VII). The reptile fauna includes representatives from nine families: the tortoises, dragons, geckoes, legless lizards, skinks, goannas, pythons, blind snakes and elapid snakes. Two families of frogs, the southern frogs and the tree frogs, are represented.

Skinks are the most numerous family of reptiles, with 17 species present. They range from small species, such as the garden skink and Grey's skink, to larger animals, such as the common blue-tongued lizard, and Cunningham's skink. Most species are terrestrial, using logs, rocks or fallen branches and litter as shelter and activity sites (for example large striped skink, White's skink).

Seven species of elapid snake are known, including the large venomous eastern tiger snake, eastern brown snake and red-bellied black snake. The carpet python, the only member of the python family in Victoria, is now rare in the study area and limited to a few local populations centred on rocky outcrops.

The woodland blind snake is a characteristic 'woodland' species that occurs across the entire region, whereas Peter's blind snake and Grey's blind snake occur in the study area peripherally to their main distributions in drier environments of the north-west and forests and woodlands in the east, respectively.

Four species of gecko occur in woodlands of the study area, of which two, the marbled gecko and wood gecko, are relatively widespread. There are six species of legless lizard, most being rare or uncommon, or localised in distribution. The pink-tailed worm-lizard, for example, is known only from mallee shrublands and some woodlands in the Bendigo area.

Few reptiles are able to thrive in areas cleared for farmland, unless remnant areas of vegetation that provide suitable microhabitats are available. A range of reptiles, especially common species such as Boulenger's skink, garden skink, marbled gecko, tree goanna and eastern brown snake have been recorded in remnant roadside vegetation and other woodland remnants among farmland, but the viability of these populations is not clear.

Tree frogs (e.g. Peron's tree frog, southern brown tree frog and plains brown tree frog) and smaller species of southern frogs (e.g. plains froglet, common froglet, barking marsh frog) occur mainly around water bodies or in areas that are seasonally inundated. During dry conditions they shelter under logs, rocks, bark or thick plant material to retain moisture and prevent drying out. Several species of southern frogs, such as the mallee spadefoot toad and southern bullfrog, are able to live in drier areas throughout the woodlands, spending much of their lives concealed underground to avoid desiccation.

## Fish

Fifteen species of native freshwater fish are known from the tributaries of the major rivers in the study area: 12 are threatened, two are secure and one is now extinct in the study area (Table 21). Threatening processes for native freshwater fish include altered flow regimes and water

temperatures as a result of impoundments of water, removal of snags and logs from waterways, construction of artificial barriers such as weirs, declining water quality, loss of riparian vegetation and degradation of stream banks, stream sedimentation, and predation by or competition with introduced species of fish such as the rainbow and brown trout, mosquitofish and European carp (Koehn and O'Connor 1990).

## HABITAT USE BY THE VERTEBRATE FAUNA

The Box-Ironbark study area has a wide range of habitats. Twenty-two ecological vegetation classes (EVCs) have been identified — 16 in the inland hills, and six on the northern plains (see Chapter 7). In this chapter, the inland hills EVCs have been amalgamated into eight groups and the northern plains EVCs have been amalgamated into one to form a total of nine faunal habitat types (Appendix VII).

EVCs are based largely on the floristic composition of the vegetation. However other factors, such as vegetation structure, also affect the distribution of animals. For example, young regrowth forest has a quite different

structure from older forest, yet both can have a similar floristic composition and be assigned to the same EVC. Also, some animals may be associated with particular tree species that are found in a number of different EVCs — for example, nectarivorous birds following the flowering of a particular species.

The vertebrate fauna characteristic of each faunal habitat type is discussed below. The EVCs comprising each faunal habitat type are listed in brackets.

### Box-Ironbark Forest (Box-Ironbark Forest EVC)

This is the most widespread habitat type in the study area and has been sampled the most comprehensively. Box-Ironbark Forest contains a rich and distinctive assemblage of animals, and characteristically includes many species of honeyeater (e.g. regent honeyeater and noisy friarbird) and parrot (e.g. swift parrot and lorikeets) which are attracted to the blossom of the dominant eucalypts — mugga ironbark, red ironbark, yellow gum and grey box — especially in autumn and winter. The diversity of eucalypts in this and adjacent habitats (e.g. yellow box, white box and red box) add to the duration and reliability of nectar as a food resource in these forests.

**Table 21: Native freshwater fish of the study area and their conservation status in Victoria**

- Conservation status from CNR (1995)

Common name	Scientific name	Conservation status
flat-headed galaxias	<i>Galaxias rostratus</i>	Rare
mountain galaxias	<i>Galaxias olidus</i>	Insufficiently Known
broadfin galaxias	<i>Galaxias brevipinnis</i>	—
bony bream	<i>Nematalosa erebi</i>	Rare
crimson-spotted rainbowfish	<i>Melanotaenia splendida fluviatilis</i>	Rare
freshwater catfish	<i>Tandanus tandanus</i>	Vulnerable
bluenose (trout) cod	<i>Maccullochella macquariensis</i>	Endangered
Murray cod	<i>Maccullochella peelii</i>	Vulnerable
golden perch	<i>Macquaria ambigua</i>	Rare
Macquarie perch	<i>Macquaria australasica</i>	Vulnerable
silver perch	<i>Bidyanus bidyanus</i>	Vulnerable
river blackfish	<i>Gadopsis marmoratus</i>	Insufficiently Known
southern pygmy perch	<i>Nannoperca australis</i>	—
western carp gudgeon	<i>Hypseleotris klunzingeri</i>	—
southern purple-spotted gudgeon	<i>Mogurnda adspersa</i>	Endangered (extinct in study area)

Box-Ironbark Forest is also an important habitat for many of the characteristic 'woodland' species of central Victoria, such as the yellow-tufted honeyeater, speckled warbler, brush-tailed phascogale and woodland blind snake. Fuscous and yellow-tufted honeyeaters often numerically dominate the avifauna of the Box-Ironbark Forest. Many other common species also occur there, as well as a suite of hollow-dependent species, such as the brown tree creeper and, in some areas, the powerful owl and barking owl. Most species of arboreal mammal and bat known from the study area have been recorded in this habitat type and it is one of the few from which the square-tailed kite has been recorded. Box-Ironbark Forest supports a large number of reptile and amphibian species. Those commonly recorded include the marbled gecko and Boulenger's skink. Several significant or notable species of snake have been recorded — the woodland blind snake, Dwyer's snake and bandy bandy.

### **Mallee Shrublands**

(Sandstone-rise Broombush and Gravelly-sediment Mallee EVCs)

The Mallee Shrublands in central Victoria contain some of the typical mallee eucalypt species characteristic of the more extensive areas of mallee vegetation in the north-west of the state. For example, in the Wychitella Flora and Fauna Reserve, the Mallee Shrublands contain a suite of typical mallee taxa, such as the malleefowl and purple-gaped honeyeater, as well as many 'generalist' species. Malleefowl mounds at Wychitella are associated with broombush thickets, which may provide leaf litter for the nesting-mound, or cover for protection. In other remnant stands of Mallee Shrublands, such as at Inglewood, Tarnagulla and the Whipstick, some typical species, such as the malleefowl, have died out.

A variety of reptiles that typically inhabit arid and semi-arid environments are found in Mallee Shrublands, including Grey's skink, which is limited to the north-central and north-western parts of the state. The endangered pink-tailed worm-lizard has been recorded in the vicinity of Bendigo. The woodland blind snake is known from several localities in relatively undisturbed Mallee Shrublands. Tree frogs are scarce; at Inglewood, for example, Peron's tree frog appeared to be associated with dams and depressions associated with mining disturbance amongst mallee vegetation. Southern frogs,

such as the mallee and common spadefoot toads, are well represented.

The Mallee Shrublands contain a relatively depauperate mammal fauna with only a few ground-dwelling species (e.g. common and fat-tailed dunnarts) or arboreal species present, and a number of common bats, such as Gould's wattled bat. None of the mallee-dependent small mammals that occur in the north-west of the state has been found in the Mallee Shrublands of central Victoria. The western grey kangaroo occurs in association with Mallee Shrublands in the Inglewood and Wedderburn areas, and overlaps there with the eastern grey kangaroo which otherwise occurs exclusively throughout most of the study area.

### **Heathy Woodlands**

(Heathy Woodland and Sedge-rich Woodland EVCs)

This habitat type comprises an EVC that occurs naturally as small patches (Heathy Woodland) and another that is limited to the far south-west of the study area (Sedge-rich Woodland). It has not been surveyed extensively, and hence the species list provided in Appendix VII is likely to be an underestimate. Common and widespread species have been recorded, such as the short-beaked echidna and grey shrike-thrush. Heathy Woodlands often contain numerous stunted hollow-bearing trees which provide favourable habitat for species such as the feathertail glider and the yellow-footed antechinus. The latter was found in higher densities in Heathy Woodlands than in other habitat types. Other species typical of Heathy Woodlands include the chestnut-rumped heathwren, crested bellbird and tree martin. Most of the reptile and amphibian species known from this habitat type are common or widespread. When the yellow gums in Sedge-rich Woodland are in flower, large numbers of lorikeets are attracted to them in areas such as Deep Lead Flora and Fauna Reserve.

### **Interface Woodlands**

(Low Rises Grassy Woodland, Alluvial Terraces Herb-rich Woodland and Creekline Grassy Woodland EVCs)

These woodlands are on the interface between the inland hills and northern plains. They are largely found in the northern sections of the large blocks of vegetation in the inland hills (e.g. Kamarooka State Park), or in isolated remnants (e.g. Runnymede Flora Reserve). Interface Woodlands, especially the Creekline Grassy Woodland, often contain larger numbers of large, old, hollow-bearing

trees and support numerous hollow-nesting birds. Where these woodlands are close to open farmland they also support hollow-nesting species, such as the galah. A range of hollow-using arboreal mammals has been recorded, as have most of the species of bat known from the study area.

Another group of birds recorded in these grassy woodland habitats rich in grass seeds includes the brown quail, turquoise parrot and diamond firetail. Where these woodlands are relatively open or smaller in size they can become dominated by colonies of the noisy miner (e.g. Runnymede Flora Reserve), which actively excludes most other birds except larger species like the laughing kookaburra. Species associated with aquatic environments, such as the large-footed myotis, water rat, and Australian wood duck, are likely to occur in Creekline Grassy Woodland, which is also potential habitat for the carpet python. *Where there is an interface between aquatic and terrestrial environments along creeklines, the habitat is suited to a number of frog species, such as the plains froglet and southern brown tree frog.*

## Heathy Dry Forest

(Heathy Dry Forest EVC)

This habitat type is widespread throughout the inland hills and has been relatively well surveyed. The mammal fauna is similar to that in Box-Ironbark Forest, often with similar densities of animals recorded. The brush-tailed phascogale is well represented in this habitat type, being recorded in comparatively high densities. Large numbers of insectivorous bats have been trapped in this habitat type, especially in the Warby Ranges.

Heathy Dry Forest, like Box-Ironbark Forest, supports a rich avifauna. However, unlike Box-Ironbark Forest, the dominant eucalypts (red stringybark, red box, and long-leaf box) are not prolific winter-flowering species that attract large concentrations of nectarivores. While a range of common honeyeaters do occur in this habitat (e.g. fuscous and yellow-tufted honeyeaters), these sites are also likely to support a range of insectivorous forest birds, such as the buff-rumped thornbill, brown-headed honeyeater and dusky woodswallow. In the Warby Ranges, the turquoise parrot and leaden flycatcher are also observed in this habitat type.

Most reptile and amphibian families are represented in Heathy Dry Forest, including several burrowing species

(e.g. large striped skink), and significant or notable species, such as Dwyer's snake, bandy bandy and tree goanna.

## Grassy Dry Forests

(Grassy Dry Forest and Valley Grassy Forest EVCs)

The EVCs that make up this habitat type are not widespread and have not been specifically sampled for fauna. The Grassy Dry Forest EVC occurs on upper slopes and ridgetops adjacent to Heathy Dry Forest, and is likely to support a similar range of species. Valley Grassy Forest EVC is located towards the southern and eastern limits of the study area where it adjoins the Great Dividing Range, hence some species that are more typical of wetter forests have been recorded, such as the long-nosed bandicoot. The more common birds of Grassy Dry Forests include the eastern rosella, fan-tailed cuckoo and yellow-faced honeyeater. Several significant species have also been recorded, including the square-tailed kite, turquoise parrot, powerful owl, barking owl and bandy bandy.

## Elevated Woodlands

(Metamorphic Slopes Shrubby Woodland and Hillcrest Herb-rich Woodland EVCs)

The two EVCs which make up this habitat type are structurally quite different and this is reflected in their fauna. Hillcrest Herb-rich Woodland is an open grassy woodland, *often with large, well-spaced and hollow-bearing trees*, while Metamorphic Slopes Shrubby Woodland occurs on rocky slopes with stony soils and has a sparse tree layer over a dense shrub layer. The fauna of Hillcrest Herb-rich Woodland typically includes species that favour open woodlands, such as the long-billed corella, striated pardalote and hooded robin. In the St Arnaud area both the eastern and grey kangaroos have been recorded in this habitat type and the yellow-footed antechinus is well represented.

The tall shrubby vegetation in Metamorphic Slopes Shrubby Woodland provides habitat for insectivorous birds, such as the chestnut-rumped and buff-rumped thornbills. The black wallaby is often present, using shrubby vegetation for daytime cover and shelter; and the diggings of foraging short-beaked echidnas are commonly seen. The rocky substrates and exposed rocks in this habitat type provide microhabitats for reptiles. All woodland gecko species known from the study area — marbled, wood and thick-tailed geckoes — have been recorded there, but only a

few frog species. The tree goanna occurs in Hillcrest Herb-rich Woodland.

## Granitic Hills Woodlands

(Granitic Hills Herb-rich Woodland, Granitic Hills Woodland and Rocky Outcrop Mosaic EVCs)

Granitic rock outcrops often surrounded by thickets of distinctive shrub vegetation are characteristic of this habitat type, which includes Granitic Hills Herb-rich Woodland in the west (e.g. Kooyora State Park) and Granitic Hills Woodland in the east (e.g. Warby Ranges State Park). A similar range of mammal species is recorded in both types of woodland, except that some wet forest species, such as the common wombat, occur near the edge of their range in Granitic Hills Woodland. High densities of the common brushtail possum occur in Granitic Hills Woodland. The more common birds include the restless flycatcher and white-winged chough. Species largely restricted to this habitat type include the yellow thornbill and spiny-cheeked honeyeater. Granitic Hills Woodland supports a relatively large number of skink species, both dragon species, and three of the gecko species that occur in the study area, but few frog species. The woodland blind snake occurs in both Granitic Hills Herb-rich Woodland and Granitic Hills Woodland.

Rocky Outcrop Mosaic is limited in extent in the study area and has not been sampled for fauna; hence, few records are available. It is likely to be an important habitat for reptiles because the large boulders, surface rocks and exfoliating sheets provide refuge and basking sites.

## Northern Plains Grassy Woodlands

(West Riverine Grey Box Grassy Woodland, West Riverine Grey Box Shrubby Woodland, Terrick Terrick Cypress-pine Grassy Woodland, Central Riverine Grey Box Grassy Woodland, East Riverine Grassland, Eastern Low Rises Grassy Woodland EVCs)

Little remains of the once widespread box, pine and buloke woodlands of the northern plains. Habitats available to the fauna now occur mainly in the form of small patches (< 10 ha) amongst farmland and as linear remnants along roadsides and streams.

Vegetation along the major rivers is not within the study area but is also an integral component of the ecology of the

northern plains and has a major influence on the fauna inhabiting surrounding box woodlands.

The northern plains and inland hills components generally share a similar suite of mammals. The typical 'woodland' mammals of central Victoria — squirrel glider, brush-tailed phascogale and yellow-footed antechinus, for example — all occur in the northern plains; however, the latter two are now more restricted in distribution there than in the inland hills. Surprisingly, the sugar glider, which is relatively common and widespread in the inland hills, occurs sparsely in the woodlands of the northern plains. Both regions share a suite of about 12 species of insectivorous bat, but one (southern forest bat) has not yet been detected in the inland hills component.

The avifauna of the northern plains includes a distinctive component of the 'woodland' species, such as the bush stone-curlew, diamond firetail and hooded robin. Others, such as the grey-crowned babbler are largely restricted to the remnant mixed-species box woodlands that occur along tree-lined roads in parts of the study area. Fragmentation of box woodlands has favoured the noisy miner, which now dominates many roadsides and small remnants. Species that are largely restricted to the Northern Plains Grassy Woodlands include the little corella, pied butcherbird and apostlebird. Others that are characteristic of drier and semi-arid environments are most likely to be observed in the western half of the northern plains (e.g. Australian ringneck, black-faced woodswallow and striped honeyeater) where they occur in association with dry woodlands of box species or cypress-pines (e.g. Terrick Terrick State Park).

Thirty-five species of reptile representing eight families and 12 species of frog from two families have been recorded from the northern plains. The former total includes a species of tortoise that is mainly aquatic and unlikely to be found outside of riverine habitats. A number of these species are naturally rare or have localised distributions on the northern plains, usually as a result of specific habitat requirements, but many reptiles are now patchily distributed and scarce because almost all habitat has been cleared.

Several significant or notable species of reptile occur on the northern plains — in fact, the northern plains region supports the greatest number of threatened reptiles outside the Mallee area. The bandy bandy appears to have declined in range and is now principally located around Wodonga-Beechworth in the north-east, although historically it

occurred as far west as St Arnaud. Only five records of the hooded scaly-foot exist for Victoria, all from the western half of the northern plains, most recently from near Terrick Terrick State Park. The southern spiny-tailed gecko is confined to the arid north-west of Victoria, with one outlying population from Mt Hope, north of Terrick Terrick State Park. Three other significant or notable species, the tree goanna, carpet python and Dwyer's snake, also occur on the northern plains.

## SIGNIFICANT AND NOTABLE VERTEBRATE FAUNA

The native vertebrate fauna of the study area has already been reduced by the loss of at least eight taxa (eastern quoll, rufous bettong, eastern hare-wallaby, bridled nailtail wallaby, white-footed rabbit-rat, dingo and southern purple-spotted gudgeon). Of the remaining native taxa, 43 (14 per cent) are considered threatened in Victoria or Australia and all of these (except the freshwater fish) are considered here for fuller treatment as 'significant' or 'notable' taxa. These threatened taxa comprise 16 per cent (6 of 38) of the remaining native mammals; 10 per cent (20 of 205) of the native birds; and 10 per cent (6 of 58) of the reptiles and amphibians. The high number of species in these categories reflects the continuing threats to fauna in a region where the original vegetation has been extensively cleared, fragmented and modified, from the time of European settlement. Some species that are declining within the study area, but are not considered threatened in Victoria, are also included here as notable species, to indicate the likely need for conservation measures.

### Criteria used to assess significant or notable status

A taxon is considered significant if it is considered threatened in Victoria, Australia or globally (Commonwealth *Endangered Species Protection Act 1992*), and:

1. it is known or suspected to breed in the study area; or
2. it migrates to or regularly utilises box-ironbark Ecological Vegetation Classes in the study area.

A taxon is considered notable if:

1. it is threatened in Victoria, Australia or globally, but only visits the study area irregularly; or

2. it is not threatened in Victoria, Australia or globally, but has declined substantially within the study area.

Twenty-five significant taxa are discussed in the following sections. Maps of the distribution of 18 of these species are provided in Figures 6-8.

### Significant taxa — mammals

#### Spot-tailed quoll *Dasyurus maculatus*

The spot-tailed quoll is the largest carnivorous marsupial on the Australian mainland. Since European settlement, clearing for agriculture has reduced its Victorian distribution by about 50 per cent. Its current distribution is concentrated around the forested areas of the Great Dividing Range, and in south-western Victoria. Records from the study area are relatively few and scattered. The most recent are from Mt Pilot and the Warby Ranges in the mid 1990s, with earlier records from Devenish cemetery (west of Wangaratta), Chiltern and Lockwood (south-west of Bendigo) in the 1970s. The current status of the spot-tailed quoll is uncertain in the study area and, indeed, throughout northern Victoria — as highlighted by a recent unexpected record from near Swan Hill, several hundred kilometres north-west of the nearest recent record. Although there is little information on its habitat requirements in the study area, it is likely that extensive areas of habitat are needed for viable populations, because of the large home range of this species. It is believed they are also susceptible to poisoning by 1080 baits set for wild dogs. The spot-tailed quoll readily climbs trees, and feeds on a range of mammals, birds and invertebrates. Den sites are located in rock crevices, and hollows in trees and logs.

#### Brush-tailed phascogale *Phascogale tapoatafa*

The brush-tailed phascogale (or Tuan) is a medium-size nocturnal marsupial with a distinctive bottle-brush tail. It is predominantly arboreal, foraging for large invertebrates under the bark and in fissures of tree trunks and branches. Dead trees are favoured foraging sites, while large smooth-barked trees, such as yellow gums, are avoided as they are difficult to climb. Nests are constructed in large tree hollows, especially those with small entrance holes. Where there are few large hollow-bearing trees (as in much of the study area), there is competition for this limited resource with other species, such as the sugar glider, squirrel glider and feral bees.



*Brush-tailed phascogale.*

Soderquist (1993) found that individual brush-tailed phascogales use up to 40 nest sites each year, thus increasing the requirement for numerous hollow-bearing trees within their range. This species occurs in low densities because individuals occupy largely non-overlapping home ranges. These home ranges are large for an animal of this size (over 100 ha for males and 30–60 ha for females). During the mating season males travel greater distances to seek out females — one male was recorded travelling over 15 km in six weeks (Platt 1993). All males, at less than one year of age, die after the brief mating season in early winter. Females live longer, but rarely manage to raise a second litter. In conjunction with predation and environmental events (such as droughts and fire), these biological characteristics of the brush-tailed phascogale (low densities, large home ranges, male die-off), mean that it is very susceptible to local extinctions. Habitat fragmentation exacerbates this situation: vegetation remnants may be of insufficient size to support viable populations, and may not be accessible to dispersing

young due to the barrier created by cleared farmland or urban areas.

The brush-tailed phascogale currently occurs in a broad band across lowland Victoria inland of the Divide, with the study area comprising a significant proportion of its range. It was formerly found in Gippsland and woodlands along the coast but has disappeared from these areas within the last few decades. It is estimated that its distribution in Victoria has declined by over 40 per cent since European settlement, and may still be decreasing.

#### Common dunnart *Sminthopsis murina*

Contrary to its name, the common dunnart is classified as Rare in Victoria. It is widespread but rarely recorded throughout much of the remaining native vegetation of western and northern Victoria. Locations where this species is found usually have a dense layer of bark and leaf litter, with only a sparse shrub and ground vegetation layer. As much of its preferred habitat has been cleared since European settlement, it is likely that numbers of this species have declined in Victoria. Because the common dunnart is strictly terrestrial, any activities which alter the ground layer may adversely affect it. This species was not recorded during a recent, extensive survey of the northern plains, although it may have once occurred there.

#### Squirrel glider *Petaurus norfolcensis*

The squirrel glider is an arboreal gliding possum, with distribution in Victoria that is almost entirely confined to the study area. Preferred habitats include mixed-species box woodlands dominated by grey box, yellow box and white box, and river red gum forests with a wattle understorey. The squirrel glider makes extensive use of the mugga ironbark in the north-east, at places such as Chiltern Box-Ironbark National Park and Killawarra State Forest. It has not been recorded from the extensive tracts of the closely-related red ironbark in the central parts of the study area. Hollows in both dead and live trees are used as nesting sites, and the squirrel glider has been recorded moving up to 1 km from its nest tree to foraging areas. Much of the remaining squirrel glider habitat in Victoria is contained in remnant vegetation within cleared farmland. Roadside reserves and linear strips along streams, especially those which have numerous large hollow-bearing trees and which are connected to more extensive areas of

vegetation, are extremely valuable as habitat for this species.

#### Large-footed myotis *Myotis macropus*

The large-footed myotis is a rare insectivorous bat whose distribution is closely associated with permanent water bodies. The large-footed myotis was, until recently, thought to be widespread in eastern Australia; however, a taxonomic revision (see Kitchener *et al.* 1995) has revealed that the species occurring in the study area is confined to a small number of river systems in south-eastern Australia. It has been recorded along the major rivers in the northern plains, such as the Goulburn, Ovens and Murray rivers, and it is possible that it also occurs along some of the minor creek systems throughout the study area; where it is likely to roost in large, hollow-bearing trees associated with the creek lines.

### Significant taxa — birds

#### Malleefowl *Leipoa ocellata*

The malleefowl is a ground-dwelling species that builds a mound of soil and litter in which to incubate its eggs. Fewer than 1000 breeding pairs are left in Victoria, mostly in the Mallee and Wimmera areas, but an isolated and now endangered population exists within the study area in the Wychitella Flora and Fauna Reserve. According to Simpson *et al.* (1988) this population contained an estimated five to 12 breeding pairs in the mid 1980s, but the number that now remain is not known, though at least one nesting-mound was still being worked in 1996 (C. Tzaros pers. comm.).

Another population once occurred in the Whipstick of Bendigo and was apparently so numerous in 1900 that individuals were sold in the local poultry market. However, nesting was last reported there in 1922 before a fire burnt through the area. Since then, an individual was reported in 1936 and another was found dead in December 1974. The Whipstick population is now extinct.

Individuals of other populations formerly bred in patches of mallee scrub at Tarnagulla and at Inglewood but are now extinct at both localities. The major threatening processes contributing to the Australia-wide demise of the malleefowl include fox and cat predation of chicks, frequent fires in remaining habitats and competition from introduced herbivores — sheep, goats and rabbits.

#### Square-tailed kite *Lophoictinia isura*

The square-tailed kite is a very rare bird of prey that migrates south to Victoria in spring, breeds and then departs northward again in autumn. According to Debus and Silveira (1989) fewer than 50 pairs are estimated to breed in Victoria. Reports of both nesting behaviour in spring, and family groups comprising adults and juveniles in summer, suggest that some of these probably nest within the study area. Despite the extreme rarity of this species, no efforts have been made to locate nests or to protect them from egg-collectors and other human disturbances, such as timber-harvesting and gold-mining.

#### Grey goshawk *Accipiter novaehollandiae*

The grey goshawk is a rare bird of prey with two distinct colour forms, one grey and the other white. In the study area, the grey goshawk has been recorded breeding at Chiltern in the 1970s, but is now extinct there. It has also been recorded nesting near Lyall Glen, in the Lake Eppalock area, in 1966 and 1968.

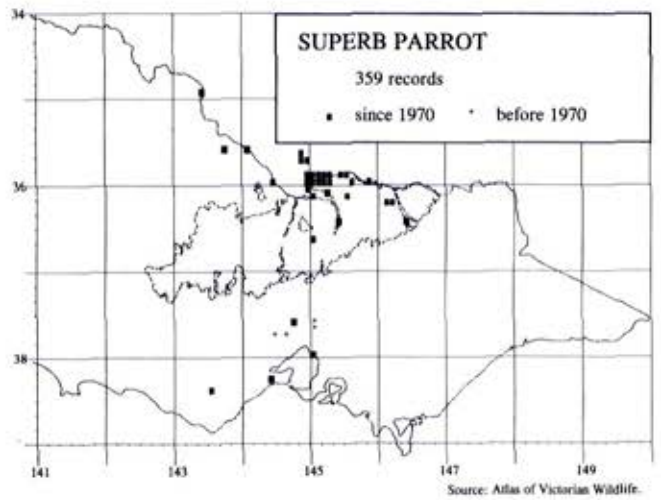
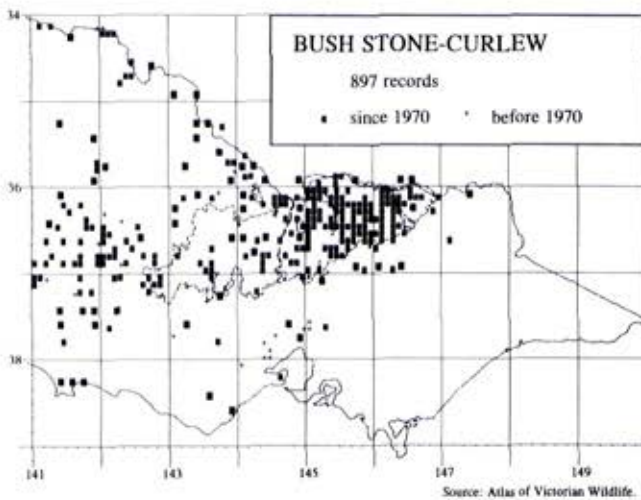
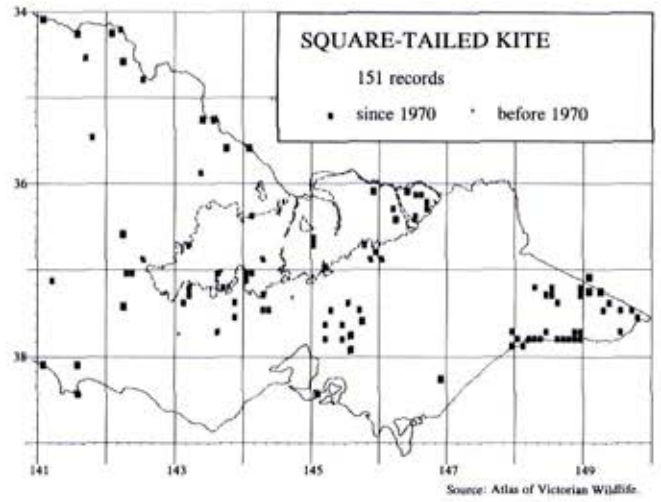
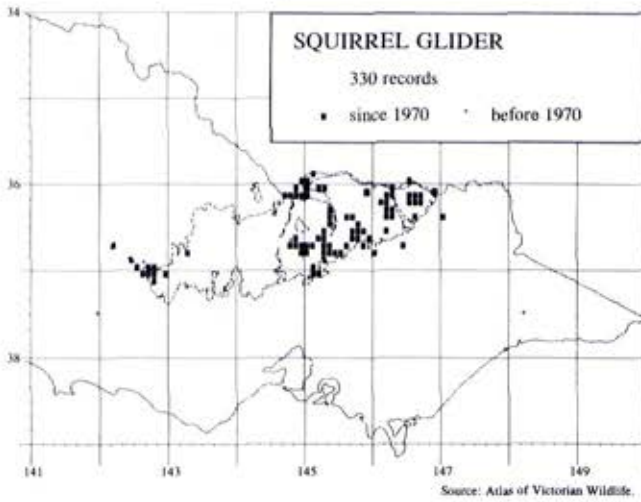
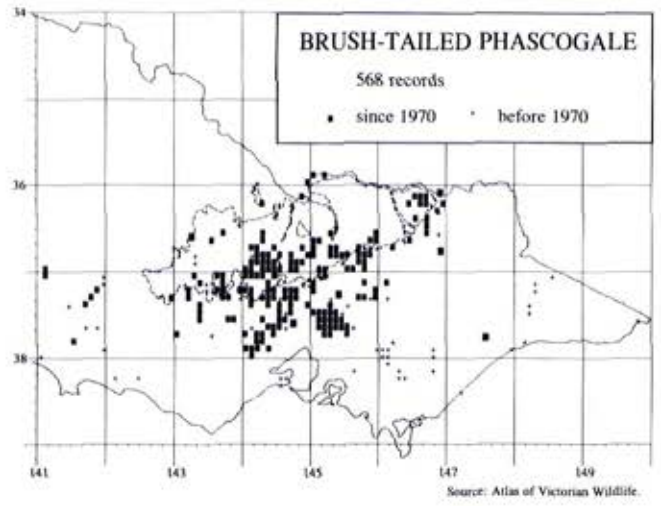
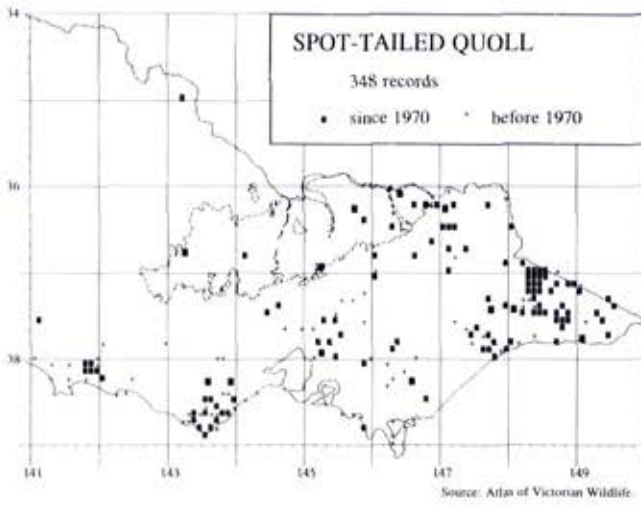
#### Black falcon *Falco subniger*

The black falcon is a rare bird of prey that is usually seen hunting over grasslands, croplands and grassy woodlands. It nests in scattered trees but rarely enters more densely timbered habitats. Consequently, in Victoria, it mainly occurs in the drier north and north-west. It has bred near Rutherglen and it is likely that a few other nest sites exist within the study area.

#### Bush stone-curlew *Burhinus grallarius*

The bush stone-curlew is a long-lived, nocturnal species that forages and nests on the ground, leaving eggs and nestlings vulnerable to introduced predators and to trampling by grazing stock. Consequently, it is possible that the aging adult population is not being replenished by sufficient numbers of younger birds. The population of the bush stone-curlew began to decline around 1900 and continues to do so. For instance, declines were recorded at 42 per cent of sites surveyed in 1985 and again in 1991, and reports from landholders suggest that densities have decreased from four pairs to one pair on some properties over the last 30 years (Webster and Baker-Gabb 1994). It has been estimated that fewer than one thousand individuals remained in Victoria in 1985 — it is likely that many fewer remain now. Most of the Victorian population now occurs

Figure 6: Distribution of significant fauna species I



in the study area on private land. On public land some pairs utilise the margins of larger blocks of vegetation, but most occur in small vegetation remnants, especially those with adequate cover provided by fallen tree debris.

#### Superb parrot *Polytelis swainsonii*

The superb parrot is a beautiful, green, long-tailed parrot that breeds in tree hollows in loose colonies in riparian habitats. Fewer than 5000 pairs exist in the wild and only 100 pairs are suspected to breed in Victoria — in river red gums in Barmah State Forest and Barmah State Park. Although the breeding sites are outside the study area, breeding birds forage as far as 9 km from the nest, mostly in the scarce remnant blocks of vegetation and linear roadside strips adjacent to the riverine forests. It often forages in yellow box and grey box, as well as river red gums with abundant mistletoe, and feeds on fallen grain in paddocks and roadsides. It has declined markedly in historical times, having previously been known from both the Melbourne and Mallee areas. Three main threatening processes have been identified by Garnett (1992): a shortage of nest sites; degradation or clearance of foraging sites, flight paths to foraging sites and possibly flight paths during migration; and continued illegal trapping for aviculture.

#### Turquoise parrot *Neophema pulchella*

The turquoise parrot is one of the few threatened species in Australia that has increased in numbers and expanded in range without management intervention. This is remarkable as it had declined spectacularly from being a common species up to the turn of the century in some parts of south-eastern Australia, to being considered apparently extinct in New South Wales and Victoria soon after (Mathews 1917). From 1920 onwards, records of the turquoise parrot became more frequent with a noticeable increase in the 1940s.

In Victoria, it re-emerged in the 1950s and has been progressively building-up its numbers and moving back into former territory ever since. It is now commonly observed near Chiltern and in the Warby and Barambogic Ranges. Elsewhere in the study area, it has been recorded at Killawarra State Forest, Reef Hills Regional Park and, in 1996, in Kamarooka State Park. To further assist the recovery, Quin and Baker-Gabb (1993) recommended that all forest-pasture ecotones be protected from future clearing of native vegetation; that major breeding sites be protected

from logging and control burning to preserve hollow-bearing trees and stumps; that all habitat trees with visible hollows be retained and protected; and that greater numbers of mature trees be allowed to develop.

#### Swift parrot *Lathamus discolor*

The swift parrot is a small, bright green, nectarivorous parrot that breeds only in Tasmania where it nests in tree-hollows. In autumn it migrates to mainland Australia, where semi-nomadic flocks range widely and dramatically throughout winter, before returning to Tasmania from late winter to early summer. Fewer than 1000 pairs exist and, when on the mainland, most of them feed on eucalypt blossom and lerps in box-ironbark forests and woodlands of Victoria and New South Wales. Forestry operations and firewood collection have altered, and continue to alter, the age structure of these forests and woodlands and have resulted in the loss of the older trees which provide a substantial food resource for the swift parrot.

#### Powerful owl *Ninox strenua*

The powerful owl is a large hollow-dependent forest owl that feeds largely on tree-dwelling mammals, such as the common ringtail possum. Garnett (1992) estimated that fewer than 500 breeding pairs occur in Victoria, where its main habitat was usually considered to be mixed-species eucalypt forest in the foothills of the Great Dividing Range. However, with more search effort in recent years, an increasing number of pairs have been located throughout the study area. The powerful owl requires large hollows in which to nest and these hollows take centuries to form. Many of the species on which it preys also depend on hollows. Consequently, the powerful owl may be amongst the species most sensitive to activities that reduce numbers of the largest hollow-rich old trees.

#### Barking owl *Ninox connivens*

The barking owl is a medium-size hollow-dependent owl that feeds on tree-dwelling mammals, bats, rabbits, insects and birds. It generally occurs in drier forests and woodlands of Australia and is now very rare in south-eastern Australia, probably as a result of the extensive clearance of its preferred habitats. Fewer than 50 breeding pairs are likely to occur in Victoria, mostly within the study area. The barking owl is found at sites with moderate

tree cover, generally not in the forest interior, but rather in wooded farmland close to forest patches or on the edges of large forest blocks. A variety of eucalypts are used as nest-trees, including red box, grey box, white box, apple box, red stringybark, river red gum and hill red gum. It seems unlikely that such a small population can survive unless suitable protection and management is afforded to all remaining habitat.

Masked owl *Tyto novaehollandiae*

The masked owl is a large, hollow-dependent owl, with a Victorian population estimated at between 300 and 400 breeding pairs. It has been described as an opportunistic generalist that is widespread in coastal and subcoastal open forests and woodlands, and that extends inland in locally rich patches of habitat which provide tree hollows and adequate prey (Debus 1993). It has not been recorded breeding in the study area. However, reports from near Rutherglen and Redesdale, combined with its known occurrence at sites dominated by river red gum or grey box, including some in plains grassy woodland (Peake *et al.* 1993), suggest that it probably breeds within the study area.

Regent honeyeater *Xanthomyza phrygia*

The regent honeyeater is a striking black, yellow and white, nectarivorous species that is highly mobile and largely restricted to the drier forests and woodlands on the inland slopes and foothills of the Great Dividing Range. Its Australian range has contracted significantly and its population has declined sharply to an estimated 500 to 1500 individuals (Webster and Menkhorst 1992). Within the study area, Chiltern Box-Ironbark National Park, Killawarra State Forest, Reef Hills Regional Park and the Lurg area contain most of the Victorian habitat in which the regent honeyeater now occurs.

Sites now occupied by the regent honeyeater have a greater percentage of tall, mature trees in flower and a taller shrub layer than surrounding unoccupied sites. Preferred nectar-producing trees include mugga ironbark, white box and yellow box and, in the western part of its range, yellow gum. The regent honeyeater was amongst a range of bird species that moved into a small degraded patch of mugga ironbark forest after experimental removal of the noisy miner (Grey *et al.* in review). The noisy miner is an aggressive colonial honeyeater that excludes most other species from its territory, contributing to low bird diversity in

strips of forest or small, grazed patches of forest in farmland. It is possible that the regent honeyeater may benefit from measures that disadvantage the noisy miner, such as protecting forest patches from grazing or establishing new woodlots on fenced patches rather than exposed strips.



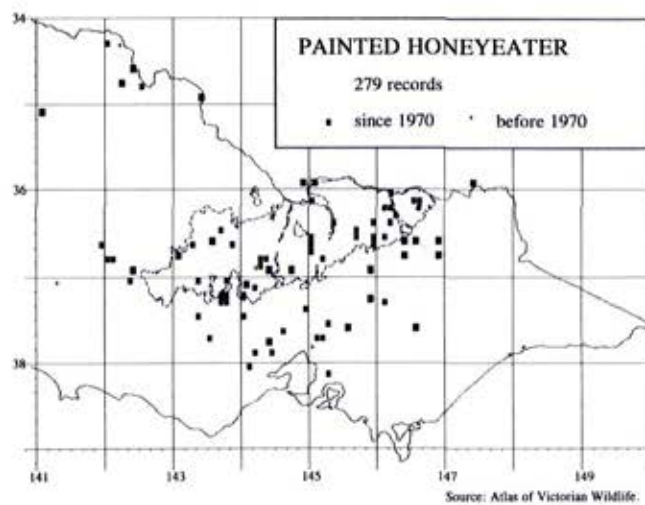
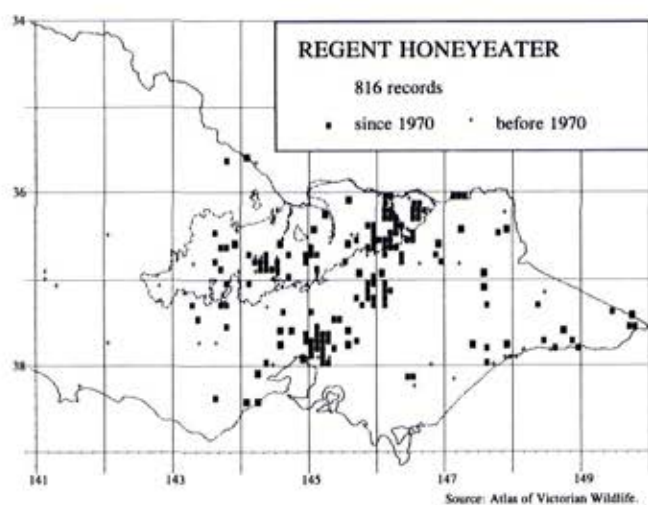
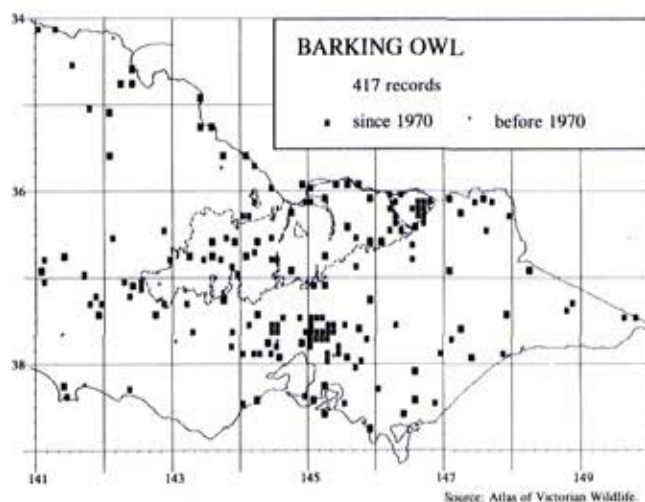
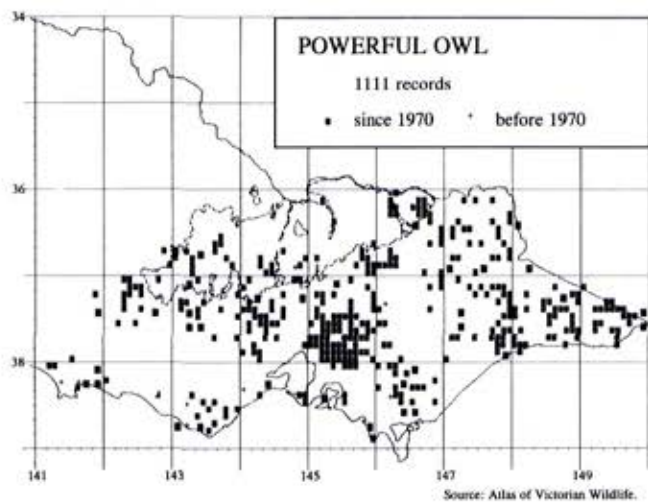
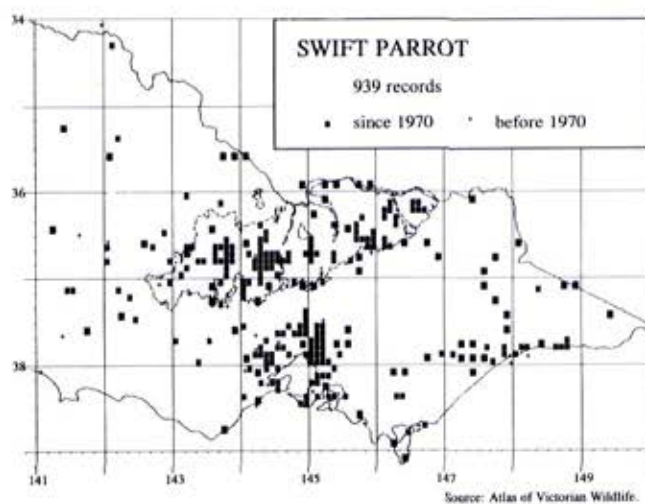
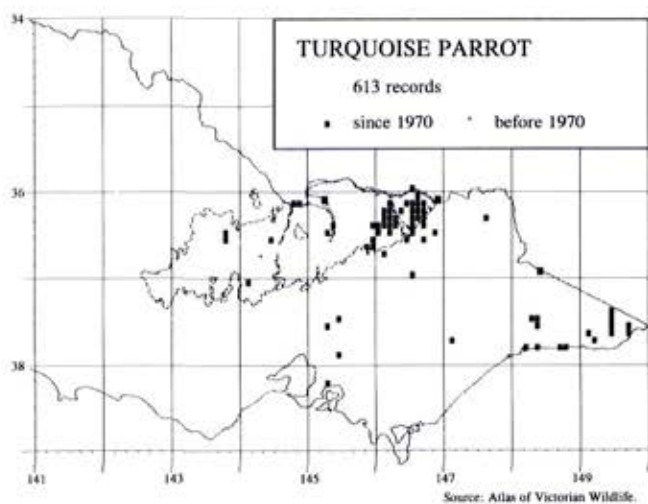
Regent honeyeater.

Painted honeyeater *Grantiella picta*

The painted honeyeater is a specialised, small and attractive rare species with a conspicuous far-carrying call. Its life history is strongly linked with *Amyema* mistletoes that grow on eucalypts and acacias: it feeds on mistletoe fruits, often nests in mistletoes and its movements are apparently correlated with the flowering and fruiting of mistletoes in different localities. It migrates south to Victoria in October, breeds, then mostly departs northward to the semi-arid and arid woodlands of inland and northern Australia by late autumn.

When in Victoria, it largely occurs within the forests and woodlands of the study area, especially near Rushworth,

Figure 7: Distribution of significant fauna species II



and in Chiltern Box-Ironbark National Park and Killawarra State Forest. Robinson (1994) found that it seems to prefer patches, rather than strips, of habitat. In the Bendigo district, the painted honeyeater was a constant visitor until the mid 1950s, but decreased in numbers when the local forest areas were invaded by the cup moth whose larvae defoliated eucalypts, particularly red ironbark, and caused mistletoes on most trees to die. Since then, the painted honeyeater has continued to decline in abundance through to the mid 1970s, but some individuals still visit the area despite the now annual spring defoliation of eucalypts by cup moth larvae.

#### Grey-crowned babbler *Pomatostomus temporalis*

The grey-crowned babbler is a lively and sociable species that uses sticks to build a number of large, domed 'dormitories' in which to roost at night. Once numerous and relatively widespread in Victoria, it has now disappeared from the south-west and is barely surviving elsewhere south of the Great Dividing Range. Most of the Victorian population of about 1500 individuals occurs in the study area, especially in the region between Longwood and Benalla, the Hume Highway and the Broken River (Robinson *et al.* in press). In the Bendigo district, colonies once known from the Kamarooka area disappeared by the end of the 1980s, but according to Bridley (1991) several birds were still present at one site in the southern Whipstick in 1990. The major cause of its decline has been extensive habitat clearance. Other causes include continuing fragmentation, isolation and degradation of the remnants along roadsides and on private land where it now occurs.

#### Apostlebird *Struthidea cinerea*

The apostlebird is a dark grey, noisy species that forages in groups on the ground, and breeds communally in nests constructed of clay. It has declined in south-eastern Australia and is now extinct in both South Australia and the Australian Capital Territory. In Victoria, it has been reduced to two small populations, one in the Mallee and the other in the north-east of the study area where it occurs in remnant *Callitris* pine woodlands, and yellow box and grey box woodlands along the Murray floodplain. It was formerly found in parts of the northern plains that earlier this century had been extensively cleared of box-buloke and *Callitris* pine woodlands.

## Significant taxa – reptiles and amphibians

### Pink-tailed worm-lizard *Aprasia parapulchella*

The pink-tailed worm-lizard is endemic to south-eastern Australia and known only from two disjunct areas: the Australian Capital Territory and neighbouring parts of New South Wales, and around Bendigo in north-central Victoria. The northern populations of the pink-tailed worm-lizard occur in relatively open areas, either tussock grassland or open woodland, characterised by rocks and stones. In Victoria, the species has been recorded from a handful of sites in box-ironbark woodlands or mallee isolates, all in the vicinity of Bendigo. Four 'sub-populations' are known, and this patchiness in the distribution is probably a result of the disturbance (from mining) the area has experienced since European settlement.

The pink-tailed worm-lizard is a small and slender burrowing species, that lives beneath stones and in burrows created by ant colonies. It is a dietary specialist, which according to Osborne and Jones (1995) feeds on at least five species of small ants. The pink-tailed worm-lizard is most threatened by those processes that remove or modify the ground layers it inhabits. Hence, habitat clearance, urban development and pasture improvement will all disadvantage this species. Sites where this species has been recorded have a history of land-use practices such as mining, intensive grazing by stock, eucalyptus oil harvesting, firewood collection and cropping, and these are expected to continue.

### Hooded scaly-foot *Pygopus nigriceps*

The hooded scaly-foot is a heavily-built (up to 17 cm long) legless lizard that is found in arid environments over continental Australia, northern Victoria approximating the southern margin of its distribution. There are very few records for this species in Victoria – three historical records exist for Kewell, north of Murtoa in western Victoria, and Kerang, while more recent records include Lake Ranfurly (west of Mildura), Quambatook and several records from near Mitiamo in 1996 and 1997. The principal threats to this species appear to be those processes that modify or destroy the ground layers it inhabits: habitat clearance, grazing and pasture improvement.

### Bandy bandy *Vermicella annulata*

The bandy bandy has been recorded from across the northern half of the state, although its numbers appear to have declined markedly. There are only 61 records of this species for the state and many of these pre-date 1970. Most recent records are from the Sunset Country in the north-west, and the Wodonga-Beechworth area in the north-east. It is known from a range of habitats, including Mallee Shrublands and dry woodlands. A nocturnal, burrowing elapid snake, this species eats blind snakes. It shelters under embedded rocks or logs, often displaying a high fidelity to the same shelter sites. It probably no longer occurs through much of its known range, due primarily to the impact of habitat loss, cropping and pasture improvement. It is also susceptible to processes that reduce numbers of blind snakes, including soil disturbance by agriculture, predation by feral animals and the reduction in insect prey by insecticides.

### Woodland blind snake *Ramphotyphlops proximus*

Blind snakes are specialised burrowing snakes that are cryptic and infrequently encountered. Four species of blind snake occur within Victoria, and although the woodland blind snake is distributed most widely, it is considered the most uncommon and the most threatened. Like all blind snakes it is oviparous, laying 3–34 (mean 13.2) eggs. Blind snakes are the only terrestrial Australian snakes that feed exclusively on invertebrates, the woodland blind snake feeding mostly on the brood of large stinging ants (*Myrmecia*). There is a clear developmental shift in the size of ants consumed; large individuals take larger prey than smaller individuals, suggesting that a variety of ant species are taken during the life of a blind snake.

In the northern plains, the woodland blind snake is more likely to occur where substrate complexity on or near ground level is high and grazing intensity is low or absent. Blind snakes are rarely encountered on agricultural land that is subject to ploughing or intensive grazing. Their occurrence is probably influenced by soil characteristics such as penetrability, moisture content and particle sizes, and the presence of invertebrate prey. Hence, major threats to the woodland blind snake include habitat destruction and modification — for example, clearing, soil compaction, erosion, grazing — and the elimination or reduction of prey through insecticide use.

### Carpet python *Morelia spilota variegata*

The carpet python is known from woodlands along the major watercourses and rocky extrusions in northern Victoria, though it has declined noticeably and is now considered rare in the state. According to anecdotal reports and museum data, this species has suffered a similar decline in inland New South Wales. It is a semi-arboreal species and rarely found in areas devoid of trees. The major habitat requirements consist of regular shelter sites, and 'safe refugia where they can overwinter with access to basking opportunities' (Shine 1994). A thick litter layer appears to be essential, for use as camouflage and to aid in thermoregulation. Recent records for Victoria reveal that remnant black box and river red gum woodlands associated with a variety of other vegetation types (e.g. *Callitris* woodlands, lignum swamps, and grasslands) still support small populations, as does hill red gum woodlands on rocky extrusions.



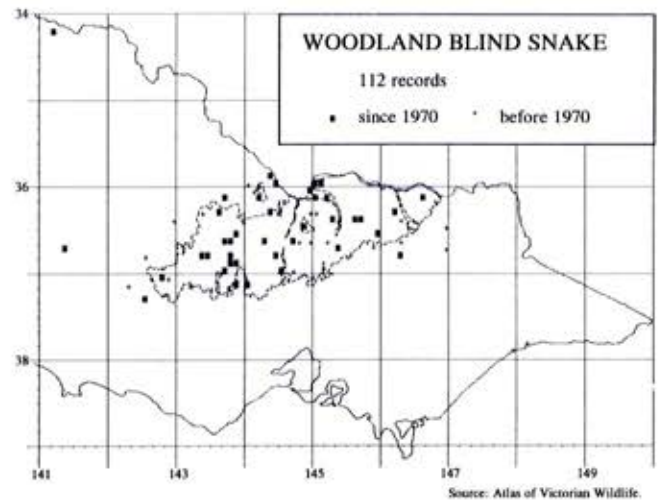
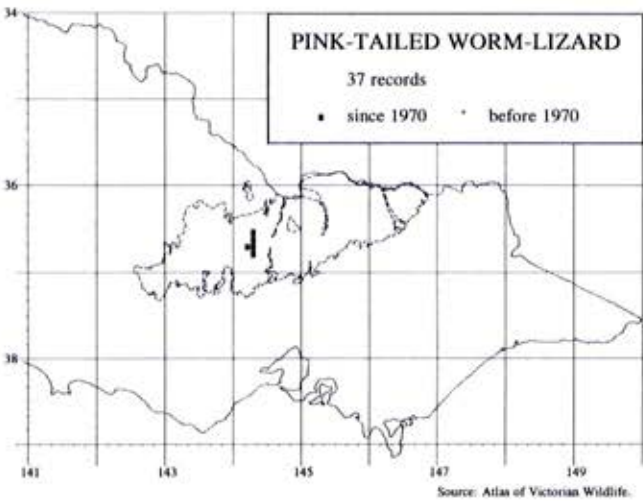
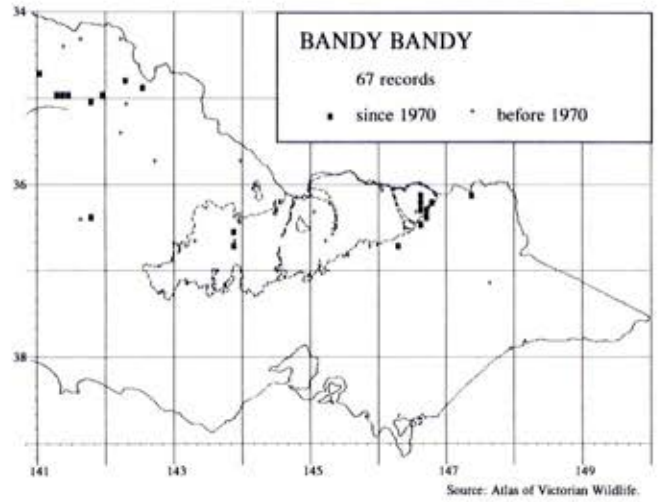
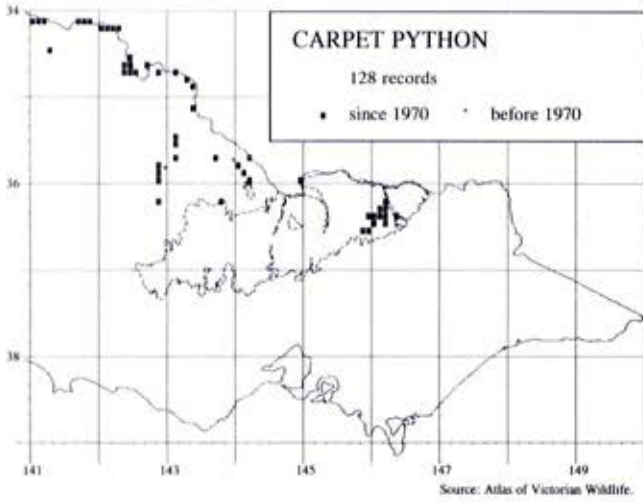
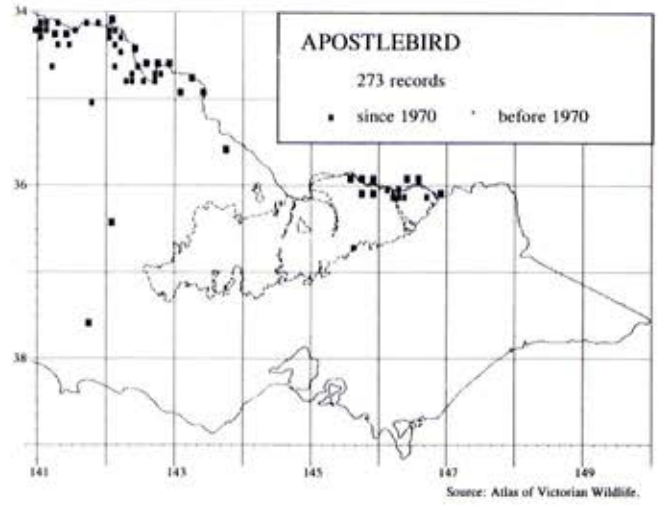
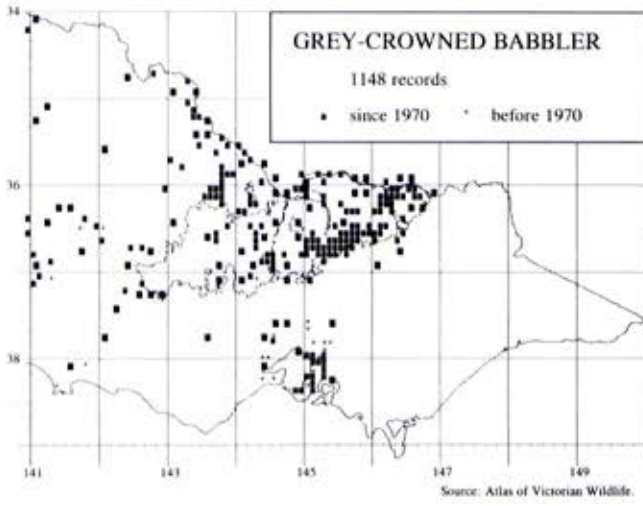
*Carpet python.*

A number of processes threaten the carpet python, including habitat destruction and fragmentation, which have been implicated in the conspicuous decline of pythons in Western Australia and Victoria; habitat degradation, including the loss of hollow-bearing trees and ground debris; and the reduction of native mammal populations. With the current and predicted decline of the European rabbit, due to the impact of Rabbit Calicivirus Disease (RCD), the substitution in the diet of native mammals for this species has precipitated a fresh threat.

### Notable taxa

Notable taxa of the Box-Ironbark study area are listed, with brief comments, in Appendix VIII.

Figure 8: Distribution of significant fauna species III



## FACTORS AFFECTING THE STATUS AND DISTRIBUTION OF THE VERTEBRATE FAUNA

The principal factors that influence patterns of animal distribution comprise those that are environmental, such as climate, topography and major land systems, and hence operate at a regional or continental scale; and those that relate to human land use, modification and disturbance and essentially operate at a local scale. Only anthropogenic (human-generated) factors will be addressed in this section.

### Habitat loss

The removal of over 85 per cent of native vegetation in the study area (mostly from private land), largely for agriculture, is the most profound factor affecting the status and distribution of fauna. As indicated in several chapters (particularly Chapter 7), this clearing has varied in intensity — vegetation on the more fertile soils (with dominant overstorey species of grey box, white box, yellow box and yellow gum) has been cleared extensively, especially on the northern plains. Vegetation types on poorer soils (dominated mostly by red ironbark, mugga ironbark, red stringybark, red box and some grey box) have not been cleared as extensively and form a high proportion of the remnant vegetation.

As a consequence, population sizes of most faunal species present before land clearance are now only a small fraction of what they once were, at least commensurate with and probably in excess of the amount of lost habitat. Grazing and timber removal add to the loss of habitat and further affect abundance.

### Habitat fragmentation and isolation

Remaining habitats across the study area occur as fragments of varying size, increasingly isolated by cleared land. Fragmentation is most severe in the northern plains, whereas there are still some comparatively large blocks in the inland hills (e.g. Rushworth, Dunolly, St Arnaud, Warby Ranges—Killawarra). Small habitat fragments are more susceptible to degrading processes such as fire and weed invasion. Many species are unable to maintain viable populations in small remnants, and this is a problem on the northern plains in particular.

## Timber harvesting and firewood collection

In their original state, box-ironbark forests and woodlands consisted of fairly open stands of comparatively large trees, the largest of which had diameters of up to 1.5 m (Newman 1961). These stands were first felled in the years following the discovery of gold in 1851 and, by the turn of the century, the regrowth that arose was felled at least twice more over extensive areas. The consequent changes in stand structure have resulted in changes to faunal occurrence. Many hollow-dependent species that favour the original hollow-rich open woodlands (e.g. large owls, cockatoos, parrots, squirrel glider and tree goanna) have declined and may have disappeared locally, whereas those species that favour dense seedling regeneration and coppice growth (e.g. superb fairy-wren, chestnut-rumped heathwren, white-eared honeyeater, brown thornbill and yellow thornbill) are likely to have benefited.

Since the turn of the century, much of the most productive forests and woodlands have continued to be harvested, but at greater intervals. However, the overall effect on hollow-dependent fauna is much the same because trees are harvested before tree-hollows form and alternative hollows are limited because most old trees and dead standing trees have been removed. Consequently, many hollow-nesting species have declined or disappeared from forests with few hollow-bearing trees and stumps. One outcome of intensive forestry activities in the larger tracts of native vegetation is that the habitat quality is often significantly poorer than in some smaller fragments (10–80 ha), in which there are larger trees and well-developed understoreys. According to Deacon (1996) densities of widespread arboreal, herbivorous mammals may be almost an order of magnitude greater in good-quality fragments compared with larger tracts. These good-quality fragments may house relatively diverse faunas and may serve as models for habitat restoration in larger tracts.

Firewood collection in forests and woodlands on public land is practised widely and often intensively in the study area (see Chapters 16 and 21). It results in the loss of elements of the ground layer that provide shelter, refuge, foraging and breeding sites for many animals, and there are numerous documented examples of the negative consequences for fauna.

Eucalyptus oil harvesting in the Mallee Shrublands of central Victoria has a major impact on the fauna of those locally-affected areas. The vegetation is cropped every few years and is markedly different from natural Mallee Shrublands in many key respects. Few vertebrate species occur in harvested areas, and those are often inappropriate species of open habitats. The diverse natural fauna disappears. Most affected are mallee-dependent species, including the pink-tailed worm-lizard which is only found around Bendigo, predominantly in Gravelly-sediment Mallee.

## Mining

Box-ironbark forests and woodlands have in the past been degraded severely by gold-mining activities, especially along streams and drainage lines. These are areas that contain the most productive habitats (e.g. deeper soils, larger trees and greater water availability) and may act as drought refuges for fauna. More recent mining operations have extracted gold from alluvial deposits on the more fertile soils, using open pits.

## Habitat degradation

Most of the smaller woodland remnants, especially those amongst farmland, are being degraded through processes such as over-grazing, tree dieback, weed invasion, rising saline groundwater, nutrient inputs, increased temperatures and increased wind speeds (Robinson and Traill 1996). Some of these processes lead to soil compaction, loss of topsoil and erosion of slopes and stream channels, and changes in the structure and floristics of the vegetation with consequent changes to the status and distribution of the fauna.

The cinnamon fungus, which has spread with the assistance of vehicular, human and animal traffic, has seriously affected vegetation in some parts of the study area (e.g. Warby Ranges), reducing habitat quality for indigenous fauna.

## Introduced species

Introduced species in the Box-Ironbark study area interact with native fauna in two main ways: predation and competition. Introduced carnivores (i.e. red fox, cat), prey on a wide range of native species, opportunistically taking animals that are readily available in the area.

The fox is a significant threat to ground-dwelling birds and may be the principal cause of the decline of some species. For example, in New South Wales, the fox has been shown to be a major threat to the survival of the malleefowl. The cat is also considered a significant predator of birds and has been estimated to kill about 11 million birds annually in Victoria (Seebeck *et al.* 1991), while also taking terrestrial mammals and reptiles. Predation of native wildlife by the red fox has been listed as a potentially threatening process under the Victorian *Flora and Fauna Guarantee Act 1988*.

Competition from introduced species may affect native species by limiting the amount of, or access to, available resources. For instance, carnivorous predators potentially compete with large native predators (e.g. spot-tailed quoll, goannas, snakes) for nest-hollows. Also, introduced hollow-nesting bird species, such as the common starling, compete with native species for nesting sites, especially in areas of remnant vegetation.

## Apiculture

Box-ironbark forests and woodlands are one of the major sources of honey in Victoria (see Chapter 16). Commercial hives of the honey bee are located throughout the study area. The honey bee also occurs as feral populations as in other Australian forest systems (Briggs 1993). The effects of the honey bee on native fauna and flora are not well known, but potential effects include:

- competition with native nectar-feeders for nectar and pollen;
- competition for tree hollows with hollow-dependent vertebrate fauna;
- declining reproductive success of native bees; and
- increasing hybridisation of native plant species.

## Fire

Fire affects the structure and floristics of vegetation, and the abundance of other important habitat features (such as fallen timber, tree hollows and leaf litter), and thus in turn, the status and distribution of fauna. Any substantial change in fire regimes is likely to have affected the status and distribution of many vertebrate species, but nothing is known of such effects beyond the links between fire and habitat requirements mentioned above.

## AREAS OF HIGH VERTEBRATE FAUNA CONSERVATION VALUE

With so little remaining, all existing remnant native vegetation has some conservation value for both flora and fauna. Some aspects of the environment that are particularly important for fauna are outlined below.

### Old-growth forests and woodlands

There are very limited areas of old-growth forests and woodlands left in the study area (see Chapter 8). However, an investigation has recently been undertaken to identify areas in the inland hills which have most elements of an old-growth system (T. Soderquist pers. comm.). The largest of these are found within Rushworth State Forest, St Arnaud Range, Wehla State Forest, Mt Bolangum Flora and Fauna Reserve, and Morrl Morrl and Killawarra State forests. As mentioned in Chapter 8, there has been no systematic survey of old-growth or even larger trees on the northern plains but, although disturbance is generally high, many areas — such as along the Broken and Boosey creeks — are known to contain a relatively high proportion of large, old trees.

### Gullies and drought refuge areas

Recent research (T. Soderquist pers. comm.) has demonstrated the importance of gullies for some groups of fauna in box-ironbark forests and woodlands. These gullies contain moist habitat surrounded by drier forest and may act as critical habitat or refuges during summer or dry periods. This study showed that large possums (common brushtail possum, common ringtail possum and sugar glider) were three times more abundant in gullies than on adjacent ridges, and most reproduction in these species was occurring in the moister areas.

### Remnant vegetation in intensively utilised agricultural areas

Most species of wildlife can not survive in totally cleared farmland, and so remnant vegetation is critical for their persistence throughout the study area. Much of the study area now consists of a mosaic of large and small patches and linear strips, isolated amongst cleared grassy paddocks and croplands. In many areas these are all that remain of the native vegetation, and hence are critical to maintaining vertebrate populations. The size, shape and context of particular

remnants determine which vertebrate species can exist there. Those that are part of an interconnected network of remnant vegetation will support a greater species diversity, and can maintain populations of significant species. For example, the extensive roadside network around the Violet Town-Benalla area contains an important population of the grey-crowned babbler.

### Large intact blocks

Large intact blocks of native vegetation are important for a wide range of vertebrate fauna. Some species can survive in remnants surrounded by farmland, but others require extensive areas of habitat. Many bird species are rare or absent from small remnants or narrow roadsides, and are most likely to be found in larger blocks of indigenous vegetation — grey shrike-thrush, rufous whistler, golden whistler, white-throated treecreeper, weebill, and grey fantail, for example (see Bennett *et al.* 1997). In contrast, narrow roadsides are often dominated by birds that use them for nesting or roosting, but feed in farmland (e.g. galah, eastern rosella, Australian magpie, magpie-lark, Australian raven).

### Areas with an undisturbed ground layer

The structure and complexity of the ground layer has an important influence on the occurrence and abundance of many vertebrates. Areas that contain a relatively undisturbed ground layer are significant for ground-dwelling species. Shrubs, grasses, dead trees, logs and woody debris sustain different kinds of animals, providing shelter, basking and reproduction sites. For instance, some of the small reptile species, especially skinks and legless lizards, are adversely affected by simplification of the ground-level structure.

Some roadsides, despite occasional use for the spelling of farm stock and for droving, remain relatively undisturbed environments. There is usually a range of substrate types — such as fallen timber, grass tussocks and leaf litter — along roadsides, offering comparatively high structural heterogeneity. The shrub, herb and litter layers are usually well-developed and soil compaction is rare.

### Revegetation and linkage of existing fragments

The revegetation programs being conducted by Landcare and other community groups in parts of the study area will

benefit fauna, especially the generalist vertebrate species. While farmland revegetation is primarily for land protection, it can have an impact on the future potential for wildlife conservation. According to Bennett *et al.* (1997) revegetated areas will have the greatest benefit for wildlife when:

- they are large, rather than isolated small patches;
- they expand areas of remnant native vegetation;
- they consist of tree species indigenous to the area and soil type;
- they are planned to form linked systems of vegetation; and
- they mimic the native vegetation in composition and structure.

## INVERTEBRATE FAUNA

It is difficult to draw many conclusions about the invertebrate fauna of the Box-Ironbark study area because of the limitations in the data available. There has never been a broad-scale survey of the fauna encompassing the great variation in geographical, physical and temporal factors in the area. The few studies that have been undertaken are limited in their area of sampling, reliance on one collecting method (generally pitfall trapping), and their predominantly short term nature.

### The roles of invertebrates

In numbers of species and individuals, invertebrates dominate the fauna in most ecosystems, where they perform a multitude of ecological functions. The primary functional groups include herbivores (feeding on plants), pollinators, decomposers (of both plant and animal material), parasites, and predators. In terms of the food web, invertebrates are the major food source for many vertebrates. Without invertebrates, the essential ecological functions would not operate successfully.

The diversity of invertebrates is such that the factors determining their distributions are also very diverse. While the EVC is a practical unit for conserving habitat on a coarse scale, the enormous variation associated with invertebrates requires habitat assessment at a finer scale. To this end, habitat is divided into a number of arbitrary, but interacting and intergrading, levels: overstorey, understorey (shrubs, herbs and grasses), the ground layer, the litter layer, and the soil.

Plants are the most obvious habitat. These include the overstorey trees, the understorey shrubs, and the smaller herbs and grasses. The most visible invertebrates are the obvious plant feeders (herbivores), generally insects such as beetles, moths and bugs. Less obvious are the internal plant feeders: the leaf-miners, the gall-formers, and the internal wood feeders (on the woody plants); these are insects such as moths, flies, bugs, and beetles. In some cases, the herbivores may have a very specific relationship with a particular species of plant. Often there are numerous parasitoids and predators associated with these herbivores. Other invertebrates include the pollinators (native bees to name one group), the fungal feeders, and the scavengers (such as ants). Some species of ant have a mutualistic relationship with certain insects; in return for food products (such as sugary secretions), the ants provide protection.

The ground has several layers which are often difficult to distinguish because of the decomposition process. The soil is an obvious and critical habitat for many invertebrates: many of these are decomposers and fungal feeders, but there are also parasitoids and predators. The plant litter (leaves and fine woody debris) and coarse woody debris are important habitats and food sources for many other invertebrates. Many families of moths feed on dead eucalypt leaves as part of the decomposition process. Living trees produce logs (coarse woody debris) and fine woody debris; both of these decompose into leaf litter, humus and soil. Coarse woody debris is important as an invertebrate habitat and as food for invertebrates, and is an important microhabitat to protect against climatic and other extremes such as fire. Invertebrates play key roles in the decomposition of coarse woody debris by attacking wood directly or by influencing other organisms. The ground layer is also the main foraging site for scavengers and seed harvesters such as ants.

The invertebrate faunas associated with these habitats are not static. They can vary in time and space, and one of the important temporal components is succession. Succession can be viewed in the short term (succession of particular components such as leaves and coarse woody debris) or in the long term (age span of trees). Ecologically mature and dead trees are critical for many vertebrates because they provide habitat (hollows, thick bark, fallen limbs) and food (nectar). Some vertebrates forage for invertebrates in rotten wood or under thick bark. Insect secretions (lerps and honeydew) are important food sources for many animals.

## Availability of information

Information for invertebrates is sparse in view of the large number of species that are known and those that remain to be described, and the variety of ecological processes with which they are associated; much remains to be learned about the specific roles of invertebrates in ecological processes. Hence, invertebrates need to be considered differently. From the invertebrate information that is available it is not possible, in the majority of cases, to distinguish between the invertebrate fauna of public land and that of private land, and between different types of habitats.

## The box-ironbark invertebrate fauna

### Composition

Most of the available survey information is at the higher taxonomic (Order) level, although there is species information available for some groups.

### Ordinal level

Representatives from 39 invertebrate orders have been collected in the study area, and derived from the following studies: 34 orders collected by pitfall traps, sweeping and direct searching in the northern plains grey box woodlands (Yen *et al.* 1996), and 37 orders collected in pitfall traps in the current box-ironbark invertebrate survey (Hinkley, unpublished data).

In the case of the northern plains grey box woodland, the numerical dominance of orders varied according to the collecting technique. The dominant groups were ants, spiders, mites, crickets and grasshoppers, bugs, thrips, beetles, and flies.

The current box-ironbark invertebrate survey has recorded the largest number of orders, but this may be due to its wide geographical spread with sites in selected EVCs across the whole inland hills component. The number of orders collected from 12 EVCs ranged from 20 (Low Rises Grassy Woodland) to 35 (Box-Ironbark Forest). However, it is likely that EVCs that were more widely distributed received a greater sampling effort (more sites), resulting in a higher number of orders.

In the inland hills, the dominant elements were ants and wasps (Hymenoptera), beetles (Coleoptera), flies (Diptera)

and bugs (Hemiptera). However, the following Orders were nearly always collected, although in much lower numbers: spiders (Araneae), pseudoscorpions, slaters (Isopoda), cockroaches (Blattodea), crickets and grasshoppers (Orthoptera), psocids (Psocoptera), thrips (Thysanoptera), lacewings (Neuroptera), and moths and butterflies (Lepidoptera). Groups that were collected more sporadically included scorpions, centipedes and millipedes, silverfish (Thysanura), and termites (Isoptera). In most EVCs, the fauna was dominated by ants, followed by beetles or flies. The other major groups were wasps (parasitic Hymenoptera) and bugs (Hemiptera), with larger numbers of grasshoppers and crickets (Orthoptera) in one Heathy Woodland site.

In some of the studies listed above, select orders were identified to the family level (or below). Yen *et al.* identified four orders to family level: 29 spider families, five Orthopteran families, 36 beetle families, and ants (one family).

### Species level

The number of invertebrate species in the Box-Ironbark study area is not known. There are over 100 000 known species of invertebrates (not necessarily formally described) in Australia, and there could be over three times this number remaining to be discovered.

The Museum of Victoria Entomology database has the records for 381 species of insects and for 42 species of arachnids from the study area. The insects include 69 species of beetle, 3 species of cockroach, 3 species of Neuroptera, 8 species of stonefly (Plecoptera), 13 species of caddisfly (Trichoptera), 17 species of Diptera, 22 species of Hemiptera, 9 ant species, 30 species of native bee, 25 species of other Hymenoptera, 110 species of moth, and 72 species of butterfly. The arachnids include one species of Opilionida, 3 species of Pseudoscorpionida, 7 species of Acarina, and 31 spider species. The Invertebrate Zoology Database at the Museum has records of nine native and two introduced species of Molluscs. This record is only a fraction of the collection at the Museum because the database is currently limited to type material and butterflies. Any attempt to determine the actual number of species in the study area would be speculative at this stage.

Some groups of invertebrates are considered in more detail below.

## Gastropoda (slugs and snails)

The Museum of Victoria database has records for 11 species from the study area. Nine species are native, while there are at least two introduced species (*Arion intermedius*, *Helix aspera*).

## Araneae (spiders)

The Museum of Victoria database has records for 31 species. In the northern plains grey boxwoodlands, Yen *et al.* (1996) recorded 29 families: the main families were Araneidae, Clubionidae, Gnaphosidae, Lycosidae, Oxyopidae, Salticidae, Theridiidae, Thomisidae, and Zoridae.

## Isoptera (termites)

In their atlas of Australian termites, Watson and Abbey (1993) record 15 species of termites of which eight species are broadly distributed through the study area.

## Coleoptera (beetles)

The Museum of Victoria database has records for 69 species. Burns and Burns (1992) record 115 species of jewel beetles (Buprestidae). Yen *et al.* listed 36 families of beetles; the main families were Staphylinidae, Curculionidae, Anthicidae, Chrysomelidae, Elateridae, and Lathridiidae.

## Lepidoptera (moths and butterflies)

The Museum of Victoria database has records for 182 species: 110 species of moths and 72 species of butterflies.

## Hymenoptera (ants, wasps and bees)

The Museum of Victoria database has records for 55 species: nine species of ant, 30 species of native bee (Halictidae), and 16 species of other Hymenoptera. Yen *et al.* recorded 74 species of ant, most of which (62 species) were caught by pitfall trapping. Of the 74 species, 17 species were found with more than 100 individuals; one species of *Iridomyrmex* had over 13 000 specimens trapped. The main genera, with numbers of species were *Rhytidoponera* (2 species: one species > 100 individuals), *Meranoplus* (3:1), *Monomorium* (7:3), *Pheidole* (2:1), *Iridomyrmex* (10:4), *Ochetellus* (1:1), *Tapinoma* (1:1), *Camponotus* (10:3), *Melophorus* (10:1),

and *Paratrechina* (3:1). The ants in the box-ironbark disturbance project are still being sorted and identified; already 30 species have been identified from two of the 800 samples taken in this project.

## Threatened species

Eight species from the Box-Ironbark study area have been assigned a conservation significance rating (either listed under the *Flora and Fauna Guarantee Act 1988* or included in the Threatened Fauna List for Victoria — CNR 1995). Seven of the species are Lepidoptera and one is an ant.

### Large ant blue butterfly

*Acrodipsas brisbanensis* (Lepidoptera: Lycaenidae)

Conservation status: Rare in Victoria (CNR 1995); Threatened (*Flora and Fauna Guarantee Act 1988*).

A species found in dry eucalypt forest and woodland habitat adjacent to potential hill-topping areas. It is associated with *Papyrius* ants. It has been found in areas within the greater Melbourne region, the You Yangs, and the Little Desert. In the Box-Ironbark study area, it has been found at Mt Korong (near Wedderburn).

**Fiery jewel** *Hypochrysops ignitus ignitus* (Lepidoptera: Lycaenidae)

Conservation status: Rare in Victoria (CNR 1995).

A species found in open eucalypt woodland and mallee. It is associated with ants (*Papyrius* sp.). In the study area, it has been found near Tallarook.

**Icilius blue** *Jalmenus icilius* (Lepidoptera: Lycaenidae)

Conservation status: Rare in Victoria (CNR 1995).

This species has a wide distribution but is very local in occurrence, especially in Victoria, where it is found near Red Cliffs, in the Grampians, and in Kooyoora State Park near Wedderburn.

**Genoveva azure** *Ogyris genoveva araxes* (Lepidoptera: Lycaenidae)

Conservation status: Rare in Victoria (CNR 1995).

A species confined to central and western Victoria. It is found in woodland, mallee and dry forests that have

the mistletoe *Amyema miquelii* and a species of *Camponotus* ants. Within the study area, it has been recorded at the Warby Ranges, Heathcote, and Mt Kooyoora.

### Eltham copper butterfly

*Paralucia pyrodiscus lucida* (Lepidoptera: Lycaenidae)

Conservation status: Vulnerable in Victoria (CNR 1995); Threatened (*Flora and Fauna Guarantee Act 1988*).

This species feeds on *Bursaria* and is attended by ants of the genus *Notoncus*. It is now only found in three areas: Kiata, Eltham, and in remnant bushland within the Castlemaine Botanic Gardens.

### Sun moth *Synemon theresa* (Lepidoptera: Castniidae)

Conservation status: Extinct in Victoria (CNR 1995); Extinct (*Flora and Fauna Guarantee Act 1988*).

This species was originally found at Ararat and Castlemaine, but it has not been recorded in Victoria since 1910. Little is known about its habitat requirements.

### Golden sun moth *Synemon plana* (Lepidoptera: Castniidae)

Conservation status: Endangered in Victoria (CNR 1995); Threatened (*Flora and Fauna Guarantee Act 1988*).

A species whose range has contracted considerably since European settlement. It requires open woodland with a

ground cover of the native grasses *Danthonia* and *Stipa*. In the Box-Ironbark study area, it has been found north of Tallarook.

### Bullant *Myrmecia* sp. 17 (Hymenoptera: Formicidae)

Conservation status: Vulnerable in Victoria (CNR 1995); Threatened (*Flora and Fauna Guarantee Act 1988*).

Across central Victoria, populations have been found at 56 sites ranging from west of Horsham to north-west of Wangaratta; 54 of these sites are located within the Box-Ironbark study area. They are in 17 state forests, 4 flora and/or fauna reserves, 2 historic reserves, 2 State parks, and one roadside verge. Wainer (1996) undertook a survey of this species in the Fosterville region. It is primarily found in grey box, yellow gum or mallee eucalypts with a sparse understorey but with conspicuous and dense leaf and twig litter layer. Higher population densities were found at the Mt Bolangum Flora and Fauna Reserve, the Tottington, Kamarooka, Mt Brenanah, Crosby, Rushworth and St Arnaud State forests.

### Threats

The major threats facing invertebrates are habitat destruction and disturbance, and exotic species. These are similar to the processes which threaten vertebrate species and include habitat loss and disturbance, mining, grazing, pests and introduced species.

## 10. PUBLIC LAND USE

### BACKGROUND

In comparison with other Victorian regions, public land use of the Box-Ironbark study area has a distinctive pattern. It is characterised by a fragmented public estate and diverse public land use, within a dominant freehold land matrix. Several moderate sized State forest areas, one national park and seven State parks are spread in a setting of private land, along with thousands of small Crown land parcels.

In contrast, the Eastern Highlands forests have an extensive, almost continuous band of State forest surrounding the major Alpine and Snowy River national parks and other parks, with some freehold areas. The west is mainly freehold, with large national parks — Murray-Sunset, Wyperfeld, Grampians, and Little Desert — and relatively small areas of State forest and other reserves.

Present public land uses in the broad Box-Ironbark study area derive largely from 11 Land Conservation Council area investigations, reviews and special investigations. Boundaries of the investigation areas are shown on Map A. This chapter outlines the relevant recommendation categories and comments on some changes in public land status, implementation of past recommendations, and minor categories of particular relevance to the area.

Approved LCC recommendations apply to most public land in the State outside Melbourne's municipalities. Crown and public authority land in rural cities and townships was also excluded from previous studies. This included urban Crown lands around Ararat, Bendigo, Benalla, Wangaratta, Shepparton, Echuca, Eaglehawk, Kyabram, Maryborough, Castlemaine, Stawell and St Arnaud. Ararat, Stawell and St Arnaud were included in the recent Historic Places South-western Victoria Special Investigation, but have not had a comprehensive public land use investigation. The former Rural City of Seymour was excluded from the recent Melbourne Area District 2 Review, but public land there is subject to the 1977 Melbourne Area recommendations.

### PUBLIC LAND USE CATEGORIES

The Box-Ironbark study area displays most of the public land use categories used by the LCC. However it has no wilderness areas, essentially natural catchments, coastal or marine uses, or alpine resorts.

In its Statewide Assessment of Public Land Use report in 1988, the LCC proposed simplifying the previous system of 48 land use categories. A simpler system of 19 categories was used in the Melbourne Area District 2 Review recommendations. However the old categories are still in force for most of the study area. Table 22 lists the past and present public land use classification systems for categories represented in the Box-Ironbark study area. The following overview uses the new system of categories, with reference to the old system where necessary. Map A shows public land by category. Within the Box-Ironbark study area they are labelled by category letter.

#### National parks

At opposite ends of the Box-Ironbark investigation area are two national parks — the Grampians in the west, outside the study area, and the 4230 ha Chiltern Box-Ironbark National Park, newly designated at Chiltern. Along with State parks, national parks are set aside to conserve and protect natural ecosystems, while providing opportunities for recreation and education associated with the enjoyment and understanding of natural environments. The natural features of the national and State parks in the study area are documented more fully in Chapter 11.

#### State parks

State parks and national parks are parts of the primary system of substantial reserves in natural environments, selected to represent major land systems occurring on public land across the State. For example, the seven State parks in the study area reflect a variety of geological material: Kara Kara in St Arnaud Range and Paddys Ranges south of Maryborough are located on Palaeozoic sediments;

**Table 22: Public land use categories relevant to the Box-Ironbark study area**
**Present and former classification systems**

Simplified LCC category	Sub-categories	Equivalent former LCC category
Reference Area		Reference Area
National Park		National Park
State Park		State Park
Regional Park		Regional Park
		Multi-purpose Park
Nature Conservation Reserve <sup>1</sup>		Flora Reserve
		Flora and Fauna Reserve
		Wildlife Reserve <sup>1</sup>
Natural Features Reserve	Natural and Scenic Features Area	Scenic reserve
	Geological and Geomorphological Features Area	Geological Reserve
	Wildlife Area <sup>1</sup>	Wildlife Reserve <sup>1</sup>
	Stream-side Area	Streamside Reserve
	Stream Frontages, Beds and Banks	Public Land Water Frontage Reserve
	Bushland Area	Bushland Reserve
	Highway Park	Highway Park
	Mineral Springs	Other Reserves and public land (Mineral Springs)
Water Production		Water production (reservoirs and buffers)
		Water use and regulation
Historic and Cultural Features Reserve		Historic Area
		Historic Reserve
Community Use Area	Education Area	Education Area
	Recreation Area	Recreation Reserve
	Parklands and Gardens	
	Buildings in Public Use	Utilities and Survey (schools, public halls, other buildings in public use etc.); Other Reserves and Public Land (as above)
State Forest		State Forest
		Hardwood Production
		Uncommitted Land
		Forest Area
		Eucalyptus Oil Production
Plantation		Softwood Production
	School Plantation	School Plantation
Earth Resources		Mineral and Stone Production
	Stone Reserve	
Services and Utilities	Transport	Roadside Conservation, Utilities and Survey
	Electricity and Gas	Utilities and Survey
	Communications, Survey and Navigation	Utilities and Survey
	Municipal Buildings and Services	Utilities and Survey Township Land, Other Reserves and Public Land
	Hospitals, Public Offices and Justice	Utilities and Survey
	Water and Sewerage Services	Water Production, Water Regulation and Drainage; Utilities and Survey (parts)
	Cemeteries	Cemeteries
	Other Utility Uses	Utilities and Survey Township Land, Other Reserves and Public Land
Uncategorised Public Land		Other Reserves and Public Land, Township Land
	Revegetation Area	Revegetation Area
Land not required for public purposes		Township Land, Agriculture

**Notes:**

1. *Wildlife reserves provisionally classified by NRE as not available for hunting are shown on Map A as Nature Conservation Reserves. Those wildlife reserves where hunting may be permitted are shown as Natural Features Reserves.*
2. **Victorian Heritage Rivers** — identified in the Rivers and Streams Special Investigation — are overlays on other reservations.

granitic landscapes constitute Kooyoora near Rheola, Terrick Terrick at Mitiamo, and Warby Ranges west of Wangaratta; while Kamarooka and Whipstick north of Bendigo are on remnants of a Tertiary surface rich in ironstone gravels. These parks total 27 780 ha. State parks are generally smaller and less diverse than national parks.

Other State parks in the investigation area — Mt Langi Ghiran, Mt Buangor, Mt Samaria and Barmah — do not carry box-ironbark vegetation, and are outside the study area.

## Regional parks

Situated close to towns, the LCC recommended these parks to give opportunities for nature-based informal recreation to large numbers of people. Regional parks at Ararat, Maryborough, Wodonga, Reef Hills near Benalla, Eaglehawk and One Tree Hill at Bendigo total 7445 ha. Part of the Beechworth Historic Park and a small part of the Hepburn Regional Park are also included. These provide for recreation and also aim to protect vegetation and faunal habitat. Regional parks are generally of the order of 1000 ha.

### Multi-purpose park (former category)

Mt Pilot multi-purpose park, 13 630 ha, is the only one of its type in Victoria. The objects of management were to provide opportunities for recreation and environmental education, to conserve and protect natural ecosystems, and to rehabilitate degraded areas. Permitted uses include low-intensity hardwood production, gravel extraction, apiculture, grazing, fossicking and military training. The LCC indicated that this area should eventually be reserved as a State park. The multi-purpose park category is obsolete and could be reviewed in this investigation.

## Reference areas

To maintain natural ecosystems into the future, and as a reference for comparison with similar land under other uses, reference areas have been identified and most have been securely reserved. Eleven small areas totalling 3760 ha have been set aside in the Box-Ironbark study area. They were selected on the basis of their constituent land systems, forming parts of a representative network across the State. Land systems (see Chapter 6) have repeating

patterns of components, and all components should be adequately represented.

The reference areas are, from west to east: Mt Separation, Korong Vale, Kooyoora, Sandhurst, Terrick Terrick, Kamarooka, Rushworth Forest, Warby Range, Killawarra, White Box Ridge and Pilot Range. They range in size from 90 ha to 1130 ha.

Many land systems, particularly those sought after for agriculture, have been almost entirely modified from natural or semi-natural condition, and suitable land for reference areas is not available.

## Nature conservation reserves

Some 33 areas have been previously recommended as flora reserves or flora and fauna reserves. These are recommended to be securely reserved, and managed primarily to conserve and protect indigenous plant or animal species, communities or habitats. Together they contain important sites with particular biological significance. Their total area is 20 320 ha.

The values of the nature conservation reserves vary, but include occurrences of individual rare or threatened plant species; representative, diverse or intact examples of particular communities; limit-of-range sites; remnants of largely modified land systems; places with recorded presence of rare or endangered fauna, or diverse faunal assemblages; and representative examples of habitat.

Wildlife reserves are included with nature conservation reserves where hunting is not permitted; other wildlife reserves are natural features reserves. Five recommended wildlife reserves — Gum, Lehmann, Shire Dam and Bells Swamps, and Tabilk Lagoon — are considered by the land managers, the Department of Natural Resources and Environment (NRE), to be nature conservation reserves (NRE 1996).

## Historic and cultural features reserves

The LCC recommended 9 Historic areas and 36 Historic reserves in its various earlier investigations, including 12 proposed reserves in the recent Historic Places South-western Victoria Special Investigation, a total of 10 030 ha. This excludes the Stuart Mill Historic Area, recommended to be revoked in the Historic Places Special Investigation. Some study areas — Murray Valley,

Wimmera and North-eastern Area District 3 — did not have detailed surveys of historical sites. Additional material has recently been collected in these areas for this investigation.

### Natural features reserves

This public land use category combines several former categories which are represented in the Box-Ironbark study area, on the basis that they have broadly similar land use objectives. Table 23 lists these and summarises their occurrence in the study area.

### Community use areas

Education areas representing a range of land types have been recommended to be set aside for environmental education. In the study area they are at Deep Lead near Stawell, Mt Egbert near Wedderburn, Faraday near Castlemaine, Lake Eppalock, Waranga near Rushworth, Wallaby Hill in Killawarra State Forest, and Mt Barambogic near Chiltern. They contain 2890 ha.

Recreation reserves are also community use areas. These are available for organised sports (team sports, horse racing, golf etc.), or for informal recreation (picnicking, camping etc.) as appropriate, and total 3410 ha. Many are located near large and small towns across the area.

### Water production

The water production category includes water supply storages, areas used primarily for water supply protection around the margins of domestic supply reservoirs, and offtakes that obtain their supply from catchment flows. In the Murray Valley and Wimmera study areas, where water was not produced but water from outside was distributed for stock and domestic or irrigation uses, the equivalent category was 'water use, regulation and drainage'.

The Box-Ironbark study area contains several major catchment reservoirs — Tullaroop, Laanecoorie, Cairn Curran, Eppalock — and off-stream storages — Waranga and Mokoan — as well as many smaller public domestic supply offtakes and storages, diversions, and distribution structures for irrigation. Total area — mainly water surface — is 25 900 ha.

### State forest

For the North Central, Ballarat and South-western District 2 study areas, LCC previously recommended

**Table 23: Natural Features Reserves — occurrence of former categories in the Box-Ironbark study area**

Former public land use category	Number and total area (ha)
Geological reserves	5; 65
Bushland reserves	356; 6130
Wildlife reserves (note 1)	15; 3390
Scenic reserves	10; 2400
Highway parks	3; 75
Public land water frontage reserves	23 500 (note 2)
Streamside reserves	72; 1830
<b>TOTAL AREA</b>	<b>37 390</b>

#### Notes:

1. These wildlife reserves may be seasonally available for hunting.
2. Public land water frontage reserves exist, often as 20 m-wide strips, along one or both sides of many streams. Some are shown on Map A. They are depicted on original recommendations maps, and are shown accurately on parish plans.

core timber harvesting areas as 'hardwood production' category, and unreserved Crown land areas (unless subject to another recommendation) as 'uncommitted land'. After 1983, the LCC combined such lands along with 'forest areas' — native bush around softwood plantations — as 'State forest' category. The old categories apply to most of the area of native forest currently available for timber in the study area, which totals 204 320 ha. Eucalyptus oil production areas totalling 11 440 ha were specifically recommended in the North Central area. The hardwood production, uncommitted land and eucalyptus oil production areas are coloured the same as State forest on Map A, but are separately labelled.

The recommendations also included guidelines for operations and identified research needs.

### Softwood production

Only small areas — at Castlemaine, Mt Alexander and Chiltern (Barambogic), totalling about 920 ha — in the Box-Ironbark study area were recommended for softwood production. Wetter parts of the investigation area have extensive plantations, but generally the typical box-ironbark environment is too dry for productive pines.

The Mt Alexander and Barambogic plantations are at present managed by the Victorian Plantations Corporation, although in 2015 Mt Alexander reverts to the Crown, and is to be restored to eucalypt forest.

## Earth resources

These areas were recommended specifically for mineral and stone production. 'Stone' is defined broadly to include many extractive industry products. Most of the recommended area, totalling 1880 ha, is small parcels set aside for municipal gravel resources. In large public land areas, the land managers may extract stone as required for management needs. Under the *Mineral Resources Development Act 1991*, much public land other than key parks and reserves is available for exploration for and production of minerals, mainly gold. The recommendations for mineral exploration and production varied between study areas, but most public land is available.

## Services and utilities

Numerous service and utility installations are located on public land, some involving Commonwealth-controlled activities such as communications towers. Areas specifically recommended total 1830 ha, but these are generally small and are not shown on Map A.

## Uncategorised public land

This category includes land, often in small rural parcels or in townships, that was previously recommended as *Other reserves and public land* or *Township land*, or for which no

primary use was recommended. With new information from subsequent surveys or NRE Crown land assessments, these areas can be categorised for a particular public use, or if no public land values are present, assessed as surplus. On Map A, land in cities and towns for which no previous LCC recommendations were made is also shown as uncategorised public land. Some 16 560 ha are included.

## Agriculture

This includes 1000 ha of public land recommended to be alienated, generally for agriculture. Also shown in this category are 1090 ha used for agricultural research. If this use is ongoing, the latter may be better classified as Services and Utilities.

## CHANGES OF STATUS

Chiltern and Reef Hills parks were recommended as regional parks and brought under Schedule 3 of the *National Parks Act 1975*. Chiltern is now a national park following recent legislation. Several areas have been reappraised in response to changing needs, for example, the recommendation applying to part of the Bailieston Historic Area was revoked in 1996 after reassessment of its historical values and consideration of a mining proposal. Two of the small softwood plantations in the study area are vested in and managed by the Victorian Plantations Corporation, a Government business enterprise. Numerous small blocks, particularly in rural cities and towns, have been sold after assessment. Several institutions, including

**Table 24: LCC investigations in the Box-Ironbark investigation area — final recommendations dates and areas**

Investigation	Year final recs. published	Date of approval of final recs. <sup>1</sup>	Total land in the investigation area (ha)	Public land in the study area (ha)
North Central	1981	24/8/82	1 933 200	322 070
Murray Valley	1985	30/9/86	1 541 700	43 830
Ballarat	1982	22/11/83	485 000	5 490
North-eastern Area (Benalla-Upper Murray) Review	1986	11/2/87	441 800	29 350
Melbourne Area	1977	1978-1982	498 200	24 120
Melbourne Area District 1 Review	1987	23/8/88	316 300	21 330
Melbourne Area District 2 Review	1994	17/6/97	181 900	190
South-western Area District 2	1982	22/11/83	590 800	9 480
Wimmera Area	1986	22/9/87	311 100	1 330
Mallee Area Review	1989	8/5/90	76 900	—
Rivers and Streams	1991	7/7/92	(All public land along streams)	
Historic Places South-western Victoria	1997	24/6/97	1 437 000	41 870

Note: 1. This is the date of the Order in Council for most or all of the recommendations, except for the Melbourne Area 1977.

Aradale (Ararat), have been closed in recent years. These sites generally do not carry box-ironbark vegetation. Privatisation of electricity supply utilities has meant certain parcels are no longer public land.

## ACCEPTANCE AND IMPLEMENTATION OF RECOMMENDATIONS

Table 24 lists the dates of Government approval of the previous recommendations for the Box-Ironbark study area. Government variations, LCC amendments and other charges are summarised in Table 25. The recommended State parks have been reserved under the *National Parks Act 1975*, and management plans completed for Kooyoorra, Kamarooka and Whipstick, and drafted for Kara Kara, Terrick Terrick, and Paddy's Ranges. A draft plan is in preparation for Warby Ranges. The Mt Pilot park has not been reserved. Some of the recommended nature conservation reserves have been reserved, and various bushland and other minor reserves brought under the *Crown Land (Reserves) Act 1978*. According to the Department of Natural Resources and Environment, other areas are being managed in accordance with the recommendations.

## SMALL BLOCKS AND LINEAR PUBLIC LAND

There are some 7000 small blocks of public land in the Box-Ironbark study area. The Council holds information on several hundred of these in small block reports from previous investigations. NRE regional offices have been carrying out Crown land assessments in particular areas. To update this information and to collect data on blocks not previously assessed, and with the support of the Commonwealth Government through Environment Australia, LCC initiated a survey of 180 small blocks selected using aerial photos. The outcome from that study will combine with data from several NRE studies of small reserves and blocks with habitat value, to greatly expand the information base.

Road reserves and unused roads often contain important remnant habitat, particularly in mainly cleared farm landscapes. Public land water frontage reserves are often of value for their contributions to habitat, stream condition, recreation, public access and bank stability. Many are also

licensed to adjoining landowners. All public frontages are subject to the recommendations of the Rivers and Streams Special Investigation.

Closed railway lines across the study area can have recreation, habitat or historical values. Where they are surplus to the Public Transport Corporation's requirements, they are being assessed by NRE for public land values including possible 'rail trail' establishment.

## COMMONWEALTH LAND

The Department of Defence utilises and manages the following areas in the Box-Ironbark study area:

- Puckapunyal Military Area (PMA) — Situated 10 km west of Seymour and comprising 41 400 ha of gently undulating cleared and forested land. Approximately one-third of the area is covered by box-ironbark forest and woodlands, much of which has high conservation value. PMA is the Army's largest and most intensively utilised training area in southern Australia, being used 365 days a year for live firing and dry training activities. The PMA includes the Graytown Proof and Experimentation Establishment (P&EE) which is used for testing and proving ammunition, weapons and propellants.
- Mangalore Munitions Depot — 10 km north of Seymour and approximately 510 ha in area. Used for storage and distribution of ammunition. Approximately one-third of the Mangalore Munitions Depot is covered with box and stringybark forests.
- Stawell — 160 ha rifle range which is mostly cleared.
- Small Reserve Army Depots situated at Bendigo, Maryborough, Horsham and Shepparton, each 1 to 5 ha in area with little if any native vegetation.
- Longlea Munitions Depot (disused) — approximately 600 ha located adjacent to the Wellsford Forest, north-east of suburban Bendigo. This area is no longer required for Defence purposes. It contains Box-Ironbark Forest over most of the area.

Other Commonwealth owned or controlled land consists of very small parcels of land generally within town boundaries and used as offices.

## PAST INVESTIGATIONS

This section outlines the past LCC investigations in the Box-Ironbark Investigation area.

The investigations were of four types:

- (1) original study area investigations — the areas partly within the Box-Ironbark study area are described below;
- (2) reviews of the original study areas, after at least 10 years — four areas partly within the Box-Ironbark study area were reviewed;
- (3) special investigations of particular regions — the recent Historic Places investigation of South-western Victoria and the Ovens Softwood Plantation Zone investigation affected parts of the study area;
- (4) State-wide studies — the Rivers and Streams special investigation resulted in some relevant recommendations.

The year of publication and date of approval of each set of final recommendations, and areas of public and total land, are listed in Table 24. The boundaries of the various investigations are shown on Map A, along with the recommended public land use. Appendix IX summarises public

land uses by category in each of the former investigation areas, and also lists the EVCs occurring in each category.

### Rivers and Streams Special Investigation

This study identified 17 heritage rivers, of which the Goulburn River is partly within the Box-Ironbark study area, and the Lower Ovens River adjoins it.

The Rivers and Streams investigation also developed general recommendations for improved management of rivers, creeks, water frontage reserves and their various environmental, recreational, scenic and cultural heritage values, as well as consumptive and productive uses.

### Historic Places Special Investigation — South-western Victoria

Numerous historic places on public land in and around Ararat, Stawell, St Arnaud and Charlton were the subject of recommendations in this investigation. Implementation of recommendation M16 (at Deep Lead near Stawell) is to be held in abeyance until the Box-Ironbark investigation considers this site, where both heritage and natural values are present.

**Table 25: Summary of Government variations, amendments and other changes**

<b>North Central Area</b>	
<ul style="list-style-type: none"> <li>• A1(b) Kara Kara State Park — grazing reviewed, discontinued 1995</li> <li>• A2 Kooyoora State Park — A2(a) deleted, gravel site excluded</li> <li>• A3 Kamarooka State Park — gravel extraction ceased and reclaimed by 1991; additions to park by land exchange and purchase</li> <li>• A8(g) Eaglehawk Regional Park — conditional timber extraction permitted</li> <li>• C18 Murchison Lagoon — wildlife reserve added</li> <li>• D45A Inglewood Reservoir — off-stream storage added</li> <li>• E6(iv) Pyrenees Range hardwood production area — yellow box stands along the ridge to be protected</li> <li>• H13 Dalyenong Flora Reserve — grazing phased out in 1991</li> <li>• I49 deleted — not public land</li> <li>• I67, I76 bushland reserves — gravel clause inserted</li> <li>• I152 deleted — added to public land water frontage</li> </ul>	<ul style="list-style-type: none"> <li>• J2 Percycdale Historic Area — approved 26/6/84</li> <li>• J19 Bailieston Historic Area — part revoked 5/12/95</li> <li>• M4 Waranga Education Area/R77 stone reserve — boundaries altered</li> <li>• N5 Pink Cliffs Geological Reserve — revoked 8/8/95</li> <li>• R67 stone reserve deleted; uncategorised public land</li> <li>• R86A additional stone reserve; vegetation to be protected</li> <li>• S16A addition to Carisbrook tip</li> </ul>
<b>Murray Valley Area</b>	
<ul style="list-style-type: none"> <li>• A3 Warby Range park — quarry reserve R18 included</li> <li>• B1 Terrick Terrick reference area — relocated</li> <li>• L7A Dell'oro Road — additional roadside conservation site</li> <li>• Q10A Killawarra — additional land for agriculture</li> </ul>	
<b>North-eastern Area (Benalla-Upper Murray) Review</b>	
<ul style="list-style-type: none"> <li>• I2, I13 bushland reserves — affected by Hume Freeway</li> <li>• U23 part excised</li> </ul>	

# 11. NATURE CONSERVATION

## INTRODUCTION

In the last three decades or so nature conservation has been a consistent and significant consideration in land use and management. The benefits of nature conservation — see DEST (1993) — are now recognised throughout the community, and there is widespread commitment to conserving natural values, as exemplified in the *National Strategy for the Conservation of Australia's Biological Diversity*, signed by the Commonwealth and all State and Territory governments.



*Narrow strip of Creepline Grassy Woodland EVC (dominated by river red gum) in Box-Ironbark Forest EVC, Killawarra State Forest.*

## Biodiversity and nature conservation

Both the popular and the scientific notions of nature conservation have changed greatly over the course of

a few years: concepts such as old-growth forest and wilderness conservation for example have come under the nature conservation umbrella. Perhaps the most significant recent development in this context has been the rise to prominence of the concept of biodiversity. Biodiversity — or biological diversity — encompasses the full extent of nature's variety, including not just all life forms, but also such things as ecological and evolutionary processes, the variety of genetic material contained in the life forms, and their relationships with each other. Thus, it is a broad concept and has the potential for expansion as our understanding of nature's variety improves.

The complexity and extent of the concept of biodiversity presents many practical difficulties in its application to nature conservation. Conservation biologists use various approaches and approximations when working with biodiversity. The most common approach is to consider it at three levels: genetic, species and ecosystem diversity. Another common perspective is the division between alpha — or local — diversity, and beta diversity — variety among areas (such as the number and distinctness of habitat types in a region). Species richness — the number of species in an area or an ecosystem — is one of the simplest approximations of biodiversity.

## Approaches to nature conservation

There are numerous, often complementary or overlapping, perspectives from which nature conservation can be approached.

- Efforts to **save threatened species and communities** represent the most widely known and readily understood approach. Threatened birds and mammals in particular sometimes assume symbolic status for the full complement of biodiversity with which they share their habitat. The Victorian *Flora and Fauna Guarantee Act 1988* and the Commonwealth *Endangered Species Protection Act 1992* are the most pertinent legislative manifestations of this approach. Appendix II lists some other examples.
- The maintenance of biodiversity is a central tenet of **ecologically sustainable development**, which characteristically operates at the broad policy framework level

— the National Strategy for Ecologically Sustainable Development, for example.

- The **management of threatening processes** is often related to the conservation of threatened species, but may also be applied for less specific biodiversity conservation. Programs to control pest plants and animals that threaten natural values exemplify this approach.
- **Environmental impact assessment** and amelioration in response to specific development proposals usually includes the assessment of potential adverse impacts on natural (and other) values and recommendations for amelioration. In Victoria, formal environmental impact assessment is conducted in accordance with the *Environment Effects Act 1978*.

Ultimately, the most important approach to the systematic conservation of biodiversity is the establishment of **reserve systems** that specify the appropriate use and management of land against relevant criteria. The establishment of a national reserve system is central to the National Strategy for the Conservation of Australia's Biodiversity.

## RESERVE SYSTEMS

Closely linked to the evolving concepts of biodiversity and nature conservation have been significant developments in the theory and practice of reserve selection and reserve system design. Most developments have been in two main areas — protected areas and management categories, and the incorporation of comprehensiveness, adequacy and representativeness into reserve system design — which are described below.

### Protected areas and management categories

The World Conservation Union (IUCN 1994) defined a 'protected area' as:

*An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means.*

Six management categories have been developed to group the different kinds of protected areas found around the world:

- Ia Strict Nature Reserve — protected area managed mainly for science.
- Ib Wilderness Area — protected area managed mainly for wilderness protection.
- II National Park — protected area managed mainly for ecosystem protection and recreation.
- III Natural Monument — protected area managed mainly for conservation of specific natural features.
- IV Habitat/Species Management Area — protected area managed mainly for conservation through management intervention.
- V Protected Landscape/Seascape — protected area managed mainly for landscape/seascape conservation and recreation.
- VI Managed Resource Protected Area — protected area managed mainly for the sustainable use of natural ecosystems.

Recently in Australia and Victoria, the National Strategy for Ecologically Sustainable Development, the Intergovernmental Agreement on the Environment and the National Strategy for the Conservation of Australia's Biodiversity have prompted a clearer and more consistent approach to protected area management.

### Comprehensiveness, adequacy and representativeness

Several government initiatives have highlighted the need for a systematic reserve system to conserve biodiversity in Australia. Two initiatives in particular — the National Reserve System Program and the National Forests Policy (which has led to the Regional Forest Agreement, or RFA, process described in Chapter 1) — have provided the impetus for developing a practical framework in which to create a comprehensive, adequate and representative (CAR) reserve system. The Interim Guidelines for Establishing the National Reserve System (ANZECC 1997) define these terms as follows:

*Comprehensiveness — includes the full range of ecosystems<sup>1</sup> recognised by an appropriate scale within and across each bioregion.*

<sup>1</sup> In the East Gippsland Regional Forest Agreement (RFA), signed in February 1997, Ecological Vegetation Classes (EVCs) were used to represent ecosystems.

*Adequacy — the maintenance of ecological viability and integrity of populations, species and communities.*

*Representativeness — those sample areas that are selected for inclusion in reserves should reasonably reflect the biotic diversity of ecosystems.*

The CAR reserve system concept has been further developed under the auspices of the National Reserve System Program and a National Forest Policy Statement sub-committee known as JANIS. The most recent formulation of the reserve system criteria (JANIS 1997) provides a thorough discussion of many aspects of the concept, and expands on the definitions presented above.

Based on the JANIS criteria, the CAR reserve system on *public land* would incorporate three different components:

1. *dedicated reserves*: reserves established by legislation for conservation purposes and for which a parliamentary decision is required to revoke their status — dedicated reserves should be equivalent to IUCN categories I, II, III or IV;
2. *informal reserves*: areas reserved under other secure tenure or management arrangement (for example special protection zones in State forests — see Chapter 16) where it is not possible or practical to include conservation values in dedicated reserves;
3. *protection by prescription*: values protected by prescription where protection in reserves is impossible or impracticable because of the nature of the value (Chapter 16 also provides an outline of timber harvesting prescriptions designed for biodiversity protection).

While the JANIS criteria specify that reserves following the CAR system should in the first instance be selected from public land, private land may also be included, effectively forming a fourth component. However, to be included in the reserve system, private land should have some security of management for nature conservation, such as a covenant attached to the title.

#### Criteria for the CAR reserve system

A key element of the reserve system as proposed by JANIS (1997) is criteria for the conservation of biodiversity, old-growth forests and wilderness. The criteria for old-growth forests and wilderness are of marginal relevance to

box-ironbark forests and woodlands (see below). The JANIS criteria for biodiversity are (in abbreviated form):

1. As a general criterion, 15 per cent of the pre-1750 distribution of each ecosystem should be protected in the CAR reserve system.
2. At least 60 per cent of the remaining extent of vulnerable ecosystems (those that have been depleted in area by 70 per cent or more) should be reserved.
3. All remaining occurrences of rare and endangered ecosystems should be reserved or protected by other means as far as possible.
4. Reserved areas should be replicated across the geographic range of the ecosystem.
5. The reserve system should seek to maximise the area of high quality habitat.
6. Reserves should be large enough to sustain the viability, quality and integrity of populations.
7. The reserve system should sample the full range of biological variation within each ecosystem.
8. In fragmented landscapes, remnants that contribute to sampling the full range of biodiversity are vital parts of a reserve system. The areas should be identified and protected as part of the development of integrated regional conservation strategies.

The interim biogeographic regions discussed in Chapter 7 and shown on Map 10 have been proposed by JANIS as a basis for identifying regions to which the criteria should be applied.

The choice of parameters used in the application of these criteria — in identifying 'high quality habitat', for instance — may play a major role in the development of reserve systems. Recent research by Kirkpatrick and Gilfedder (1995) has indicated that the occurrence of threatened plant species does not correlate with other factors, such as vegetation integrity (as indicated by characteristics such as native and exotic species richness and cover abundance), which may be better indicators of high levels of biodiversity. They recommended that representativeness and vegetation integrity be considered along with the occurrence of threatened taxa when planning the conservation of vegetation remnants. In regions which contain substantial areas of wilderness and old-growth, conservation of ecological

integrity may be largely accomplished through conservation of these areas, but in other regions the conservation of ecological integrity will depend on the application of the biodiversity criteria.

## The reserve system in Victoria

The existing system of conservation reserves in Victoria is largely a product of the work of the Land Conservation Council, aiming at balanced land use — the LCC did not adopt targets for reserves such as the 15 per cent biodiversity criteria mentioned above. The LCC considered public land use in Victoria in study areas that, to varying extents, parallel bioregions. Within study areas, reserves were generally selected to include identified sites of biological significance and to sample land systems where possible. Land systems have a similar basis to, and therefore will approximate, most ecosystem classifications (such as EVCs). However, the CAR reserve system as presently conceived covers a broader range of natural attributes, recognising that the occurrence of these attributes are often not correlated with each other, as illustrated by Kirkpatrick and Gilfedder (1995).

## NATURE CONSERVATION AS A LAND USE IN THE STUDY AREA

The factor dominating the setting for nature conservation in the study area is the high level of depletion of indigenous vegetation since European settlement. This includes both the loss of tree cover and the degradation of areas where tree cover has not been lost. Across the study area, over 85 per cent of native tree cover has been removed, rising to 97 per cent in some vegetation types (Table 13). Such levels of depletion raise a number of questions about the viability of reserve systems in these vegetation types, regardless of the tenure of remaining areas of indigenous vegetation. This issue is discussed further in Chapter 21.

Frood and Calder (1987) noted that 'box-ironbark forests and woodlands' in northern Victoria were present in a range of reserves, and that grazing and mining posed the main threats. Several other vegetation types identified by Frood and Calder (1987) include alliances that fall within the study area: 'dry open forest: dry sclerophyll forest'; 'rocky outcrop and cliff face habitats'; 'savannah

woodlands and grasslands of the lowland plains and hills'; 'whipstick mallee and other outliers'; and one or more heathy woodland types. The 'rocky outcrop and cliff face habitats' were considered to be well represented in Victoria generally, but no comments were made pertaining to the study area specifically. Otherwise, Frood and Calder considered the reservation status of all these vegetation types to be poor or worse, and in many cases several threats were identified. 'Savannah woodlands and grasslands of the lowland plains and hills', which include the northern plains in the Box-Ironbark study area, were placed in the most threatened category: 'conservation measures urgently required'.

The early history of nature conservation in the study area is described in Chapter 3. Most of the existing parks and reserves in the study area were established in the 1980s as a consequence of LCC investigations, particularly the North Central and Murray Valley Investigations. No national parks originated from these investigations, but the Chiltern Box-Ironbark National Park has been established following the passage of legislation in early 1997.

## Nature conservation in public land use categories

The existing conservation reserves in the study area have largely arisen from a number of LCC investigations into study areas that were not defined biogeographically. The resulting 'system' contains conservation reserves totalling approximately 61 000 ha, or around 2 per cent of the study area. The following paragraphs describe the categories of public land in the study area where nature conservation is a primary objective according to previous LCC recommendations.

### National park

A national park is an 'extensive area of public land of nation-wide significance because of its outstanding natural features and diverse land types, set aside primarily to provide public enjoyment, education, and inspiration in natural environments' where 'conservation of native flora, and other natural features' is an essential part of management.

Chiltern Box-Ironbark National Park (4230 ha) is the only national park in northern Victoria containing box-ironbark vegetation. Box-Ironbark Forest is the most common EVC, but the park contains an unusual diversity

of EVCs because the zone of transition from wetter mountain forests to northern plains vegetation is especially narrow in this area. It is one of the most important sites in Victoria, and in some cases Australia, for a number of plant and animal species — turquoise parrot, swift parrot, regent honeyeater, Deane's wattle (subspecies *deanei*), and broom bitter-pea, for example.

### State parks

A State park is an 'area of public land, containing one or more land types, set aside primarily to provide public enjoyment, education and inspiration in natural environments' where conservation of native flora and fauna is an essential feature of management. There are seven state parks in the study area: Kara Kara, Kooyoora, Paddys Ranges, Terrick Terrick, Whipstick, Kamarooka, and Warby Ranges.

Kara Kara State Park (3840 ha) is located in the central part of the St Arnaud range, which includes some of the steepest and most rugged terrain in the study area. It is dominated by *Heathy Dry Forest* and *Grassy Dry Forest* EVCs.

South-west of Inglewood, Kooyoora State Park (3593 ha) is centred on the granite massif of which Mt Kooyoora is the highest point, and Melville Caves is the main visitor focus. *Granitic Hills Herb-rich Woodland*, *Box-Ironbark Forest* and *Metamorphic Slopes Shrubby Woodland* are the dominant EVCs.

Paddys Ranges State Park (1700 ha), south-west of Maryborough, is noted for its wildflower displays in spring, and a number of threatened plant and animal species. *Box-Ironbark Forest* is the dominant EVC in the park.

Terrick Terrick State Park (2493 ha) is centred on an outlier of the Pyramid Hill granite massif — a prominent granitic outcrop on the northern plains, about 60 km north-east of the nearest inland hills near Wedderburn. Only preliminary vegetation mapping has been completed for the park, but *Rocky Outcrop Shrubland/Herbland Mosaic* and *Central Riverine Grey Box Grassy Woodland* have been documented there, and *Terrick Terrick Cypress-pine Grassy Woodland* — which occurs over much of the park — is distinctively different from all other EVCs in the study area.

Whipstick State Park (2300 ha), located to the north of Eaglehawk, contains *Box-Ironbark Forest* and

*Gravelly-sediment Mallee EVCs* which support diverse flora and fauna assemblages, including many rare species. Many important historical relics of the gold-rush era are also found in the park.

About 10 km north-east of Whipstick State Park is Kamarooka State Park (6900 ha). This park contains the largest area of *Low Rises Grassy Woodland EVC* in the study area, which is also one of the largest remnants of lowland grassy woodland in Victoria. Consequently, it supports many rare species and is of great biological interest. It also has substantial areas of *Gravelly-sediment Mallee* and *Sandstone-rise Broombush EVCs*.

Straddling the central and southern part of the Warby Ranges north of Glenrowan is the Warby Ranges State Park (6640 ha). Granitic hills dominate the park, but the topography is highly varied, resulting in a diverse range of EVCs, with *Heathy Dry Forest* and *Granitic Hills Woodland* the most widespread. Many significant plants and animals occur in the park.

### Regional parks

Regional parks are located close to towns to provide nature-based informal recreation. Although nature conservation is not a primary aim in these parks, management will generally be consistent with its objectives in order to maintain opportunities for nature-based informal recreation. There are six regional parks in the study area — Ararat, Maryborough, Eaglehawk, One Tree Hill, Reef Hills, and Wodonga — as well as parts of *Beechworth Historic Park* and *Hepburn Regional Park*.

### Multi-purpose park

Mt Pilot Multi-purpose Park is the only park in the study area in this now obsolete category. As its name suggests, the park was set aside for a number of purposes, including to 'conserve and protect natural ecosystems' as well as some purposes which potentially conflict with nature conservation.

### Reference areas

Reference areas are 'tracts of public land containing viable samples of one or more land types that are relatively undisturbed and that are reserved in perpetuity'. Although not reserved primarily for this purpose, reference areas make a substantial contribution to nature conservation in the study area. The criteria used in the identification of

appropriate sites for reference areas would also tend to distinguish sites of high ecological integrity. In addition, several aspects of reference area management are generally favourable to nature conservation, for example restricted access and maintenance of a protective buffer, from which potentially damaging processes are excluded. The 11 reference areas in the study area are listed in Chapter 10.

### Nature conservation reserves

As explained in Chapter 10, the new category of nature conservation reserve covers reserves that were formerly categorised as flora reserves, and flora and fauna reserves, as well as those wildlife reserves that are not available for hunting — Gum, Lehmann, and Shire Dam swamps north-west of Violet Town; Tabilk Lagoon near Nagambie; and Bells Swamp south-east of Laanecoorie. Generally, nature conservation reserves have been set aside for the conservation of one or two particular conservation values, such as a significant population or assemblage. There are 38 nature conservation reserves in the study area (see Map A).

Few reserves are the subject of management plans, although one has been prepared for the 3930 ha Wychitella Flora and Fauna Reserve north of Wedderburn. Management objectives identified in the plan are outlined in the Appendix X.

The LCC recommended that in nature conservation reserves, wood production not be permitted, while honey production was to be allowed as was prospecting, subject to certain principles and guidelines. Those guidelines specified that some areas of special public significance — for example, sites with important nature conservation values — warrant exclusion from exploration and/or extraction of gold. At Wychitella, the Government decided in 1984 to exempt the whole reserve from prospecting and issue of mining tenements other than for exploration. Existing tenements continued. As with other such reserves (see Chapter 17), future exploration would require the consent of the Minister for Conservation and Land Management.

### Natural features reserves

This category combines the former categories of geological reserve, bushland reserve, wildlife reserve or area (hunting permitted), scenic reserve, highway park, public land water frontage reserve, and streamside reserve. Maintaining native vegetation is generally a management

aim for most natural features reserves. Excluding public land water frontage reserves, there are 461 natural features reserves, covering around 14 000 ha, in the study area. All wildlife reserves in the study area are centred on wetlands — that is, they contain relatively little box-ironbark vegetation — with the notable exception of Doctor's Swamp near Murchison, which has relatively large areas of Central Riverine Grey Box Grassy Woodland. On the other hand, and despite their names, streamside reserves and public land water frontages support relatively large areas of often highly significant box-ironbark vegetation (Robinson and Mann 1996a). Although they commonly contain wetlands and riparian forests, box-ironbark vegetation occurs throughout many of these reserves, including along stream banks.

### Nature conservation on other public land

Most other areas of public land retain some indigenous vegetation and consequently play a role in nature conservation in the study area. One category, State forest, is of particular importance because it supports nearly 50 per cent of the indigenous vegetation remaining in the study area, and over 75 per cent of that remaining on public land. Many threatened species occur predominantly, and in some cases exclusively, in State forest. The production of hardwood timber is the primary objective in State forests; as discussed in Chapter 16 nature conservation is an important subsidiary objective, as are some other commercial uses. An exception in this regard is the eucalyptus oil production areas where there is no provision for nature conservation. Previous LCC recommendations have specified various mechanisms for nature conservation in State forests, including prescriptions and suggested reserves under the *Forests Act 1958*.

Other land use categories (see Chapter 10) relate to specific uses — 'Earth Resources', for instance. These areas have a relatively minor role in nature conservation: they cover a relatively small total area, are generally less likely to support indigenous vegetation, and have no particular management specifications for nature conservation.

Because of the high level of depletion and fragmentation of box-ironbark vegetation, remnant vegetation on roadsides is often of particular importance for nature conservation. It may ameliorate fragmentation by forming 'habitat links' between scattered remnant patches and, in the most severely depleted areas (the northern plains, in



*Remnant vegetation along a roadside near Murchison.*

particular), it often constitutes a high proportion of the total remaining indigenous vegetation, forming important habitat in its own right. The latter role is well illustrated by threatened species such as the squirrel glider and grey-crowned babbler, which occur predominantly in roadside vegetation across large parts of the study area (see Chapter 9). Several studies have identified the value of road reserves for nature conservation, both generally and at particular sites. However, LCC recommendations specify that roadsides be used primarily for communication, transport, access, surveys and utilities, with nature conservation as a subsidiary objective.

## NATURE CONSERVATION ON PRIVATE LAND

Private land plays a significant role in nature conservation in the study area: over 20 per cent of remaining indigenous tree cover is on private land, and the corresponding figure in some vegetation types is around 50 per cent (see Chapter 7 for more details). In recent

years, several initiatives have begun to maintain and enhance the contribution that private land makes to nature conservation in the study area:

- **Trust for Nature covenants.** The Trust for Nature (formerly the Victorian Conservation Trust) promotes and facilitates the use of covenants as attachments to the titles of land parcels of conservation significance. Covenants specify, in perpetuity, conditions of management to maintain nature conservation values. Within the study area, a total of around 670 ha is currently covered by 25 Trust for Nature covenants. The Trust also purchases land for nature conservation.
- **Land for Wildlife.** The Land for Wildlife scheme provides assistance for landholders who register under the scheme to manage all or part of their properties for nature conservation.
- **Landcare.** Landcare is a major, joint government-community initiative to promote sustainable land use. Under various sub-programs, local Landcare groups receive government support for appropriate activities, many of which have nature conservation as a subsidiary, or in some cases primary, aim.

In addition, planning schemes provide opportunities to protect nature conservation values on private land. For example, a State-wide planning scheme amendment controls clearing of native vegetation, although Catchment Management Authorities have initiated regional vegetation strategies that may modify the present approach. Similarly, local government can use local planning schemes to control land use and management and protect particular values.

Finally, governments can purchase private land for nature conservation — parts of Kamarooka State Park and the recent purchase of 1277 ha of land of very high conservation value for addition to Terrick Terrick State Park, for instance.

## SITES OF HIGH NATURE CONSERVATION VALUE

### Assessing and identifying sites of high nature conservation value

There has been no published formal assessment and inventory of sites of high nature conservation value across the study area. However, a considerable number of completed studies provide essential preliminary information

and, in some cases, assessments of particular sites that will form a solid basis for systematic identification of sites of conservation significance. Table 26 provides a list of some of the more geographically extensive and broadly relevant examples of these studies.

In the Box-Ironbark study area, many currently known sites of high nature conservation value are located where there has previously been some degree of disturbance. While it may be argued that this indicates the resilience of particular values to disturbance, it cannot be assumed that this is the case, or that there is a correlation between high conservation value and disturbance. In many cases, the conservation values are likely to exist in spite of the impacts, not because of them, or because the impacts have now ceased and the natural values are recovering (e.g. regeneration of forests after clearing for mining). In the latter case, the values that exist may not reflect their optimal expression had there been no disturbance. In some instances, the values may exist now but their ongoing and long-term survival may be under threat from particular disturbances.

### Register of the National Estate

Although not directly applicable to reserve system design, the Register of the National Estate provides relevant information on some areas of high conservation value. The Register is a national inventory of natural and cultural

heritage places compiled and maintained by the Australian Heritage Commission (AHC). In accordance with the Commonwealth *Australian Heritage Commission Act 1975*, the Register contains:

*those places, being components of the natural environment of Australia, ... that have ... scientific, or social significance or other special value for future generations, as well as for the present community.*

Nominated places are assessed against eight criteria outlining national estate values and, after interim listing, advertised opportunity for public comment and objection, and final consideration by the AHC, entered on the Register, if accepted. Listing places on the Register of the National Estate highlights their importance and helps to make planners, land managers, decision-makers, and the general public aware of their value. Places on the Register may be private or public land held by local, State, or Commonwealth governments, but only the Commonwealth Government is directly constrained in its actions in relation to listed places, including listed places owned by other parties. Commonwealth ministers, departments, and authorities are required not to take any action that would adversely affect places on the Register unless there is no feasible and prudent alternative. If there is no such alternative, they are required to inform the AHC of the proposed action (allowing adequate time for comment), and to take all reasonable measures to minimise adverse effects.

**Table 26: Indicative examples of flora and fauna studies in the study area**

Subject	Area	Citation
Description and conservation status of vegetation	inland hills (called 'Box-Ironbark Ecosystem')	Muir <i>et al.</i> (1995)
Description and classification of vegetation	northern plains	Foreman (in prep.)
Survey for selected rare or threatened vascular plants	inland hills (called 'Box-Ironbark Region')	Berwick (1996)
Overview of remnant vegetation	inland hills (called 'Box-Ironbark Region')	Davidson (1996)
Natural values of public land	Broken, Boosey, and Nine Mile Creeks	Robinson and Mann (1996a, b)
Inventory of drought refuge sites	inland hills (called 'Box-Ironbark Ecosystem') in the Campaspe, Goulburn and Loddon catchments	Robinson and Rowley (1994)
Mature tree sites	Bendigo Forest Management Area	Soderquist and Rowley (1996)
Flora and fauna survey	Puckapunyal Military Area	Kinhill Engineers (1996)
Fauna surveys and studies (series)	northern plains	numerous, e.g. Bennett <i>et al.</i> (1997), Lumsden <i>et al.</i> (1995)
Threatened hollow-dependent fauna	Bendigo Forest Management Area	Alexander (in press)
Status and ecology of the regent honeyeater	Victoria and New South Wales	Webster and Menkhorst (1992)
Population monitoring of the bush stone-curlew	northern Victoria	Webster and Baker-Gabb (1992)

Nationally, over 11 000 places are listed on the Register, including places with nature conservation and geomorphological values, and places with cultural values. Cultural places in the study area are discussed in Chapter 14; Table 27 lists the 11 natural places in the study area that are on the Register or which preliminary assessments indicate have National Estate values for nature conservation. Sherwin's (1996) recent detailed review of the biological values of box-ironbark forests and woodlands in northern Victoria, in the context of National Estate criteria identified 69 sites with National Estate values (incorporating all but three of those in Table 27), as well as describing and discussing a number of related issues, such as ecological processes and threats.

## OLD-GROWTH AND WILDERNESS

Prior to European settlement and the subsequent dramatic increase in the disturbance of indigenous vegetation, box-ironbark forests and woodlands were generally of much greater age than those which presently exist. It is likely that the older forests differed considerably from younger forest,

with older and larger trees leading to a greater abundance of characteristics such as tree hollows and fallen timber, especially large logs, and structural complexity. The formulation of the concept of old-growth forest reflects the special significance and scarcity of these characteristics and the few remaining areas where they are found. Old-growth characteristics are particularly rare in box-ironbark forests and woodlands, as indicated by the small area that satisfies formal criteria for the definition of old-growth forest (see Chapter 8). Given the intrinsic significance of old-growth forests, and their significance as habitat for flora and fauna, Soderquist and Rowley (1996) have looked beyond the formal definition with a view to conserving some of their features. Criteria that have been developed to assess wilderness values have even less relevance to box-ironbark forests and woodlands than old-growth criteria. As well as requiring high levels of naturalness, wilderness criteria also require high levels of remoteness from European settlement and access. No areas within the Box-Ironbark study area approach the relevant thresholds. However, the LCC Wilderness Special Investigation recommended that public land managers throughout the State, 'wherever possible protect trackless areas of appreciable size'.

**Table 27: List of natural places in the Box-Ironbark study area on the Register of the National Estate**

Only sites with nature conservation values are listed here — sites with geological or geomorphological values are listed in Appendix IV.

No.	Place	Status
004553	Beechworth Park	Registered
004353	Bendigo Whipstick	Registered
004614	Chiltern Park including ironbark forest	Registered
100380	Dookie Bushland Reserve	Indicative Place
016504	Mt Pilot Range Multipurpose Park	Indicative Place
019713	Mysia-Fernihurst Road remnant grassland	Indicative Place
016489	Reef Hills Park	Indicative Place
004495	Warby Range area	Indicative Place
015426	Warby Range	Indicative Place
010146	Warby Range <i>Eucalyptus cadens</i> sites	Registered
014669	Warby Ranges State Park	Registered

'Indicative Place' = place which appears to satisfy National Estate criteria, but for which more information is required for listing on the Register.

## 12. RECREATION AND TOURISM

### INTRODUCTION

Box-ironbark forests and woodland areas are highly fragmented; only the larger blocks, or clusters of blocks, offer real opportunities for forest recreation. A number of characteristics of these larger areas shape their recreational value.

Many of the forest remnants in the study area are on relatively gentle terrain, are irregularly shaped and are dissected by roads and tracks. Recreation is dispersed throughout these areas, usually unconstrained by obvious starting and finishing points, and lacking strong nodes of attraction, and dominant natural routes defined by ridges or watercourses. Areas outside the more general pattern that provide more focused recreation, include Kooyoorra State Park and Warby Ranges State Park.

These forest blocks contain virtually no permanent watercourses. Some water storages (for example Lake Eppalock) are adjacent to box-ironbark forests and woodlands, but there are no opportunities for water-based recreation in the forests proper, nor is there water for campers unless tanks are provided. Forest dams provide water for horses and limited opportunities for yabbing.

Box-ironbark forests and woodlands are largely regrowth, often on land which has been mined previously. Not only do most of the forest blocks lack a sense of remoteness, they also lack the pristine qualities associated with nature-based recreation. At the same time, they are open, safe, and in some areas reveal a remarkable diversity and abundance of flora and fauna to those who take the time to get to know them. Some activities conducted in the forests are not considered compatible with areas of high conservation value, and there is disagreement between those who see and enjoy remarkable and sometimes fragile biological diversity surviving under increasing pressure, and those who regard the forest as a legitimate place to practise activities which have come to be regarded as part of a cultural heritage.

Fossickers, orienteers, car rally enthusiasts and naturalists see box-ironbark forests as of State-wide and even national significance, although not for the same reasons. At the same time, over 100 000 people live

adjacent to or in the box-ironbark forests and woodland areas; for some of those, the forests are of intense local importance, providing a focus for either lifestyle or recreational interests. For others these areas provide a scenic backdrop and a pleasant place for picnics or firewood collection. Because of easy access, box-ironbark forests and woodlands are particularly vulnerable to degradation by off-road driving and riding, and to vandalism, littering and rubbish dumping.

Much of the recreational activity in the forests of the study area has been initiated by enthusiasts, rather than by tourism development and marketing. There is an increasing number of projects and initiatives designed to actively attract tourists to the forests, and a similar increase in cooperative endeavours between shires, tourism organisations, and land managers. These provide some indications of the potential for forest-based tourism, and highlight questions about the sustainability of recreation activities, and the potential for recreation and tourism to contribute to the conservation, and perhaps restoration, of the forests and woodland areas.

### TOURISM AND RECREATION

While tourism and recreation may seem one and the same (tourism being recreational travel), distinguishing between the two highlights important differences. Forest recreation includes both activities by locals (who have not travelled) and activities of those who have purposely travelled there. Tourists may visit box-ironbark forests by chance (having travelled to an area for other reasons) or may pass through them on their way elsewhere.

Recreational planning tends to emphasise the personal and social benefits of recreation. Tourism planning tends to emphasise marketing and the direct economic value of travel. Forest recreation in the study area has been largely managed by the Department of Natural Resources and Environment, while tourism more generally has been managed by local tourism boards or associations, often in conjunction with local shires and Tourism Victoria. While some forest and woodland areas may be tourism attractions in their own right, the role of box-ironbark forests in

tourism is less developed and more low key than areas such as the Alps or the Grampians. However, some travellers do not think of themselves as tourists, and prefer to visit places which are not seen as 'tourist traps'. For such individuals low-key development may be an attraction in itself.

It is not clear to what extent regional tourism visitation figures, derived from surveys of accommodation providers and visitor centres, overlap with visitation figures for forest areas. In some of the smaller towns fossickers make up both the largest group seeking accommodation and the largest group visiting State forests. In the larger towns, it appears that many tourists have limited access to information on forest visits. A large proportion of tourism in box-ironbark regions (for example in Bendigo), may be unrelated to the public land forests and woodlands. On the other hand, many forest visitors either do not stay overnight, or camp in the forest, in each case not contributing to tourism accommodation figures.



*Viewing platform at Woolshed Falls, Beechworth Historic Park.*

## Trends

The Australian tourism industry has shown sustained growth, and is an important source of employment. Various estimates attribute around 5 per cent of all employment directly to tourism. In the period 1985-94, annual employment growth in tourism of around 5 per cent exceeded overall employment growth of 1.8 per cent.

The Australian Tourist Commission (1995) has noted that there is an increase in the proportion of tourists with greater awareness of ecological issues, better education and a preference for outdoor activities, who seek experiences in touch with nature and the society of the country visited. Not surprisingly, tourism growth has not been uniform across the country. In Victoria the rate of growth in hotel and motel rooms sold in 1991-94 was the second lowest of all States (12 per cent over the three years), and occupancy rates remained well below the levels achieved in the 1980s (Tourism Forecasting Council 1995). While the eastern-most box-ironbark areas such as Chiltern Box-Ironbark National Park are close to areas that attract relatively high numbers of tourists, or through which large numbers of tourists pass, box-ironbark forests and woodlands generally are in areas which attract a small proportion of the State's tourism dollars. Accommodation takings in the region bounded by Bendigo, Castlemaine, Maryborough and St Arnaud amount to approximately 3 per cent of the Victorian total; rising to approximately 5 per cent if caravan parks alone are considered.

The future of tourism in the forests and woodlands of the study area will be determined by a range of factors including economic conditions, marketing, and what facilities or programs for tourism are developed. It will also depend on how the forests are managed for recreation and tourism and the development of cooperative arrangements between shires, tourism organisations, and public land managers. Positive examples of such arrangements include the Bendigo Bushland Trail, and the Castlemaine Diggings Project. In the long to medium term, the condition of the forests and woodland areas themselves will be crucial. Important factors include the diversity of understorey flora, control of erosion and litter, whether sufficient fossickable gold remains, and the proportion of large trees in the forests. There is a worldwide trend towards tourism that contributes to environmental sustainability. The future attraction of the box-ironbark forests for tourism, as

distinct from local recreation, may depend on how restoration of the forests proceeds, and to what extent such restoration is underwritten by income from tourism.

Planning for local recreation is no longer based on confident predictions of a 'leisure society' as might have been the case a decade ago. Increasing hours for those in work, higher unemployment, and increases in paid work by women without a corresponding reduction in unpaid domestic work are factors which indicate a slowing in demand for at least some forms of recreation. In general, the study area has a high proportion of households on low or very low incomes compared to the State average, and has considerably lower proportions of households on very high incomes. According to the Department of Infrastructure (1996a, 1996b), annual population growth is predicted to be between 0 and 2 per cent in these regions, with the higher figure applying in and around the areas of highest population (Bendigo and Wodonga). However, populations are ageing, and net losses in some or all younger age groups are expected in most parts of the region by 2021.

Demand for particular kinds of recreation may change quickly and unpredictably, as was the case with the development of trail and mountain bikes, and metal detectors. The present peak in metal detecting activity, for example, is unlikely to be sustained at current levels. However, the above figures suggest that the role of box-ironbark forests and woodlands as sites for local, relatively informal, low-cost recreation will increase, but that activities which might be broadly considered youth-related may slowly diminish.

## RECREATION ISSUES

Dealing with recreation involves assessing the value of recreation, its impacts (social, cultural, and environmental), competition between different recreational activities, and competition between recreation and commercial uses of the forests. Regional Forest Management Plans and management plans for parks and reserves adopt a range of strategies, such as regulation, education, and zoning to resolve issues and minimise conflict.

Issues can continue to arise for a number of reasons. Community values change over time. Perceptions of forests may change over time (as when one generation's litter becomes a later generation's historic relic), and the forests themselves are changing. New forms of recreation

develop from time to time, and levels of involvement in different activities may wax and wane. Management plans are developed within a broader context of community debate over forest use. At the same time, management plans cannot be expected to anticipate or cover every local contingency. There is also the possibility that management plans and practice may not always succeed in resolving issues as intended; however, forest recreation management was not evaluated in this study. The remainder of this chapter focuses on recreation and recreation issues in box-ironbark forests considered as a whole, rather than on existing management units or zones.

## Recreation and economic value

While the value of recreation may be measured in economic terms, there can be difficulties both in determining the level of an activity and its value, and further difficulties in reconciling economic with social, environmental, or cultural values. Because box-ironbark forests and woodlands are so accessible, and usage is so dispersed, it is particularly difficult to measure the number of people using the forests, or to quantify or describe what they do. Where it is possible to do so, for example when accommodation is paid for or where there is a focus of activity which allows a count to be made (for example on the entrance road to Kooyoora State Park) detailed questioning is required to determine expenditure and hence the economic contribution of the activity. Campers, for example, may have purchased equipment some time before, and in another place.

While forested areas and roadside remnant vegetation may contribute to the attractiveness of a town for both tourists and residents, the effect is difficult to evaluate. The costs of driving to a venue may be counted as a benefit in economic terms, but as a cost in social and environmental terms. Similarly, activities that require substantial expenditure on equipment (such as trail bike riding) provide more direct economic benefits than simple activities such as walking, but at the same time may be more consumptive, cause more environmental damage, have fewer health benefits, and be more disruptive to other users.

Economic benefits may be diffuse (as when the scenic value of the forest surrounding a town improves its attractiveness to tourists generally), or deferred in time. For example, backpackers who travel through an area on a budget may return many years later with families and spend more on accommodation. A proportion of recreation in

forests and woodland areas has an educational aspect, which may provide a range of future economic benefits.

## Impacts of recreation

The specific impacts of particular forms of recreation are discussed in sections relating to each activity. These impacts may change over time. For example, increases in participating numbers may require a reappraisal. Impacts may be intrinsic to an activity, but may also depend on the behaviour of individuals, or on sub-cultural values which develop within groups. For example, while trail bike riding causes inconvenience to other users and substantial damage to vegetation and soil, most of the problems arise from illegal off-road riding, and may be amenable to education, policing and other management strategies, such as the provision of special areas.

While the impacts of some activities may be satisfactorily managed by providing specific zones for certain activities (such as areas for four-wheel drive training) or designating areas for different levels of protection, problems may remain. As more detailed studies are completed the map of areas of historical, cultural, or natural significance becomes more complex. While relatively large areas of conservation value can be recorded on access maps, signposted and protected to some degree, smaller areas are more difficult. Publishing a map of such areas (such as the site of a rare plant) may itself put the plant at risk. Informing users of the location of such sites is difficult in any case; users may come from different directions and may use any one of a number of maps or guides.

A number of recreational activities in the forests and woodlands of the study area are dispersed, and necessarily so. Car rallies and orienteering events must be conducted in areas that have not been used for some time. Fossickers are uninterested in searching the same areas over and over. Individuals living throughout the box-ironbark forest areas have local places where they run, walk the dog, ride horses or study the birds and plants.

## RECREATIONAL ACTIVITIES

### Local recreation

Many box-ironbark forest blocks are either adjacent to, or almost surround towns. In the case of larger towns, particularly, dispersed activities such as long-distance

running, trail bike riding, horse riding, short walks, cycling and mountain bike riding are the dominant uses on public land around the urban fringes. Subdivision and building on small blocks (4–10 ha) has been extensive, and continues to grow around the larger towns. The complex shapes of many of the public land blocks result in boundaries between public and private land that are extensive in proportion to the area of public land. Though the forests have a relatively low profile as tourist destinations, physical evidence and the observations of forest users, suggest that local use is extensive. A characteristic of this use is that there is no single focus or centre; individuals centre their activities around areas which are closest to where they live. The development of trails around Bendigo and Castlemaine appears to have increased use of the forest by those living right in the towns, but this has not been measured.

A majority of those visiting the forests and woodlands by car are locals. As Bennett (1976) found in a survey of the Rushworth Forest, travelling times of less than one hour are much more common than longer trips.

The majority of horse riders are local. The extensive networks of tracks suit horse riders, and the problems of weed invasion sometimes associated with horse droppings appear not to be an issue on the relatively hard, dry tracks of the box-ironbark forests. There are few instances of riders failing to stay on the tracks.

Other activities associated with local recreation cause problems. Damage to vegetation and soil by trail bike riding is a chronic problem, which tends to concentrate around centres of population, and in steeper areas such as the Pyrenees. Increasingly, mountain bike riders use the same areas and cause similar damage. Illegal rubbish dumping, together with unlicensed removal of stone or firewood, are likewise problems particularly associated with the proximity of towns to the forests (R. Jarvis pers. comm.). Smashed bottles and vandalism are evident at particular sites close to towns, and indicate potential conflict between anti-social behaviour and use of the same sites by tourists or campers.

Fox drives are conducted throughout winter by shooters; in combination with rabbit shooting on adjoining private land this probably benefits native fauna, and appears to cause no problems. There is some illegal shooting of kangaroos and other wildlife, but the problem appears to be on a small scale.

## Fossicking and prospecting

Most of the present forests grow on sites of past goldmining activity, and searching for gold and relics (fossicking) remains an important recreational activity through much of the study area (see also Chapter 17). In places, such as the forests around Dunolly, Wedderburn and Tarnagulla, searching for gold using metal detectors is the main recreational activity. In some of the smaller towns, caravan parks, and to a lesser extent hotels and food stores, rely on fossickers to stay in business. Public land in the study area contains most of the regions in the state where gold nuggets can be found with metal detectors, and are of national renown because of the size of the nuggets and the purity of the gold found, past and present. A number of businesses offering fossicking tours, maps, and detector sales or hire operate in the area.



*Fossickers' club camp, Whroo.*

### Gold fossicking and prospecting with metal detectors

A metal detector consists of an electronic coil which responds to metallic objects or other magnetic influences within its field of sensitivity. The operator listens for changes in a tone generated by the coil as it is passed over buried metal. Modern detectors have large areas of sensitivity and can detect at depths of up to one metre in ideal circumstances. However, metal detecting is a painstaking process which requires the operator to sweep the coil in careful arcs while moving very slowly forward, and endeavouring to keep the coil a consistent distance above the ground. False signals can be caused by incorrect tuning of the machine, various forms of ground mineralisation or disturbance, or unwanted metal objects such as bullets, ring-pulls and so on. Historical records

provide important clues to likely places to find gold, and a number of commercially produced maps and guidebooks are available to assist in locating gold. Fossickers often develop a keen interest in local history and geology.

Fossicking with metal detectors peaked in popularity in the early 1980s, sparked by improved detector design and publicity following the discovery of some large nuggets. Activity gradually diminished until the release of a new generation of detectors in 1995 which were less prone to false signals and could detect gold deeper and over a wider area than previously had been possible. Sales of Miners Rights increased dramatically, and the number of nuggets found also increased considerably. Records of nuggets weighed at the Dunolly Caravan Park indicate that 70 per cent of those found are less than 0.5 ounce, and 96 per cent weigh less than 10 ounces. Nuggets of more than 100 ounces are found from time to time, but are very rare. The price of gold is presently about \$450 an ounce; large nuggets are sometimes sold for well above the gold price as specimens.

In spite of their rarity, the possibility of finding a large gold nugget distinguishes fossicking from other forest recreations. While the chance of finding a large nugget in any 10-minute period of searching is comparable to the chance of winning a lottery, stories of large nuggets found, past and present, together with relatively frequent finds of small pieces of gold, motivate fossickers to keep searching. The chance of sudden riches may suggest a comparison with gambling; however, skill, experience and research is involved in fossicking, and after an initial outlay of around \$5000 for a metal detector (plus \$18 for a Miners Right for two years, see below) the fossicker faces no further direct expenses.

Fossicking is an attractive activity for retired people and those on low incomes. The possibility of finding gold is important, but camping in the bush, relaxation, and 'getting away' are also important to recreational fossickers.

While most fossickers never find enough gold to pay for their detectors and other expenses, and in any case keep what gold they find, some search for gold virtually full-time. These full-time fossickers may supplement other income with gold found, or may work over old ground persistently enough to make the equivalent of wages. A small number probably find 'new' ground and make more substantial profits; however, professional fossickers are

understandably secretive about how much gold they find and where they find it. Some fossickers are prospectors, in that they are hoping to find a rich site and would apply for a small mining lease if they did.

Purchase of a Miners Right entitles the holder to fossick, using hand tools only, and without damage to trees or shrubs, Aboriginal places or objects, or archaeological sites. Fossicking is not permitted in national or State parks (except where legislation specifically allows it in designated areas), in areas gazetted under the *Heritage Act 1995* as heritage and archaeological places, in reference areas and in other specifically exempted areas. Fossicking is not permitted on mining leases, but is not excluded in areas under exploration licences (virtually the whole of the study area is subject to exploration licence — see Map 11). Fossickers are required to fill in any holes dug and to repair any other damage caused.

Recreational and tourist fossicking (special licences are available for tourist operators) may be educational, have the expected social benefits of all bush camping activities, and be important for local economies, but the sustainability of these forms of fossicking is unclear. As gold becomes harder to find, interest in fossicking wanes, as was the case in the late 1980s. New detector designs may again allow fossickers to find gold previously missed, but digging holes with hand tools deeper than the limit of current detectors (typically about 60 cm) can be hard work. Fossicking ceases if an area is mined commercially for alluvial gold, since all detectable gold is recovered. Full-time detector operators and small scale 'doze and detect' mining (using a bulldozer to remove layers of soil prior to detecting) probably hasten any decline in recreational and tourist fossicking. While there have been conflicts between fossickers and mining lease-holders over access to sites, underground and open cut mines occupy relatively small areas and extract much deeper, finer gold than is sought by fossickers, ultimately having little impact on fossicking.

Fossicking can have significant impacts on environmental and heritage values. A number of metal detector operators fail to fill in holes dug. Other problems, such as instances of vehicles driving off formed roads or parking off-road, have been caused by a minority of fossickers. Serious fossickers may rake the ground clear of leaf-litter and sticks, and sometimes drag a chain behind them to mark where they have been. Even though the litter is

sometimes raked back, there is the likelihood that smaller plants are damaged in the process. Removal of leaf litter, small shrubs and sticks may place at risk certain rare orchids which depend on the protection of small prickly shrubs and sticks to flower. Field naturalists report instances of orchid buds damaged by the sweeping actions of the metal detector coil.

Historic sites may be damaged by fossickers, who on occasion focus particularly on the remains of puddlers or around the foundations of old buildings. Conflicts arise over access to sites where fossicking is not permitted, with instances of both accidental and deliberate transgressions occurring. Rare instances of illegal use of machinery such as bob-cats have occurred.

### Relics

Metal detectors respond to all metal, including bottle tops, bullets, ring pulls, and so on. Old coins or other metal relics may be dug up in the course of searching for gold around former diggings. Many detector operators seek out such sites and actively search for relics; tour operators, maps and guides often refer to both gold and relics as possible finds. Old coins are widely regarded as highly collectible, and some fossickers research and seek out historic sites.

While a Miners Right confers ownership of gold found to the finder, such is not the case for relics. While in certain circumstances it is legal to collect relics (artefacts more than 50 years old) from the surface (provided Heritage Victoria is immediately notified), it is an offence to knowingly or negligently dig up, excavate, or expose an unregistered relic (and fossicking is not permitted at all at registered sites).

Fossicking for relics may damage the archaeological record, where relics are found in otherwise intact sites, or diminish the historical record where other disturbances have already destroyed archaeological layers and associations.

Fossickers searching for old bottles have caused damage to heritage sites by excavating large pits and leaving broken bottles scattered around.

### Other forms of fossicking

Some gemstone fossicking occurs, particularly around Beechworth and Chiltern. Reedy Creek at Eldorado is a

particularly important site. Various gemstones are found around Heathcote, Dunolly, Castlemaine, and Maldon. A small amount of fossicking for fine gold by panning or other methods occurs, but is limited by the availability of water and the labour involved.

## Bushwalking

Box-ironbark forests and woodlands generally lack some of the qualities most often prized by regular bushwalkers, and have tended to be visited infrequently (exceptions include the region around Castlemaine for day walks, and overnight walks in the Kooyoorra State Park, particularly by school groups). Particularly in comparison with the Grampians (adjacent to the Pyrenees and St Arnaud Range) or the alpine area (adjacent to the forests around Beechworth and Wangaratta), the forests and woodlands of the study area are less pristine and less conventionally scenic. They are dissected by roads, which increases the chances that walkers will be disturbed by vehicles, particularly trail bikes, and walkers may be reluctant to camp in areas accessible to cars where there is evidence of vandalism or drinking (in the form of broken bottles).

There is very little fresh water available in box-ironbark forests, and the arduous requirement to carry drinking water negates the otherwise relatively undemanding nature of overnight bushwalks. The potential to find satisfying walking routes, along ridge lines, along valleys, or in some kind of circuit or traverse, is limited by the irregular shapes of the public land blocks and roads, which do not necessarily follow suitable routes. To combine walking along roads with cross-country traverses requires a level of map-reading skill which more casual bushwalkers may not have. The potential popularity of long distance walks, for example linking Rushworth with Heathcote and Bendigo with Lake Eppalock, remains untested.

While bushwalking enthusiasts have not been attracted to the region in large numbers, short walks in the forests requiring little in the way of special equipment or knowledge are the most widely available activity for casual visitors. All State parks have designated walking trails in place or planned, and signposted short walks have been developed near many of the towns and camping areas. Walking is the simplest, and perhaps the most common, local forest activity. Multiple access points allow walkers to find solitude, and the relatively gentle terrain and lack of undergrowth in many areas also favour walkers. Where

guided walks have been offered (for example as part of the Maryborough Wattle Festival, or as part of the Spring in the Bendigo Bush program) response has been strong. The Bendigo Bushland Trail, the O'Keefe Trail east of Bendigo and walking tracks around Castlemaine are reported to have attracted large numbers of walkers once completed.

Walking off tracks can damage vegetation or cause erosion, and numbers of walkers may disturb wildlife. Littering and vandalism can occur when access is provided for walkers. The overall impact of walking is generally considered to be slight, and while the lack of spectacular features or key destinations is sometimes considered a disadvantage, it points to the remarkable capacity of box-ironbark forests and woodlands to offer dispersed opportunities for short walks suitable for non-experts, which in other areas would be confined to zones near key access points and characterised by large numbers of walkers and crowding.

## Orienteering

Orienteering is a sport combining cross-country running or walking, and map-reading. Orienteering events range from local competitions attracting around 30 to 40 participants, to State events attracting around 200 participants, and national and international meetings attracting over 1000 participants and lasting several days. One or two local events are held in box-ironbark forests each month, along with four or five State events annually, and major events less than annually. Orienteers seek areas of moderate steepness, relatively open forest, and complex features. Special maps are prepared, and major events are always conducted on either a map of a new area or a new map of an area which has not seen a major event for many years.

Box-ironbark public land blocks around Castlemaine, Bendigo, and Heathcote are of State importance to orienteering because of the suitability of the topography, closeness to Melbourne, relatively open forest and the technical complexity of the maps due to either past mining activity (mounds, pits, and erosion gullies), or granite boulders and outcrops in the case of areas such as Mt Alexander. Of approximately 120 non-metropolitan areas mapped for orienteering since 1980, 50 are in the Box-Ironbark study area.

While maps prepared by orienteering clubs may be used by other organisations, particularly schools and Universities

conducting outdoor education programs, and by individuals for training, orienteering generally is a highly controlled activity. Event calendars determine which areas are used and how often, and course setters place checkpoints in precise locations.

Preparing an orienteering map takes about three years; future planning for the development of maps begins up to ten years in advance. A map costs approximately \$10 000 to prepare, and orienteers expect to use a map once for a major event, and then perhaps annually for State and more minor competitions. A set of orienteering courses are planned so as to spread participants across the mapped area, and participants on any one course begin at timed intervals. Any particular area cannot be used too often for competition because regular participants would become familiar with the area, thus spoiling the map-reading element of the competition.

Wildfire or extensive timber cutting operations can render an area unusable for orienteering. Large scale mining can render sections of a map unusable, and small scale mining or track changes (for example due to trail bike riding) can diminish the value of a map. Because of the time taken to prepare a map, and the expectation that it will remain usable for up to five years, orienteering is particularly vulnerable to such changes.

Orienteering is potentially harmful to rare or delicate plants; therefore access to some mapped flora reserves has been limited, and plans for further mapping of such reserves has been discouraged. There may be potential to accommodate orienteering in such areas by careful management of the time of year events are held, with some vetting of the placement of checkpoints.

### **Car touring, car rallies, and four-wheel driving**

Car touring and picnicking are important activities through much of the study area. Picnic areas are the most common recreational facility provided in the State forests. As Bennett (1991) found, the impact of car touring is generally minimal, but road kill of native animals may be significant. However, much of the traffic through forests is not necessarily forest-related, and much is not recreational. Bennett (1976), for example, noted that a high number of drivers entering the Rushworth Forest did so by chance, or were taking a short cut. Car touring is an example of an

activity for which it is difficult to define the importance of the forest, and for which recreation, tourism, and other reasons for travel cannot easily be discerned without conducting painstaking surveys.

Box-ironbark forests and woodlands in the Rushworth-Heathcote area are important sites for car rallies, particularly older-style and historic events (which have a high navigation component and are less dependent on high-powered vehicles). Rally participants and organisers choose the forests because they are areas of public land where it is feasible to close off some roads overnight without inconveniencing others. Some areas contain networks of tracks which provide the navigational challenge sought for a style of rally favoured by those who cannot afford the high performance vehicles used in more modern competition. Loss of access to some pine plantation areas has increased the importance to the sport of suitable box-ironbark areas.

Car rallying is generally tightly controlled and organised in close consultation with the Forests Service of the Department of Natural Resources and Environment. The number of car rallies in forests of the study area is usually fewer than six per year. Their main impact is wear and tear on the roads. The Rushworth Forest, which is particularly favoured for car rallies, is the largest unbroken box-ironbark block in Victoria, has a complex network of roads which permit a whole rally to be staged in a single forest, and is a suitable distance from Melbourne.

Many individuals own a four-wheel drive, and use it as any normal vehicle; however some four-wheel drive owners enjoy driving in areas where the roads are too steep, rough, or boggy for conventional vehicles. Some organised touring takes place with clubs or commercial operators, particularly in the west of the study area where the terrain is steeper and the forests more remote. Some driver training is conducted at a former mining site north of Bendigo with the permission of the Forests Service of the Department of Natural Resources and Environment. However, the majority of four-wheel driving is practised by individuals. Four-wheel drives can cause damage to tracks, particularly in wet conditions; seasonal road closures are intended to minimise such damage. Off-road driving, while illegal, is a problem throughout the study area, causing soil compaction, damage to vegetation, and erosion. Much of the terrain is firm and flat enough for conventional vehicles to drive off road, so the problem is not confined to four-

wheel drives. Road closures can be difficult to enforce because it is often relatively easy to drive around barriers, and rangers have large areas to police.

## Nature study

Box-ironbark forests and woodlands are renowned for rich wildflower displays in spring and early summer, and for the variety and abundance of bird life. Field naturalists clubs are active in all the larger towns in the region, and conduct regular excursions along with special purpose activities such as mammal surveys or bird counts. Schools and universities also conduct regular excursions in the forests. Generalist and special interest field naturalist groups (such as bird-watchers) from outside the region also make regular trips to box-ironbark forests and woodland areas. Most nature study is, however, an activity for small groups and individuals. Organised excursions comprise only a small proportion of field naturalists' activity. A number of individual enthusiasts visit the forest on a weekly or daily basis. Some field naturalists work closely with land managers, in many cases offering detailed knowledge of particular locations or aspects of natural history.

Nature study may be a part of many forest recreation activities, including shooting, horse-riding, and fossicking. While nature study could in principle be confined to nature reserves, most field naturalists are interested in the forests as a whole, including remnant vegetation on roadside verges and on private land. Many regard their activity as a voluntary contribution to forest management and conservation, as much as a form of recreation. Nature study becomes intensely local when individuals study a particular area, often for many years. Individuals throughout the study area take a watchful interest in their particular locality.

Recreational nature study may have localised, generally minor adverse environmental effects, for example trampling of vegetation, disturbance to nesting birds, or scientific collecting (which is now very rare). Illegal collecting (including poaching) of birds and reptiles still occurs in the study area. Although it is impossible to know the extent of this activity, it is not considered a major threat to the conservation status of any box-ironbark fauna. On the other hand, trampling by enthusiasts and illegal collection of terrestrial orchids and other plants is a major threat to some rare species. However to recognise the location of particular orchids requires expert knowledge to identify

basal leaves, or where there are none, previous knowledge of the exact place where the flowers appear each year.

Further development of nature or heritage-based tourism in box-ironbark forests may lead to particular pressures on vulnerable sites, or to disturbance of plants and animals. Users of the bush who are unaware of what lives and grows there may do unintentional harm. Concerns expressed by field naturalists about the impact of fossicking, for example, focus on the failure of some fossickers to recognise the effect of particular practices (such as raking, or failing to keep topsoil separate when refilling holes).

Some activities may diminish the capacity of the forests for nature-based activities. 'Doze and detect' mining, for example, destroys the smaller plants over a large area in proportion to the gold recovered, and alluvial mining may also cover extensive areas. While rehabilitation follows mining, it may take decades for an area to return to its previous condition, if at all. The same applies to open cut and underground mining, though their effects may be confined to relatively small areas.

From the point of view of nature-based recreation, careful harvesting of timber may have the capacity to mitigate some of the adverse effects of past practices, particularly by reducing the number of trunks on coppiced regrowth. Current harvesting practice in box-ironbark forests is to thin existing regrowth, in order to improve the average growth rates of retained trees, with the long term aim of increasing the sawlog capacity of the forests. Retention of habitat trees is guided by both the State-wide forestry code of practice, and regional forest management plans. Box-ironbark forests presently provide small quantities of sawlogs and sleepers, and significant quantities of firewood and fenceposts.

Harvesting may diminish the value of forests for nature-based recreation, depending on the mix of species retained, the rate of cutting, and the diversity of size and growth habits remaining after cutting. Forest management practices for firewood production, hardwood sawlog production, or nature-based tourism are not identical, so timber harvesting remains an issue, particularly while demand for firewood remains high.

## Heritage study

Recreational heritage study is in many ways a counterpart to recreational nature study in box-ironbark

forests and woodland areas. The story of the present day forests is as much a human history as a natural history. For the most part, substantial historical relics are located in the goldfields towns, rather than in the surrounding forests, where sites tend to consist of foundations and earthworks rather than buildings or machinery. Heritage-based tourism has a higher profile in the towns than in the forests. However, interpretive material and trails have been developed at sites such as Whroo, and as part of the Castlemaine Diggings Project.



*Powder magazine, Beechworth Historic Park.*

The future of recreational heritage study depends in part on what interpretation (in the form of trails, guided tours and educational material) is available in the future, and the extent to which an interest in history contributes to or enriches a range of compatible activities such as bushwalking and cycling. Sites may be at risk from damage by visitors, fossickers, or future mining activity. In many cases the forests are gradually reclaiming sites, and in such cases the needs of nature and heritage conservation may conflict.

## Other recreational activities

In addition to horse riding by locals, there is some organised trail and endurance riding, and a number of commercial operators conduct trail rides.

Cycle touring and mountain bike riding are reported to be increasing. Mountain bike competitions are held in steeper areas, and competitors train regularly in the forests. Other riders tour on mountain bikes, or ride for relaxation. A number of commercial operators conduct cycle tours. While cycle touring appears to have no significant impacts, mountain bike riding can have impacts on soil and vegetation comparable to trail bike riding, particularly when riders leave formed tracks.

There is a range of occasional activities, such as dog-sled racing, or yabbing in forestry dams. Scout groups and similar organisations conduct walks, problem-solving activities, and bivouacs in the forests.

Rock climbing has been developed in several of the granite areas, including Dog Rocks on Mt Alexander, and the Courtyard and Melville's Caves in Kooyoor State Park. Problems associated with rock climbing include the possibility of disturbing nesting peregrine falcons, and wear and tear on the immediate area around popular climbs in the form of damage to vegetation and soil compaction. All forms of walking or climbing on rocks may damage mosses and lichens; such damage is clearly evident in areas where visitors walk, climb, or scramble on rocks (such as around the look-out area at Melville's Caves). Mosses are particularly vulnerable to damage by walkers.

## Recreation related activities

Apart from clearly non-recreational usage of forests and woodland areas, such as timber harvesting, grazing, honey production, and so on, there are a range of activities which are neither strictly commercial nor recreational.

Schools and universities use the forests for field trips associated with courses in the earth and biological sciences, and geography and environmental studies, as well as outdoor education programs that combine developing particular skills, such as map-reading or camping, with a range of other outcomes including nature study. School use is influenced by factors such as proximity, availability of interpretive material, and the knowledge of particular teachers.



*Primary school fitness trail in forest, Dunolly.*

Universities conduct research programs on public land in the study area from time to time. Individuals and groups undertake volunteer conservation and monitoring work, sometimes in conjunction with land managers, or as part of projects developed by other voluntary organisations.

Some recreational activities may be undertaken partly for economic reasons. A number of individuals on retirement or other benefits fossick for gold full-time. At various times, depending on the price of pelts, fox-hunting has been undertaken semi-professionally by a few individuals. Similarly, domestic firewood cutting is undertaken for a mix of economic and recreational reasons.

## FOREST BLOCK CHARACTERISTICS

The larger forest blocks each have distinctive characteristics for recreation. For visitors with an interest in natural or cultural history, many of those characteristics

require interpretation; with increasing knowledge visitors begin to see details in the forests previously unnoticed. While there has been a noticeable increase in interpretive material published recently, the effect of increasing knowledge and interest in box-ironbark forests and woodlands has yet to emerge. Ecological, geological and topographical differences between different blocks are described elsewhere in this report, and provide important indicators of how nature-based recreational and tourism activities may develop in the future.

The following brief discussion of five selected areas and an overview of several others highlights some of the range of considerations affecting recreation and tourism in each block (see Map 1 in Chapter 1).

### St Arnaud Range and Pyrenees

The St Arnaud Range and Pyrenees are the areas of box-ironbark forest with the most remote qualities. Neither block receives large numbers of visitors. Kara Kara State Park, in the middle of the St Arnaud Range, receives 7000 visitors annually, while the main picnic and camping area in the Pyrenees has 16 000 visitors annually. Distance from Melbourne (> 200 km), the alternative of the Grampians to the south, and a small regional population are contributing factors. Both ridges are steeper and more distinct than most box-ironbark (other than granitic) areas. Farmland provides a buffer around the perimeter of both blocks; by box-ironbark standards there are relatively few points of access.

Both ranges have ridge lines which offer natural routes for walkers, although most are roaded. The boundaries of both forests are relatively smooth and unbroken. These are the only forests in the box-ironbark area where it is possible to travel for many kilometres while staying more than a kilometre away from a forest boundary or main road. Both ranges are distinguished by intact north/south and hill/valley vegetation sequences, along the range and on the slopes respectively. Kara Kara State Park contains rare uncut forests, and one of a very few places to camp on permanent water in the study area. There are a number of significant heritage sites around Stuart Mill and St Arnaud. While visitors have tended not to drive for more than two hours to box-ironbark forests and woodlands, information available from recent reports and studies (see 'References') implies that there is more potential in these areas for nature-based recreation than has previously been supposed.

## Dunolly, Inglewood

The forests between Dunolly and Inglewood are gently undulating, very irregular in shape, and dissected by many roads and tracks. The forested areas extend in an arc from Tarnagulla, west to Dunolly, and then north to Kooyooora State Park, where the terrain becomes steeper. It is nearly, though not quite, possible to walk the arc of forests (approximately 63 000 ha in total) from Tarnagulla Flora Reserve to Mt Kooyooora, staying in forest all the way.

Kooyooora State Park attracted 47 000 visitors in the year to June 1996 — an unusually high concentration by box-ironbark standards. The attraction may be explained by several factors: overnight walking, some limited rock climbing areas, and an orienteering map to attract school groups, who see it as an ideal introductory outdoor education site. Melville Caves and the surrounding granite tors attract many sightseers and scramblers. Springs provide drinking water in a number of places. There are many large trees, and bird life is abundant.

The forested areas to the south of Kooyooora State Park are probably the centre of metal detecting activity in Victoria. In these areas fossicking by metal detector is the major activity, and a number of small businesses are dependent on it.

## Whipstick, Wellsford

Bendigo is surrounded by a fairly continuous ring of forest, albeit dissected by many major roads. Tongues of forest extend north to the Whipstick and Kamarooka State parks, east to the Wellsford State Forest, and south-east to Lake Eppalock. Many of the forest blocks are themselves surrounded by the town, due to extensive subdivision for farmlets. The Bendigo forests amount to approximately 45 000 ha.

The population of Bendigo is 57 500, with the population of Greater Bendigo approximately 85 000. To the east, Lake Eppalock camping area is estimated to receive 68 000 visitors per annum, though the focus for most of these visitors is the lake itself rather than the adjacent forests and woodland areas. However, several school camps on foreshore leases use the forest for bushwalking and orienteering. To the north, Kamarooka State Park receives approximately 9000 visitors annually and the Whipstick State Park approximately 25 500. Not surprisingly, two-thirds of the visitors are from Bendigo.

The forests around Bendigo have hundreds of access points; thousands of residents live within easy walking, running, or riding distance from a forest. While the extent of such visits cannot easily be estimated, as few as 1 per cent of the population walking, running or riding in the forest twice weekly would amount to about 60 000 visits. At the same time, many areas around Bendigo have high conservation values, several areas are heavily used by fossickers, and large areas are particularly favoured for orienteering. The pattern of settlement close to forested areas and a range of other sometimes competing values is repeated in Maryborough, Castlemaine, and to the west of Wangaratta.



*Notley's picnic area, Whipstick State Park.*

## Fryers Ridge, Muckleford

The forests and woodlands in the Castlemaine and Maldon area are fragmented, and amount to approximately 17 000 ha (Muckleford State Forest, Maldon Historic Area, Mt Alexander Regional Park, Castlemaine-Chewton Historic Area, Fryers Ridge Flora Reserve and Fryers Ridge State Forest). The populations of Castlemaine and Maldon are approximately 7000 and 1000 respectively.

The Castlemaine-Maldon region is the most accessible part of the Box-Ironbark study area to Melbourne. While tourist accommodation is broadly comparable to similar sized towns such as Maryborough, Castlemaine has the advantage of closeness to Melbourne and access to traffic on the Calder, Midland, and Pyrenees Highways. Day visits by rail are also possible (in fact a small number of Castlemaine residents commute daily to Melbourne). Maldon has a reputation as a tourist town, primarily as a result of tight planning controls on the heritage precinct in the town centre. To the south the spa country attractions

in the Kyneton/Daylesford area, while not in the study area, add at least in a general way to the attractiveness of the Castlemaine area for tourists.

There is a diversity of forest types in the area and an intense concentration of historical sites. The Department of Natural Resources and Environment and Mt Alexander Shire are jointly developing links and interpretation facilities at five key historic sites. The area is popular for day walks with Melbourne bushwalkers, and is linked to the Great Divide Trail. It is also popular with fossickers, and contains a number of sites suitable for orienteering.

### Heathcote-Rushworth

The forests between Heathcote and Rushworth contain the largest single block of remnant box-ironbark in Victoria (approximately 33 000 ha). With the exception of Mt Black Flora Reserve and Mt Ida Flora Reserve (1630 and 1070 ha respectively), and smaller reserves such as the Whroo Historic Area (460 ha), the forests are managed primarily for hardwood production and other forest products.

Heathcote-Rushworth is less subject to local recreational use than other areas: Heathcote and Rushworth are the two main towns adjoining the forest, each with a population of about 1000; neither town is highly developed as a tourist destination. The forests are dissected by relatively good roads, and are more likely to attract through traffic than other forest blocks.

Some of the steeper areas (such as Mt Black and the Heathcote Ranges) are of interest to orienteers. Fossicking for gold is popular in the area around Whroo, and for gemstones near Heathcote. The network of roads is attractive for car rallying, particularly since the forests are extensive enough to allow an event to be conducted wholly within them, rather than being staged through several forest areas. School groups use the forests around Whroo for environmental and historical studies, and for navigation practice.

Visitor interpretation facilities have been developed at Whroo by the Department of Natural Resources and Environment, and a forest eco-tourism project is being developed at Heathcote with some funding assistance from the Commonwealth Government.

While the forest block is large enough to attract overnight bushwalkers, the extensive road networks, timber harvesting operations, and lack of fresh water and other facilities reduce the attraction of the area to bushwalkers.

### Other forests

Maryborough is surrounded by approximately 23 000 ha of forest, and has a population of approximately 7500. Recreation in the forests shares many traits with other areas adjoining large towns, and with the forests around Dunolly to the north.

This chapter has focused on the larger public land blocks. There are many relatively small or isolated areas of box-ironbark forests and woodlands, which may have important local recreational significance, and which may be particularly vulnerable to the impacts of recreation because of their size.

Terrick Terrick State Park in the north of the study area is popular for picnics and trail bike riding. Views over the surrounding countryside and the granitic outcrops and white cypress-pine vegetation are also attractions. Ironbark State Forest near Stawell, in the west of the study area, attracts 21 000 visitors annually for walking, picnics, trail bike riding and horse riding.

To the east of the study area, approximately 7600 ha in the (granitic) Warby Ranges attract 26 000 visitors annually, for picnicking, camping, walking, bicycle riding, horse riding, nature study, bird watching, and orienteering. The nearby Killawarra State Forest (approximately 2000 ha) attracts 20 000 visitors annually, for walking, picnics, trail bike riding, bird watching, horse riding, car touring and nature study.

Chiltern Box-Ironbark National Park (4230 ha) and 14 000 ha of (granitic) forests and woodlands in the Mt Pilot area (Beechworth Regional Park and Mt Pilot Multi-Purpose Park) are the other relatively large areas of box-ironbark forest in the east. Visitation figures are not available for these areas, but popular activities appear to be walking, riding (horse, trail bike, and bicycle), camping and nature study. The Chiltern forest is of moderate interest to gold prospectors. The Reedy Creek area of the Mt Pilot Multi-Purpose Park is important to gemstone fossickers.

## 13. SCENIC LANDSCAPES

Scenic features of public land have been included as a factor in determining past recommendations for several land use categories — parks, natural features reserves, scenic reserves, bushland reserves and scenic coast — and in developing guidelines for activities in State forest, extraction and mining, and service and utility areas. These recommendations have generally not followed systematic landscape appraisals.

Landscape assessment can allow identification of places of high scenic value, and can allow land-use activities that at first sight would adversely affect scenic landscapes, be managed to reduce such effects.



*View from Mt Tarrengower, near Maldon.*

### INTRODUCTION

Although scenic landscapes are widely appreciated, not everyone appreciates the same scenes. While many enjoy coastal and alpine areas, others seek out more subtle landscapes such as the box-ironbark country, with its forested low hills, grey-green eucalypt foliage, dark fissured ironbark trunks and wildflowers, or plains woodlands of stately grey box, with white upper branches and bright young leaves over wallaby and kangaroo grasses.

Landscape perception is individual and subjective. However there are common elements in a viewed landscape that many people find scenic, and others that many people find unattractive. Research can indicate what these elements are, and landscapes can be relatively objectively assessed and compared. Systematic procedures to assess scenic landscapes are now well established.

### LANDSCAPE CHARACTER TYPES

Like must be compared with like, so landscape assessment processes do not try to compare forested alpine slopes with basalt or northern plains farmland, or either with the subdued hills of the Box-Ironbark area. Each area has its own characteristics, and these allow disparate parts of Victoria to be visually differentiated. Within the same type, however, it is valid to make careful comparisons between landscapes to assess scenic value.

Leonard and Hammond (1984) identified nine principal landscape character types for Victoria. They defined a landscape character type as 'a broad scale area of land with common distinguishing visual characteristics'. These are similar to the broad geomorphic units described in Chapter 6. Landscape character types are used as a basic tool for most broadacre scenic landscape appraisals.

Table 28 includes a generalised summary of each type in the Box-Ironbark study area.

### LANDSCAPE ASSESSMENT

Systematic appraisal of regional landscapes has varying requirements. Where the aim is to assess a small area or minimise scenic impacts of a proposed land use on views from specific points, horizontal lines of sight, inspection and ground photography are important. In comprehensive assessments of whole regions, vertical aerial photography

**Table 28: Landscape characteristics in the Box-Ironbark study area**

Feature	Characteristics
<b>West Victorian Uplands — dissected uplands (geomorphic unit 2.1 on Map E)</b>	
Landform	<ul style="list-style-type: none"> <li>• low and moderately dissected hills;</li> <li>• elevation 200 to 750 m;</li> <li>• slopes ranging from gentle to moderately steep;</li> <li>• prominent hills tending NNW-SSE;</li> <li>• elevation increases from west to east.</li> </ul>
Vegetation	<ul style="list-style-type: none"> <li>• Box-Ironbark Forest, Heathy Dry Forest, and Mallee/Broombush EVCs;</li> <li>• extensive coppicing;</li> <li>• some areas silviculturally treated;</li> <li>• introduced and native grasslands.</li> </ul>
Waterform	<ul style="list-style-type: none"> <li>• major streams run approximately south-north;</li> <li>• most watercourses ephemeral;</li> <li>• no natural lakes;</li> <li>• constructed water storages — Eppalock, Cairn Curran, Waranga, Tullaroop, Laanecoorie, Lonsdale, and small storages near towns.</li> </ul>
Land-use pattern	<ul style="list-style-type: none"> <li>• fragmented, forested public land on hills;</li> <li>• several small parks and conservation reserves;</li> <li>• mostly grazing, some cropping, vineyards on freehold land, which often extends along the floor of narrow valleys adjoining public land;</li> <li>• some forested freehold land.</li> </ul>
Leonard and Hammond equivalent	West Central Hills landscape character type
<b>Riverine Plains — older alluvial plain (geomorphic unit 4.2 on Map E)</b>	
Landform	<ul style="list-style-type: none"> <li>• flat, higher-level alluvial plains;</li> <li>• elevation 100-200 m;</li> <li>• occasional bedrock outcropping to 350 m;</li> <li>• streams entrenched and tributaries gullied.</li> </ul>
Vegetation	<ul style="list-style-type: none"> <li>• northern plains grassy woodlands, dominated by grey box in varying densities;</li> <li>• occurs especially in small patches and roadsides;</li> <li>• Granitic Hills Woodland and Heathy Dry Forest EVCs on hilly outcrops;</li> <li>• narrow river red gum strips along minor watercourses;</li> <li>• very open woodlands over pasture on farms;</li> <li>• extensive cleared dry and irrigated farmland.</li> </ul>
Waterform	<ul style="list-style-type: none"> <li>• sections of the lower Goulburn, Campaspe, Loddon and Avoca Rivers;</li> <li>• tributaries with braided channel pattern in the east;</li> <li>• Lake Waranga, Lake Mokoan.</li> </ul>
Land use pattern	<ul style="list-style-type: none"> <li>• mostly agricultural grazing and cropping land;</li> <li>• large irrigated horticulture areas with grid patterns;</li> <li>• numerous small remnant public land blocks;</li> <li>• roads and watercourses evident from tree cover.</li> </ul>
Leonard and Hammond equivalent	Murray Basin Plains — Northern District Plains landscape character type
<b>East Victorian Uplands — dissected uplands (geomorphic unit 1.1 on Map E)</b>	
Landform	<ul style="list-style-type: none"> <li>• moderate to steeply sloping hills descending from the eastern Great Divide;</li> <li>• rounded ridges, narrow valleys;</li> <li>• elevation 200-550 m.</li> </ul>
Vegetation	<ul style="list-style-type: none"> <li>• Heathy Dry Forest, Grassy Dry Forest, Granitic Hills Woodland and Rocky Outcrop Shrubland EVCs;</li> <li>• introduced pastures in cleared areas.</li> </ul>
Waterform	<ul style="list-style-type: none"> <li>• Goulburn River, minor streams.</li> </ul>
Land use pattern	<ul style="list-style-type: none"> <li>• fragmented, forested public land on hills;</li> <li>• Chiltern Box-Ironbark National Park, Mt Pilot Park, several conservation reserves;</li> <li>• mostly grazing, some cropping on freehold land;</li> <li>• freehold land mostly cleared.</li> </ul>
Leonard and Hammond equivalent	Foothills landscape character type

**Principal source:** Leonard and Hammond (1984)

**Table 29: Features of high scenic quality in the Box-Ironbark study area**

<p><b>West Victorian Uplands — dissected uplands</b></p>	<ul style="list-style-type: none"> <li>• <i>Landforms</i>: isolated peaks, ranges, hills with distinctive form and colour contrast (such as the Pyrenees, St Arnaud Range, Fryers Ridge); serrated ridges; granitic rock outcrops or boulders (Mt Kooyoora, Mt Alexander)</li> <li>• <i>Vegetation</i>: strongly defined patterns combining eucalypt forest (EVC combinations), natural-appearing openings (public/freehold boundaries), streamside vegetation, and in context, scattered exotics; vegetation stands with unusual form, colour, texture or spacing (red ironbark, mallee stands)</li> <li>• <i>Waterforms</i>: established reservoirs such as Waranga, Laanecoorie; river and stream environs</li> <li>• <i>Cultural</i>: extensive historic goldfields features</li> </ul>
<p><b>Riverine Plains — older alluvial plain</b></p>	<ul style="list-style-type: none"> <li>• <i>Landforms</i>: contrasts with plains, particularly isolated peaks or ranges such as Mt Terrick Terrick; rock outcrops or boulders; defined steep-sided drainage lines</li> <li>• <i>Vegetation</i>: trees with diversity of species, height and density; contrasts with surrounds in form, line, colour and texture (cypress-pine stands, vegetated road and stream reserves)</li> <li>• <i>Waterforms</i>: permanent streams</li> </ul>
<p><b>East Victorian Uplands — dissected uplands</b></p>	<ul style="list-style-type: none"> <li>• <i>Landforms</i>: serrated ridges emphasised by adjacent landform; defined valleys; large rockfaces or outcrops (Mt Pilot, Warby Ranges)</li> <li>• <i>Vegetation</i>: strongly defined patterns combining eucalypt forest and natural-appearing open grasslands</li> <li>• <i>Waterforms</i>: major streams</li> </ul>

**Principal source:** Leonard and Hammond (1984)

can assist delineation of extensive areas with greater or lesser scenic value. Community opinions are central when compiling an inventory of places now valued. Two main approaches to scenic appraisal have been used.

**Scenic quality assessment**

The first method, used for comprehensive regional studies, identifies the land-use settings. Valid comparisons of scenic value can then be made between land with similar uses, including mixtures of uses, within the same landscape character type.

Within land-use settings, scenic value can be assessed by detailed comparison of landscape variables, also termed *scenic quality components* or *positive and negative visual attributes*. Those variables deemed to be positive or negative have been determined by repeated comparisons and rankings of many landscape photos with test groups, identifying those features commonly seen as either favourable or adverse. Williamson (1979) summarised the following research findings. Scenic quality increases as: topographic ruggedness and relative relief increase; waterforms and water edges increase; forest and grassland patterns become more diverse; natural and agricultural landscapes increase and built landscapes decrease; land-use compatibility increases and land-use edge diversity decreases.

For assessment, components of the landscape can be divided into landform, vegetation and waterform dimensions. On-ground assessments can include the presence of cultural features and fauna, for example nesting waterbirds. The scale of the project and extent of occurrence or visual dominance of each feature are also important. The ultimate scenic assessment tallies positive and negative features in each unit to provide a relative ranking.

Some features considered to indicate high scenic quality for the main landscape character types in the Box-Ironbark area are summarised in Table 29.

This approach needs to be adapted to the particular project. The scenic assessment of Victoria’s rivers by Anson *et al.* (1987), concentrated on the immediate environs of streams. The Department of Natural Resources and Environment (NRE) *Manual of Wetlands Planning* (1996) describes a similar procedure for assessing wetland landscapes. The scenic features in those studies would have differences from those recognised in dry forest landscapes.

While many scenic components are consistently viewed as positive, landscape appreciation can depend on an individual’s cultural values, and can have an interdependence with recreation and educational interests. Some old mining

areas, for example, can be seen as having interesting cultural heritage features, or as comprising eroded moonscapes, according to individual perceptions.

### Aesthetic value assessment for the Register of the National Estate

The second approach, based on community opinions, is used by the Australian Heritage Commission to identify places of aesthetic value. The relevant Register of the National Estate (RNE) sub-criterion is E1: 'importance to a community for aesthetic characteristics held in high esteem or otherwise valued by the community'.

Places with outstanding aesthetic qualities include natural features of outstanding scenic and evocative qualities; cultural features/landscapes with outstanding scenic, evocative or other special meaning to people; recreational places popular for their aesthetic qualities; and scenes depicted in the area's art, poetry and literature.

Information about the aesthetic value of a place is corroborated from different sources such as community heritage workshops; artistic and literary depictions of places; recreation and tourism data; professional reports and studies; and departmental officers familiar with the region. This is combined with a landscape character type appraisal.

### STUDIES IN THE INVESTIGATION AREA

Several scenic landscape studies have been carried out in the Box-Ironbark investigation area for particular purposes, although the whole area has not been systematically covered by broadacre studies.

The scenic assessment of Victoria's rivers assessed all major streams across the State. In the Box-Ironbark study area, Anson *et al.* attributed high scenic landscape value to those reaches of rivers and streams listed in Table 30.

The statements of resources, uses and values prepared for NRE Forest Management Area (FMA) planning, for the Mid Murray, Midlands and Central FMAs, include sections on landscape.

Park management plans prepared by NRE consider scenic landscape as a park resource, and develop

management aims and strategies to enhance scenic values and minimise impacts. In some cases appraisals of scenic sensitivity have been used to guide management.

The National Trust's approach to landscape assessment takes a wider view of 'landscape', using expert committees for particular landscape character types to appraise nominated areas according to scientific, aesthetic, historical and social criteria. The scientific criteria are similar to those used in determining sites of botanical and zoological significance. The Trust has carried out a systematic study of north-eastern Victoria for scenic landscapes, and has considered other landscapes in the Box-Ironbark area.

### REDUCING IMPACTS OF ACTIVITIES

Several scenic study techniques have in common the object of reducing potential scenic impacts of site-specific land-use proposals, rather than evaluating regional landscapes.

#### Forest activities

The Department of Natural Resources and Environment's visual management system (VMS) aims at containing the visual impacts of forest operations. Classification of physical settings using landscape character types and scenic quality is combined with social considerations — travel routes used by tourists and recreators, and perceptions of the landscape impacts of forest operations — to produce visual management zones.

According to a location's scenic quality and sensitivity level, it is classed either A (where landscape alterations should not be visually evident, or only temporarily apparent), B or C (where alterations may be visually dominant within limits).

**Table 30: River and stream reaches of high scenic quality**

River or stream	Reaches of high scenic quality
Goulburn River	Seymour to Shepparton
Campaspe River	Lake Eppalock to Axedale
Bullock Creek	Eppalock to Epsom
Loddon River	Lake Cairn Curran to Fernihurst
Avoca River	Town of Avoca to Yawong

This process contributes to decisions on the siting and design of logging coupes and roads. In box-ironbark areas coupes are not clear-felled, and less visually dominant methods are used. However when harvesting in landscapes with low relief, such as box-ironbark forests on gently dissected land, the form, size and colour of individual foreground trees can be important scenic features. Removing such trees can have an evident visual impact.

### Landscape appraisal in environment effects statements

Environment effects statements (EES) for major projects including highway works and new mines commonly include landscape assessments. Statements containing scenic landscape chapters have been prepared for the Potential National Highway Route at Albury-Wodonga, the Shepparton Bypass, and major mining proposals around Bendigo and Nagambie. These include appraisals of scenic resources in the limited areas affected, and approaches to limiting scenic impacts.

The Woodend Bypass proposal EES, within the investigation area but outside the study area, is an example of a detailed highway EES. It identified 28 landscape setting units in the visual influence zone of alternative routes. Consultants undertook public consultation, and considered the following factors in evaluating the overall landscape effects: visual features; significant views; scenic quality for each unit; observer volumes; visual absorption capability (derived from slope steepness and tree density); land use and transport; and historic, recreation and tourism features. Along a preferred route, localised points with high constraints were specifically addressed and design action taken to reduce likely impacts.

The Fosterville Gold Project EES described the landscape context and visual amenity of the affected area. To mitigate scenic impacts, a series of detailed provisions was specified for the following: design of mine pits and overburden areas; minimisation of clearing; siting and choice of materials and colours for structures; screening with earth bunds; early plantings of indigenous species; and progressive rehabilitation.



*Woolshed Falls, Beechworth Historic Park.*

## 14. CULTURAL HERITAGE

### BACKGROUND

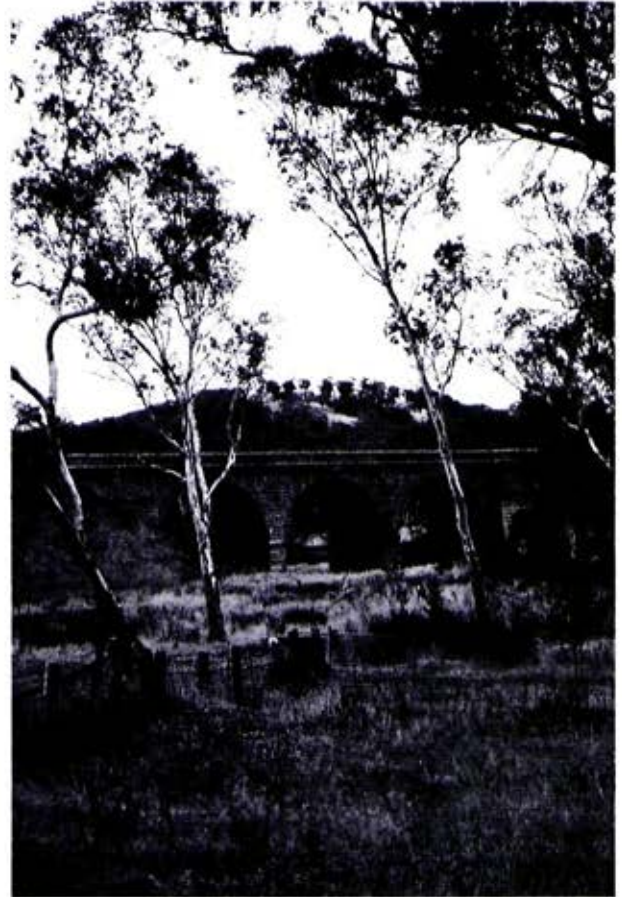
The Box-Ironbark investigation area has a rich heritage of historic places on public land. Many of these places have been documented in previous Land Conservation Council studies (including the Historic Places Special Investigation South-western Victoria, which covered public land in the south-west corner of the Box-Ironbark study area). Others have been documented in the recently completed Statewide Historic Mining Sites survey, or the survey of historic forest activity sites, both of which have had substantial Commonwealth funding. For places not covered in these surveys some of the available information is inadequate. Thematic, geographic and typological gaps also occur in the range of places identified in the region to date.

Aboriginal archaeological places (generally from the pre-contact period) are described in Chapter 2. Very few Aboriginal historic sites and places from the contact and post-contact periods have so far been identified in Box-Ironbark forests and woodland areas. This reflects a lack of research in the area, and is a significant gap in our knowledge of the cultural heritage of the region.

For the purposes of public land-use planning, it is necessary to document and assess historic places. This also assists managers in managing and conserving a range of places in the forests, identifies places of potential National Estate significance, and contributes to Commonwealth Government commitments under the National Forest Policy Statement in regard to the protection of significant values (including cultural values) of box-ironbark forests.

Accordingly, some additional Commonwealth funded field-based survey work has been undertaken by consultants to fill the gaps described above. A copy of the consultants' report is available for viewing at Council offices. Information on places already known and listed in other databases (such as the Department of Natural Resources and Environment's data from the State-wide historic mining sites survey), registers and reports has also been collated. This work was assisted by a Commonwealth-funded audit and analysis of existing information.

An inventory of selected significant historic places on public land in the region (out of more than 1200 places



*The Harcourt rail bridge illustrates the elaborate engineering of the Melbourne-Bendigo line, built between 1859 and 1864.*

identified by consultants) is included in Appendix III. Relevant themes are also identified in the Appendix. Aboriginal archaeological and historic sites and places are not included in the inventory. Aboriginal Affairs Victoria holds information on these places (see below).

This chapter provides a description of box-ironbark cultural heritage resources; an outline of the basic principles of heritage conservation; and a brief overview of management issues and requirements, and the organisations responsible for the protection of cultural heritage in Victoria.

### THE CULTURAL HERITAGE OF THE STUDY AREA

Chapter 3 provides a thematic overview of the history of the Box-Ironbark study area. It describes the activities and

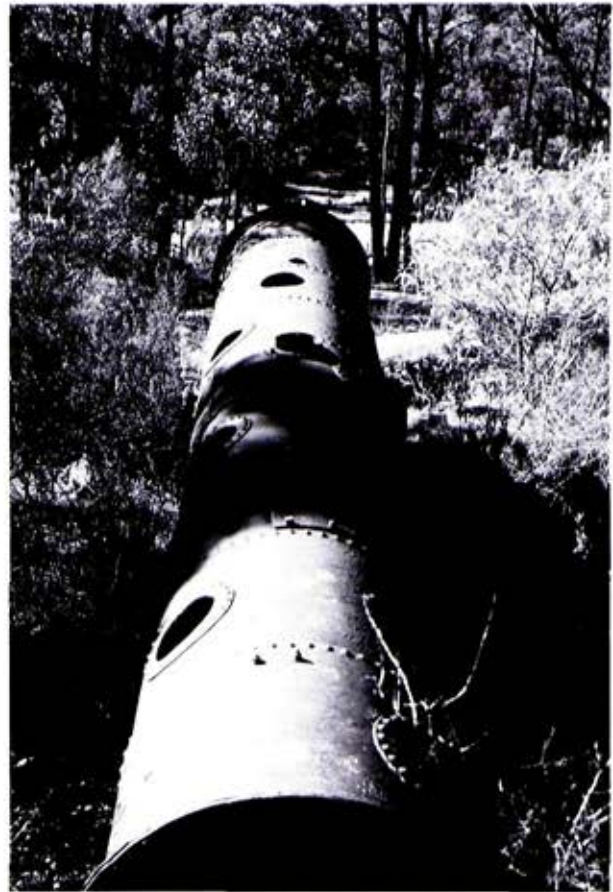
impacts of Europeans in the region, from the passing of Major Mitchell in the 1830s, through the gradual taking up of land for pastoral and agricultural purposes, to gold mining and the various commercial and other uses made of the box-ironbark forests up to the present. These historical uses, which constitute various aspects of forest disturbance, have resulted in the presence today of a range of fascinating and significant historic places that contribute substantially to the cultural heritage resources of the region.

Conflict between Aborigines and Europeans in the initial contact period, and the marginalisation and survival of Aboriginal people in the pastoral and gold rush eras, are described in Chapter 2. It is very likely that places associated with this history remain to be documented.

The Major Mitchell camp site at Expedition Pass, together with other monuments of various styles and materials, commemorates Mitchell's epic journey of 1836. Aspects of the history of the pastoral industry in the region are demonstrated through places such as Terrick Terrick Homestead, Mitiamo; the graves of pastoral pioneers (including the Evans family compound at the Whitefield Cemetery); and remnant chock and log fences in the Kara Kara State Park, which mark the original boundaries of local pastoral runs. Sites and features associated with later settlement include water supply systems such as the Coliban system and the Laanecoorie Reservoir, and irrigation features such as the Goulburn Weir and the Waranga Irrigation System.

The gold mining industry of the 19<sup>th</sup> and early 20<sup>th</sup> centuries generated an extraordinary range of historic places. This heritage includes structures, machinery remnants, pits, shafts and tunnels, and extensive water races. It also encompasses the built environment of the towns and communities associated with mining, and areas of disturbed landscape which graphically demonstrate both the techniques used in gold extraction and early attitudes to the environment. Examples of the many significant places associated with gold mining in the Box-Ironbark area include the Glasgow Reef workings at Diamond Hill (battery sites, an open cut and tramway); the comparatively intact puddler at Jib Horse Gully, Whipstick; and sites within the Maldon Historic Reserve such as the Beehive Mine, Grand Junction Battery, Porcupine Flat dredge site and areas subjected to hydraulic sluicing in Peg Leg Gully.

Other forest-based activities in the study area which have sometimes left significant evidence behind include sawmilling and sites of minor forest production. Charcoal pits (for the production of charcoal) of archaeological interest can be found at Rostron, and in the Graytown and Kamarooka State forests. Significant eucalyptus oil distillery sites have been recorded near Maryborough, Clunes, Waanyara and Kamarooka. Historic places associated with forest management include fire towers at Mt Tarrengower and in the Warby Ranges, and the sites of work camps supervised by the Forests Commission in the 1930s and 1940s.



*Boiler, Diamond Hill Historic Reserve near Bendigo.*

The development of infrastructure associated with transport and communication has given rise to significant railway structures such as the viaduct at Taradale, the tunnel at Elphinstone, and the water tower and locomotive shed at Echuca. Significant road bridges include the Bet Bet Creek Bridge at Bung Bong, and the old iron bridge at Mia Mia.

In the second half of this century, the Australian Army has made extensive use of the box-ironbark landscape around Puckapunyal for training and practice purposes. Historic places of interest associated with this activity include a tank practice area and a mock village (substantially demolished), used for recruit training during the Vietnam War.

## MANAGEMENT AND PROTECTION OF CULTURAL HERITAGE

### The Burra Charter and conservation principles

Nationally accepted principles for the care and management of historic places in Australia are outlined in the *Charter for the Conservation of Places of Cultural Significance* (Burra Charter), which was adopted by the International Council for Monuments and Sites (ICOMOS) in Australia in 1979.

Basic principles inherent in the Charter include acknowledging the importance of the place itself; understanding the cultural significance of the place; recognising that the fabric, setting and contents of the place are important; making decisions about the future of the place based on information methodically collected and analysed; and keeping accurate records about decisions and changes made to a place.

#### Cultural significance

The cultural significance of a place, as defined in the Burra Charter, is related to its aesthetic, historic, scientific or social value for past, present or future generations. Significance is determined by such factors as rarity, age, condition, integrity, research potential, aesthetic qualities, and associations with important people, events, phases or developments in history. Research into the history of a place uncovers information which can influence the assessment of significance, as does comparing similar places.

#### Management

Before making decisions about appropriate care, managers of historic places need to consider a number of factors: the significance, condition and location of the place; the availability of funds and expertise; vulnerability to impacts; and options for reuse (including disposal) of the

place. Managers are also sometimes constrained in their actions by statutory requirements (see 'Protection' below), public health and safety issues, conflicting resource use at or near the place (such as timber harvesting or a renewal of mining), or a potential reuse which may have a negative impact on the significant historic values of the place.



*Single catenary arch road bridge constructed of local granite in the goldrush era, Beechworth.*

Generally, the management of historic places aims to conserve places *in situ*, and to secure and stabilise a deteriorating place if possible. If destruction or demolition is inevitable, then managers endeavour to record the place prior to demolition. Monitoring the condition of a place is also desirable, as is collecting and keeping information about it. The management of some significant historic places is aided by the development of conservation and action strategies, or conservation management plans, drafted by a cultural heritage expert.

The management of Aboriginal cultural heritage on public land is primarily the responsibility of Aboriginal

Affairs Victoria (AAV), in conjunction with the relevant Aboriginal communities and the Department of Natural Resources and Environment (NRE). AAV's role is briefly described below. The conservation and management of Aboriginal places may require a different approach from that described above, and outlined in the Burra Charter. Aboriginal communities should be fully consulted and involved in the management of their places.

## Protection of historic places

In Victoria several groups and organisations are involved in the protection and management of historic places on public land. Those with key roles are described below, but others with responsibility also include many individual committees of management, and local and State government departments and authorities who own and manage historic buildings and structures.

### Department of Natural Resources and Environment

NRE, as the primary public land management agency in the State, is responsible for the enormous range of historic structures and relics which can be found in parks, forests and all categories of public land in Victoria. NRE manages, directly or indirectly through delegated management (such as committees of management), many redundant public buildings including former courthouses and schools; some current community buildings; abandoned historic sawmill or mining sites; and structures or works associated with various Crown land tenures, including grazing licences. These places are of varying significance, and therefore require various levels of protection.

Historic places in parks and conservation reserves are protected under the *National Parks Act 1975*. Parks Victoria is chiefly responsible for national and other parks, and conservation reserves. Management of historic places in these areas is directed by guidelines and procedures manuals, and by park management plans which set out management zones within parks, or describe special management objectives, which ensure the protection of historic places.

A number of historic areas and reserves in the study area protect significant historic places. The reserves can be implemented under the *National Parks Act 1975*, or the *Crown Land (Reserves) Act 1978*. Examples of the

34 recommended historic areas and reserves in the Box-Ironbark study area (though not all have been formally reserved to date) include the Castlemaine–Chewton, Percydale, Maldon, Whroo and Moliagul Historic Areas, and the Woolshed Swamp Sheepwash, Majorca, Timor and Graytown Historic Reserves. Historic reserves created under the *Crown Land (Reserves) Act* include former public buildings in towns, such as courthouses, which no longer perform their original function, but have been retained for community use or other purposes.

Victorian State forests also contain many thousands of historic places and relics, and these are managed by the Forests Service of NRE. Known historic places are listed in forest management plans and on regional inventories, including Geographic Information Systems (GIS) databases. The places can also be protected through reservation under the *Forests Act 1958* and zoning in forests, or be subject to specific management prescriptions. Buffers are used to protect places in areas subject to timber harvesting.

### Heritage Victoria

Heritage Victoria is an administrative unit within the Department of Infrastructure responsible for the identification, assessment and preservation of Victoria's most significant non-Aboriginal cultural heritage. The agency operates under the *Heritage Act 1995*, maintains the Victorian Heritage Register, and provides administrative support for the Heritage Council, which is a statutory body responsible to the Minister for Planning and Local Government. That Council makes recommendations for additions and amendments to the Heritage Register, which lists sites of at least State significance.

Registration affords the highest level of statutory protection available to historic places in Victoria. Owners or managers must obtain a permit from the Heritage Council prior to undertaking any demolition, alteration or works on a registered place (other than basic repairs or maintenance).

Historic (non-Aboriginal) archaeological places are another responsibility of the agency; some of them are also included on the Register.

### Australian Heritage Commission

The Australian Heritage Commission (AHC) is a Commonwealth Government statutory authority responsible for

the identification of the National Estate. The Register of the National Estate (RNE) comprises places of both natural and cultural significance, including historic and Indigenous heritage, and provides recognition for the values of these places. Places listed on State registers may also (but not necessarily) be listed on the RNE, and vice versa.

RNE registration does not generally directly affect the way in which owners or managers administer these places. The Commonwealth Government, however, is constrained in its management of registered places, to the extent that it should not take any action which would adversely affect a listed place, unless there is no feasible and prudent alternative. The AHC must also be informed of any proposed Commonwealth action which impacts on a registered place, relating to foreign investment in Australia, the granting of export licences for products from natural areas, and the provision of Commonwealth funds for programs.

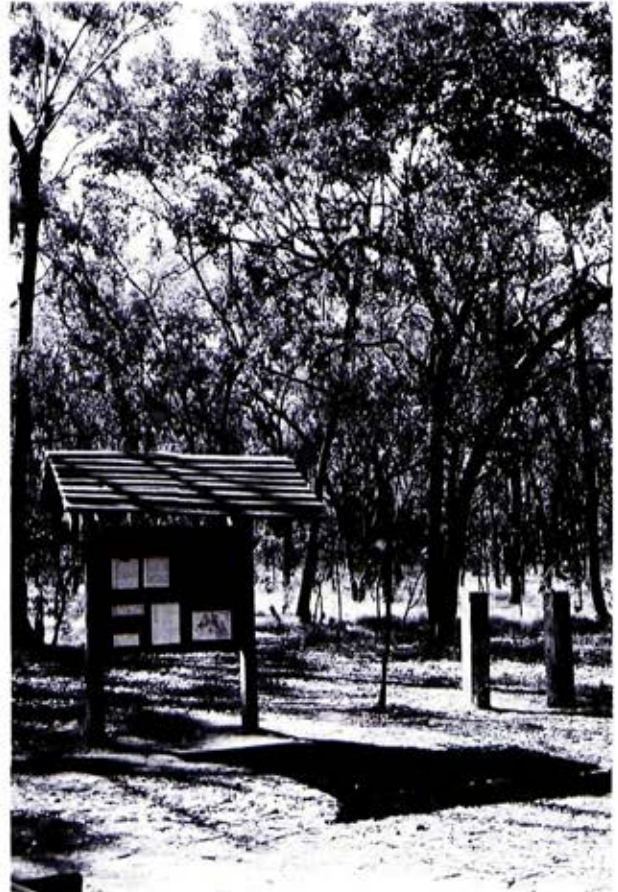
#### National Trust

The National Trust of Australia (Victoria) is a non-profit community organisation committed to the conservation of Victoria's heritage, which actively pursues protection of significant places. The Trust maintains a non-statutory register that includes buildings, gardens, trees and landscapes. It also manages a number of historic places and properties in Victoria, including several on public land (as Committee of Management) in the Box-Ironbark area, such as the Powder Magazine at Beechworth, and the historic Castlemaine Market.

#### Aboriginal Affairs Victoria

Aboriginal Affairs Victoria (AAV) is a division of the Human Services portfolio. The Heritage Services Branch of AAV is responsible, in cooperation with Aboriginal communities, for the investigation, interpretation, protection and management of Aboriginal cultural and archaeological heritage.

AAV's Site Register is an inventory of places from the pre- and post-contact periods. AAV also maintains databases of Aboriginal historic places and sites. Aboriginal cultural heritage has protection under the Victorian



*Interpretative facility at Indigo Goldfields Cemetery, Chiltern Box-Ironbark National Park.*

*Archaeological and Aboriginal Relics Preservation Act 1972, and the Commonwealth Aboriginal and Torres Strait Islander Heritage Protection Act 1984. A permit must be obtained from AAV prior to any potentially damaging activity on or near a registered Aboriginal place. It is also an offence to damage or remove Aboriginal relics and artefacts from where they are found.*

#### Local Government

Municipal planning schemes are an important source of protection for significant historic places, including places on public land. For places listed in schemes, a permit from the local council is required prior to works involving external alterations, demolition or removal, or construction of a new building.

# 15. PRIMARY PRODUCTION

## OVERVIEW

The Box-Ironbark study area encompasses a wide variety of agricultural land uses, including the heartland of Victoria's irrigated horticultural and dairy industries. *Most agriculture is on private land, which is not subject to this investigation.* However, this chapter reinforces the context of public land as a relatively small component of the extensive agricultural landscapes in the study area.

The gross value of agricultural production across the study area is in excess of \$1.6 billion per annum, which equates to approximately 33 per cent of the gross value of Victorian agricultural production at the farm gate. Productivity is expected to grow, with improvements in irrigation efficiency and a gradual shift in water resources from less productive irrigated grazing and hay production to higher value enterprises such as horticulture and dairying. There is also considerable interest in new and emerging industries, such as herb growing, cut flowers and niche market animal production.

Dryland agricultural production in the study area is prone to the effects of drought. Dryland cropping and grazing industries are particularly vulnerable, and drought has largely determined the pattern of land-use which favours low investment (low risk) extensive industry. In particular, the inland hills area tends to have shallow topsoils and, consequently, is often of limited value to intensive agricultural production.

In the last ten years, the number of farms considered in Australian Bureau of Statistics (ABS) data has declined from approximately 14 000 to 12 000 and the area of land across the investigation area classified as agricultural production has decreased by approximately 400 000 ha. The primary causes of these declines have been the loss of land to small hobby farms and the reduction of farm profitability, both of which led to the inability of many farms to meet the ABS threshold of \$5000 GVP (Gross Value of Production) for inclusion as a farm.

The ABS data used extensively in this chapter refer predominantly to the investigation area, but agricultural production within the investigation area is concentrated in the study area.

## SHEEP PRODUCTION

The investigation area encompasses approximately 30 per cent of Victoria's sheep flock, producing a gross income of approximately \$330 million at the farm gate.

Sheep production is primarily a dryland occupation, with sheep often incorporated into irrigated properties to fulfil various management objectives such as weed control and stubble grazing. The majority of grazing is carried out on annual pasture with varying degrees of sown and volunteer perennial pasture species. ABS figures indicate that approximately 25 per cent of pastures incorporate some degree of exotic perennial pasture species, indicating a significant level of investment by farmers in dryland pasture improvement practices.

Sheep production in the study area is generally reliant on self-replacing merino or 'first-cross' (border leicester-merino ewes and wethers) flocks extensively grazed over large paddocks. *The land is mostly grazed using low to moderate input practices with sheep rotated to fit the required management objectives of the individual farmer.*

Sheep provide considerable flexibility in a farming operation for a relatively low unit cost and they are readily incorporated into temporary pasture rotations in cropping situations. This has been a primary factor in the development of traditional wheat-sheep operations across much of the northern plains.

Prime lamb production is becoming an increasingly important option for producers, especially in dedicated sheep production systems faced with steadily declining returns for wool. A basic requirement of successful lamb production systems is a high degree of predictability of feed supply, requiring a move towards more intensively managed and higher productivity exotic perennial pastures.

The Victorian Salinity Management Program has promoted the adoption of perennial pastures, because of their perceived benefits for salinity control. However, significant barriers to adoption have been low commodity prices, farming population age structure, significant input costs, risks of establishment failure, and the more intensive management (compared to more traditional annual

pastures) required by the adoption of perennial *Phalaris* or lucerne based pastures.

Generally lower commodity prices, and a reliance on low productivity extensive farming, have placed greater economic pressure on the use of Crown land for grazing as producers endeavour to increase short term returns with minimal investment.

Sheep numbers have declined dramatically in the last decade. Sheep farming is also losing importance to other forms of agriculture within the study area, as many farmers seek newer and more profitable options where natural resources and capital permit.

## CATTLE FOR BEEF

The investigation area holds around 22 per cent of Victoria's beef cattle. In 1994/95 cattle sales for beef production accounted for 30 per cent of total farm gate GVP for the Victorian beef industry.

Since 1984/85 beef cattle numbers within the investigation area have risen by nearly 50 per cent to around 600 000 head. A number of factors have caused this increase, including decreases in the relative profitability and certainty of wool production and markets. The proportional mix of many properties which traditionally rely on beef-sheep mixed enterprises has changed.

Large-scale adoption of laser grading on irrigated pastures has greatly improved the productivity across the northern part of the study area, allowing for increases in stocking rates above historical levels. The emergence of feedlots has provided a new avenue for direct sales of beef, helping to maintain consistency in pricing and marketing options. The traditional high reliance of north-east Victorian producers on British breeds is particularly suited to the demands of the marbled meat export market because of the breeds' suitability for lot feeding.

Victoria's capacity for greater export to Asian markets and the increasing demand for high quality meat on the domestic market over the past ten years, have led to improved producer confidence about increasing stock levels.

There is an increasing acceptance that farms with less than 200 head of cattle are rapidly becoming unprofitable. This situation is a significant challenge to the industry, especially in the light of strong competition in traditional

Australian markets and significantly higher processing costs than competitors such as the United States and New Zealand.

If wool prices remain depressed it is likely that beef cattle numbers will continue to rise at least in the short term. Due to the perceived cyclicality of pricing, many producers are delaying sales of beef cattle thus increasing the build-up of numbers. Given depressed commodity prices, many producers have increased their production of hay for sale off farm, especially from irrigated pastures.

Some degree of industry rationalisation will be required within the Victorian beef industry to ensure its competitiveness for the long term. Unprofitable irrigated beef properties require large amounts of resources that could be diverted into industries such as horticulture, which have much greater income-producing potential per ML of water used.

## DAIRY INDUSTRY

The dairy industry supports over 500 000 dairy cattle across the investigation area, generating over \$411 million per annum at the farm gate — 31 per cent gross value of Victoria's dairy production — from milk production alone.

Dairy production in the investigation area is largely confined to the northern irrigation areas, utilising the heavier clay soils of the high level riverine plains. Irrigation to these areas is largely supported by gravity fed, open irrigation supply channels — see Chapter 18 for more details. Water is generally administered by flooding the land from metered connections to the channels.

Water entitlement is freely tradeable within supply districts, however the supply systems operate within limitations imposed by the physical capacity of the infrastructure to supply water during times of peak demand. Considerable investment in laser grading, irrigation scheduling and watertable management is taking place, which is improving the long-term returns to water use on a \$/ML basis. This investment is improving economic outcomes and freeing up water resources from lower value production for new high value developments.

As with most other agricultural industry in the study area, income from dairy production supports farming

service industries. The milk processing industry within the study area supplies milk, butter, cheese, and dried skim milk products which are marketed throughout Australia and increasingly to south-east Asia.

As dairy farming is the major income producing industry across much of the study area, changes in commodity prices or factors which influence the productive capacity of the industry, such as degradation of the region's natural resource base, can have a dramatic effect on regional prosperity. Considerable investment is being made by both the government and the community to address natural resource management issues within the study area, including attempts to lower groundwater levels and prevent the loss of productive capacity and of biodiversity from *fragmented remnant vegetation and wetlands, which are particularly prone to the effects of salinity.*

## PIG INDUSTRY

The investigation area represents the most important region for the Victorian pig industry, encompassing nearly 70 per cent of Victoria's gross value of production and comprising 318 properties. This equates to nearly \$98 million per annum at the farm gate.

*Since around 2 per cent of pig products are exported, value-adding processing and slaughter facilities remain within the local communities. The industry provides local employment, and demand for dedicated service industries such as the Bunge feed mill at St Arnaud, which in turn create demand from domestic grain markets, benefiting local producers. Castle Bacon and Daylesford Abattoirs are amongst the largest employers in the Castlemaine area.*

Pig producers are increasingly utilising novel approaches to problems such as effluent disposal. In many cases producers are contracting out operations to smaller family farms, reducing single site effluent management, disease problems and other externalities such as smell associated with large high-intensity animal production. *Contracting operations to widely dispersed farms has the potential to generate opportunities for grain producers who are more distant from urban markets for their grain, especially in the west of the investigation area and the Wimmera. A move towards red wheat production for feed purposes provides opportunities to expand the value of animal*

*products based largely on grain feeding systems, especially in the south-east of the investigation area.*

## CROP PRODUCTION

The investigation area produces approximately 30 per cent of the gross value of Victoria's cereal grain production with other grains being of local importance. Despite the drought conditions of 1994/95, production was still worth around \$113 million.

Cropping is practised across approximately 750 000 ha, or around 20 per cent of the total area of holdings in the area. The crops grown by producers vary considerably from year to year, largely reflecting market prices. *Longer term trends in grain production are generally associated with long-term changes in sustainable land-use management practices, the development of new markets and a recognition amongst producers of the need for greater diversification to offset income effects of cyclical commodity prices.*

Dryland cropping is by far the major form of cropping in the region, with irrigated cropping providing an important option for many farming operations wishing to diversify their productive base.

Wheat is the major crop on most dryland farms, followed by barley, oats and field peas. The area of land sown to wheat in the investigation area has fallen to around 40 per cent of that in 1984/85.

Grains such as triticale, lupins, and the emergence of the oilseeds industry, along with improvements in the disease resistance and productivity of canola, have provided growers with a range of productive options to fit into rotational cropping systems. These cropping systems increase the yields of subsequent crops, giving longer disease breaks, reducing fallowing and the need for sheep grazing 'ley' (pasture-crop rotation) farming systems. While this has largely accounted for the observed reduction in sheep numbers across the study area in the last ten years, it also requires an increased frequency of cultivation.

The proportion of cropped land to the total area in holdings has remained approximately the same, despite the land lost from the ABS agricultural production category in the last ten years. Cropping is generally less favoured by part-time farmers than animal-related production or novel

industries. Particular emphasis appears to be given to less labour-intensive and capital-intensive commodities such as beef cattle.

## ORCHARDS

Orchard production in the study area in 1994/5 was nearly \$170 million; a greater value of production than the cereal industry, from a total of less than 12 000 ha. The major fruits of agricultural significance grown in the study area are the pome and stone fruits, however citrus and nuts are also of localised importance.

The major orchard areas are Shepparton, Cobram, and Harcourt. Production at Harcourt is primarily of pome fruits catering largely to the Melbourne fresh fruit markets. The Shepparton region has introduced a degree of vertical integration with processors, namely SPC and Ardmona, allowing growers to target varietal, quality and production specifications based on contractual guarantees.

Orchards are more profitable per hectare and per megalitre of irrigation water than most other forms of agriculture in the irrigation districts of the study area (especially beef and dairy cattle). Consequently, the conversion of less efficient farming systems to orchard production has been advocated — in the Loddon Murray 2000+ Regional Development Strategy, for example — where land capability assessments indicate that conditions such as soils and infrastructure are suitable.

## VEGETABLE PRODUCTION

Vegetable production for human consumption has a significant potential to boost regional incomes from properties with a good combination of suitable soils, drainage and access to good quality water supplies.

Since 1984/85 vegetable production has decreased in area from around 7000 ha to about 5200 ha. This has been largely because large-scale potato growing operations have moved further downstream along the Murray River, utilising the lightly textured soils. These are more conducive to long-term tillage than the shallow duplex soils of the Goulburn Valley, traditionally used for horticulture within the study area.

The study area continues to be the largest in Australia for tomato growing, extending from the central growing

region of the Goulburn Valley between Rochester and Shepparton and the significant area in the Loddon Valley around Boort. Victoria produces around 68 per cent of Australian tomatoes, almost all of which come from the study area where production is over 120 000 tonnes annually. Most Victorian tomatoes are sold to the processing industry, with only around 11 per cent going to the fresh fruit market.

## VITICULTURE

The Box-Ironbark study area has a long association with viticulture, especially the wine industry.

Vineyards and wineries are scattered throughout the inland hills whereas on the northern plains they are generally concentrated in a few key districts. There are major vineyards in the King and Goulburn valleys, with smaller but significant developments through the Ovens Valley, Pyrenees and Rutherglen regions. Current plantings in the study area produce a farm gate GVP of approximately \$30 million, which is around 13 per cent of Victorian wine grape production.

While the soils and climate of the study area are generally well suited to growing grapes for wine, there is considerable local variation in conditions, with particular regions being more or less suitable for particular varieties. Consequently, wines produced in the study area reflect a great diversity of styles, and the production of premium varietal wines, often associated with particular regions, is a distinctive feature. Well known examples include the fortified reds of the Rutherglen area, the table reds of the Pyrenees district, the table and sparkling wines from around Great Western and Ararat, and a large number of varieties from the Ovens and King valleys. The study area encompasses the heartland of Victoria's red and fortified wine production.

The wine industry is additionally important to the economy of the study area as an integral part of the tourism industry, providing employment and tourism income to communities such as Great Western, Milawa, Rutherglen and Avoca. Sales of wines on both the domestic and overseas markets multiply the value of grape production many times over.

Owing to the large expanse of land with suitable soils and climate available within the study area, it is likely that

new regions with high value potential remain to be developed. There has been large-scale re-development of irrigated former pasture land within the Goulburn Valley, as a result of which, and other developments, wine grape production in this area is expected to increase substantially over the next few years.

## AGRICULTURAL USE OF PUBLIC LAND

Much of the land in the study area which remains under the Crown has resulted from historical land-use decisions such as setting aside forest areas for coppice regeneration to support the mining and timber industries, and excluding it from selection for agriculture because of the incompatibility of its poor soils and moderate to steep slopes with farming systems. A large proportion of small, discrete and linear parcels of public land within the study area is used under licence, for stock grazing and shelter, stream access for water in public land water frontages, farm lanes and tracks, and cropping in cleared blocks on the northern plains. There are about 8900 licences for unused roads and water frontages. A smaller proportion of the total area of land in larger public land parcels — less than 9 per cent — is used for grazing under licence.

Public land grazing within the study area is primarily by sheep, which are able to make the most agriculturally productive use of available fodder. Often the small parcels are treated by adjoining landowner licensees as a 'bush block' and incorporated as part of a larger paddock system. Some blocks are unfenced and stocked with sheep freely mobile between the freehold open pasture and public land. In certain cases the Crown land parcels have been cleared and cultivated, contrary to licence conditions, so they are physically indistinguishable from the surrounding privately owned pasture or cropping land. However, some parcels, particularly road reserves and isolated Crown blocks, are identified by remnant trees in farmland, while others exist as significant refuges for indigenous flora and fauna. Grazing on larger parcels is not managed in this way, with the separation between the public and private lands usually remaining distinct.

Factors which strongly influence the degree to which native plant communities have survived on Crown land parcels, particularly smaller parcels, include the degree to which native vegetation has been cleared and exotic pasture

species such as Toowoomba canary-grass have invaded; the prevalence of tree decline factors; the history of fertiliser use on the land and adjacent pastures; grazing patterns; and other uses such as mining. Where grazing has been permitted only at certain times of the year, for example in summer, especially where such management is used only to offset drought, species diversity may be high as many native species are relatively dormant at this time. Of course, native vegetation is also stressed and vulnerable to damage during drought.

Where horses graze native vegetation remnants, incomplete digestion within the gut is conducive to seeding of pest plants and other exotic species from faecal deposits, leading to environmental weed infestations. Horses can cause significant trampling, as can cattle grazing. The impacts of public land grazing on natural values are discussed further in Chapter 21.

### Agricultural tenure arrangements

The use of public land for agriculture is largely administered by the Department of Natural Resources and Environment (NRE), although some public land, such as ex-railway land, is administered by local agents for the Public Transport Corporation.

Grazing is practised on many unused road reserves, public land water frontages, and discrete Crown land parcels within the study area. Reference areas, water supply reserves, and most parks and conservation reserves are not grazed. Relatively small areas of State forest are grazed infrequently and at a low intensity by domestic stock. Tenures for the use of Crown land are administered by NRE under legislation, including the *Forests Act 1958*, *National Parks Act 1975*, *Land Act 1958*, and *Wildlife Act 1975*. The majority of public land grazing — about 47 000 ha — is carried out on unused road reserves, public land water frontages reserves and other small areas of Crown land held under grazing licence. Another 28 000 ha is grazed in State forest and under the *National Parks Act* (Table 31). Licence conditions are specified by the Crown as part of licence arrangements.

The *Crown Land (Amendment) Act 1994* permits 99-year licences for unused roads and 35-year licences for water frontages. Previously licences were renewed annually.

Landholders who take up 99-year licences for unused roads have payment options ranging from five-yearly to

once-off. Rental prices are based on the assessed carrying capacity of the land and calculated on the basis of the total number of dry sheep equivalents (DSE) the occupied land can support. Provided that clearance is given by NRE in consultation with local government to ensure that these parcels are not required for use as roads in the foreseeable future, occupants can apply to purchase the land at market price, determined by the Office of the Valuer General. Fees for surveying and other requirements for title consolidation are at the land owner's expense.

Water frontage land is administered as 35-year licences with payment periods in seven lots of five-year periods. Rental rates are based on an indexed figure applied per DSE of carrying capacity which the land has been assessed to produce. The rental rates charged will be adjusted in each payment period to reflect the relative profitability of sheep production.

Grazing licences in extensive public land (that is, other than unused roads and water frontages) remain based on annual licence. Fees are based on the carrying capacity, similar to the method used for unused roads.

The status of each Crown land water frontage parcel will be determined by a review of the environmental significance of parcels and recommendations made by the regional Catchment Management Authorities (see Chapter 1) relating to the environmental significance and future management of these parcels.

**Table 31: Public land currently used for agriculture under various tenure arrangements**

Tenure type	Area occupied (ha)	No of licences	Annual rental (\$)
Grazing licences			
Parks and reserves	1 180	7	1 369
State forests	27 243	328	69 413
Other Crown land	9 803	1 329	143 676
Water frontage licences	14 779	2 424	197 218
Unused road licences	22 704	6 436	454 268
Agistment permits	1 130	31	NA
Apiary site permits	156 650	1 023	NA

**Note:** these figures were compiled from those for municipalities within, or partly within, the Box-Ironbark study area.

The sale of some parcels of land will carry with it conditions in covenants with perpetual management requirements for private owners. The implementation of special area plans and land-use conditions under the *Catchment and Land Protection Act 1994* is intended to ensure that appropriate management requirements are placed on environmentally sensitive areas.

## APICULTURE

Box-ironbark forests are highly valued by bee-keepers because many of the indigenous tree species consistently produce large quantities of premium quality honey. In addition to honey, apiarists sell beeswax, pollen and queen bees, and are paid by orchardists to provide hives to enhance pollination, and hence productivity, of fruit trees.



*Bee hives in Stuart Mill Historic Reserve.*

Statistics which accurately reflect the nature of the apiculture industry in Victoria are not readily available for a number of reasons, mostly as a result of the large number of part-time or casual bee-keepers and the mobility of the major operators. It is possible to document the output of major producers living in the study area but, since they may have hives dispersed throughout the State — in order to capitalise on seasonal flowerings of different plants, frost frequency, site availability, or to prepare bee colonies for orchard pollination — it is not possible to identify what proportion of the output comes from the study area. Many of Victoria's larger producers live within the study area. As a result of such uncertainties, much of the following information should be taken as only indicative.

In Victoria in the 1996/97 year, there were approximately 1600 registered owners with a total of around 100 000 hives, and around 600 unregistered owners with a

total of around 15 000 hives. Apiculture is a part-time activity for the majority of honey producers — those with 50 hives or less account for 76 per cent of registered producers, but own and operate only 17 per cent of registered hives.

Estimates of the total Victorian production of honey and beeswax vary from \$4 to \$8 million per annum, and it is estimated that approximately 70 per cent of this production comes from the study area. Public land within the Bendigo Forest Management Area produces approximately 1750 tonnes of honey and 50 tonnes of beeswax each year. Total revenue received by the State from bee-sites on State forest within the Bendigo FMA during 1994/95 was \$44 968.

It is estimated that around 16 per cent of all registered hives are used for crop pollination each year. This is a particularly important function for the productive potential of the Goulburn Valley orchards. Hives are rented at prices typically between \$25 and \$35/hive/flowering, representing an additional \$500 000 of gross income to the industry.

### Administrative arrangements

A licence is required to place bee hives on public land, while the permission of the landholder is required on private land. Licences are not issued over popular public-use areas, or over some land use categories, such as wilderness areas and reference areas. Permanent sites (1.6 km radius) are rented annually, whilst temporary sites (0.8 km radius) are available for three-monthly periods to accommodate intermittent peak flowering periods. Wherever possible, bee-sites are located to avoid overlap between licence zones. There are 251 permanent sites and 399 temporary sites in State forest within the Bendigo Forest Management Area (see Chapter 16), and 695 temporary and 328 long-term permits current for bee sites on public land across the study area. There may be as many as three sites on private land for every site on public land, and many of them are strategically positioned to utilise nectar production from public land. Private land sites often overlap with sites rented within public land.

Of all the box-ironbark tree species, yellow box is the most highly prized by bee-keepers. In accordance with the timber harvesting prescriptions, yellow box trees are generally excluded from timber harvesting operations (occasionally a tree may need to be removed for silvicultural or safety purposes). It is thought that old,

wide-crowned trees produce more nectar than a similar area of small trees, and so apicultural production levels are also assisted by the designation of some wide-crowned trees as retained habitat trees, and by the broad aim of management to promote the development of larger sawlog trees.

### Potential impacts of apiculture

Several potential impacts of apiculture on natural and other values have been identified, and these are discussed in Chapter 21. The potential impacts have implications for the management of honey bees on public land.

#### Control of feral bees

Bees that have established hives away from those provided by beekeepers are considered feral. Very little practical or research effort has been directed to the destruction of feral honey bee hives, but many potentially effective and inexpensive options exist - see Platt (1993) and Trainor (1995) for details. Given the clear indications of an existing problem with feral bees, the identification and implementation of an effective control program is likely to have substantial benefits for nature conservation and licensed honey production regardless of the results of research into the nature and precise extent of adverse impacts.

#### Management of hives on private land

Schwarz and Hurst (1997) provided evidence of honey bees foraging over 20 kilometres from their hive, although 1.5 kilometres may be a more usual foraging radius (Thorpe cited by Manning 1997). In any event, given that beekeepers frequently site their hives on private land adjacent to box-ironbark forests and woodlands on public land, initiatives to ameliorate the effects of honey bees within the public land might be severely constrained by existing administrative arrangements which provide very little opportunity for nature conservation managers to influence the management of hives on private land.

On the other hand, it has been suggested that honey bees may have a favourable effect on particular indigenous flora and fauna. For example, Paton (1997) found that seed production in a mallee *Banksia* increased when honey bees were introduced. However, such anthropogenic changes are generally undesirable, since they almost invariably have secondary negative effects - for example, the *Banksias* may have outcompeted other plants as a result of the increased seed production.

## 16. FOREST MANAGEMENT AND TIMBER HARVESTING

This chapter provides information and outlines management principles and operational practices applied across State forests by the Department of Natural Resources and Environment (NRE). It was drafted with the assistance of the Forests Service.

The *Forests Act 1958*, the *Flora and Fauna Guarantee Act 1988* and the *Catchment and Land Protection Act 1994* provide the primary legislation under which forests are managed across Victoria. The Regional Forest Agreement process mentioned in Chapter 1 is also relevant to forest management.

### Forest utilisation history

The discovery of gold in 1851 set in motion dramatic long-term changes to box-ironbark forests and woodlands (see Chapter 3). The original forest and woodland stands were exploited to provide timber and fuel for the mining industry and associated settlements. Fertile land carrying forests was progressively selected and cleared for agricultural use.

Seedling regeneration competed with vigorous coppice regrowth from cut stumps. Both forms developed without further silvicultural treatment. After 20 or more years the regenerated timber was cut-over again to meet continuing demands from the mining industry. In the 1890s the rapidly expanding railway system across Victoria made additional demands for heavy construction and sleeper timbers, much of which came from box-ironbark areas and river red gum forests.

During the 1920s, the newly created Forests Commission introduced forest utilisation controls based on scientific forest management practices. By this time much of the box-ironbark forest, especially near population centres, had been cut over several times. The Forests Commission surveyed and reserved many commercially valuable forests for wood production. It also sought to raise community awareness of forest values. Two key issues were:

- the need to repair the adverse effects from uncontrolled exploitation;
- the desire to prevent further reduction of the public forest estate by alienation.

Early forest harvesting and regeneration efforts were greatly accelerated during the economic depression of the 1930s. Large workforces of unemployed men undertook thinning and 'improvement' works. A similar burst of activity occurred in the 1940s when licensed operators, in conjunction with 'alien' and prisoner-of-war labour, harvested extensive areas for firewood and charcoal. This was to sustain domestic industries, largely starved of coal and liquid fuel by the demands of war. Following the war the need for fuelwood diminished. However, the demand for power and telephone poles and fencing timbers increased greatly.

### Public land use

In the 1970s and 1980s government approval of Land Conservation Council (LCC) recommendations altered the extent of the State forest estate, with designation of several areas of forest as parks and other reserves in recognition of their nature conservation, historical and recreation values.

Public land across the study area totals 434 800 ha. Appendix XI summarises each substantial forest block by name, LCC recommendation number, area and comments. Table 32 indicates broad land-use categories and availability of the land for timber production.

Not all the gross State forest area is harvested. For example in the Bendigo FMA, which includes most forest parcels in the Box-Ironbark study area, the total area of State forest is some 179 000 ha but about 70 000 ha of this is currently unsuitable or unavailable for timber harvesting. The reasons are: protection given to conservation values (25 000 ha), poor productivity (42 000 ha) and steep slopes (3000 ha). As a result, the total net area available and suitable for timber harvesting approximates 109 000 ha, or 61 per cent of the total State forest area. Further, the Forests Service estimates that habitat and other trees excluded from harvesting for conservation purposes effectively reduce the available area by a further 15 per cent.

The State forest area includes the Majorca sugar gum plantations near Maryborough. A limited amount of

**Table 32: Public land use categories in the Box-Ironbark study area (ha)**

State forest <sup>1</sup>	Historic and cultural reserves	Parks and reserves <sup>2</sup>	Water production, other public land <sup>3</sup>	Commonwealth land	Total area
Timber harvesting permitted <sup>4</sup>	Limited timber harvesting permitted	Timber harvesting not permitted			
215 760	10 030	121 630	44 730	42 660	434 800

Preliminary zoning of Bendigo FMA State forest - total area 179 000 ha		
General management	Unproductive or steep	Conservation
Timber harvesting permitted	Unsuitable for timber production	Timber harvesting not permitted
109 000	45 000	25 000

**Notes:**

1. Includes areas recommended for eucalyptus oil production.
2. Includes all parks, reference areas, nature conservation reserves, natural features reserves and community use areas.
3. Includes water regulation and drainage, plantations, earth resources, services and utilities, uncatagorised public land, agriculture, and land in townships not previously considered.
4. Includes some areas either unsuitable for harvesting, or where harvesting is not permitted.

harvesting, mainly for posts and poles, is permitted in the 10 030 ha of historic and cultural features reserves.

### Forest management planning

The Box-Ironbark investigation area overlaps eight Forest Management Areas (FMAs) established under the *Forests (Timber Harvesting) Act 1990* as a basis for sustainable yield of sawlogs, and used for forest planning and administration (see Map 3). Most of the inland hills fall in the Bendigo FMA, and much of the northern plains are in the Mid-Murray FMA. State forests in portions of the Horsham, Midlands, North-east (Benalla/Mansfield and Wangaratta) and Central FMAs are within the Box-Ironbark study area.

Planning in State forest has three levels: forest management plans (FMPs), wood utilisations plans, and coupe plans. FMPs zone forests into **general management zone (GMZ)** — managed for a range of uses with timber production a major use; **special management zone (SMZ)** — managed to conserve specific features, with timber production where it does not conflict with these features; and **special protection zone (SPZ)** - managed for conservation. Appendix XII contains more detail.

## TIMBER PRODUCTION

Box-ironbark forests have yielded large quantities of mining timbers, firewood, railway sleepers, fencing timbers and poles for farm and other uses, and limited quantities of sawn timber.

Timber production is mainly from the box-ironbark forests of the inland hills. The main trees of commercial potential are red ironbark, mugga ironbark, grey box, yellow gum, red box, yellow box, and red stringybark. Red and mugga ironbark, grey box and yellow gum produce timber that has long been recognised for its hardness and strength. Box-ironbark species are preferred over mixed species for fencing timbers and poles because of their greater durability in the ground.



*Firewood harvesting between Heathcote and Rushworth.*

### Firewood production

The firewood market in Victoria has been rejuvenated in recent decades through the increasing popularity of modern slow-combustion heaters, and firewood now represents one of the highest volume products from the public forested estate. Total annual firewood consumption in Victoria is estimated to be 1.2 to 2.5 million cu.m, with at least half

from private land. For comparison, sawlog production from public lands is 1.0 million cu.m, and pulpwood amounts to 0.9 million cu.m per year. The likely annual retail market value of firewood is between \$60 and \$125 million. The study area accounts for about half of Victoria's firewood.

Firewood constitutes over 80 per cent by volume of the licensed timber output of the study area. Red ironbark, mugga ironbark, grey box, red box, yellow box and white box woods are valued for their burning qualities.

Firewood collectors utilise both large blocks of public land and small remnant patches including roadsides. Permits to collect firewood along roadsides may be issued by some municipal councils. Gathering firewood for external use is generally not permitted in national and State parks, reference areas, flora reserves, flora and fauna reserves and bushland reserves. It is generally permitted in areas subject to other public land use categories, primarily State forest. Private plantations (and farm woodlots) may also be a source of firewood.

Illegal firewood collecting occurs in all land use categories in the study area, particularly close to towns. State-wide it is estimated that 60 000 tonnes are illegally harvested annually. The bulk of firewood collected under permit now comes from logging residues (stems and branches unsuitable for higher-valued products) and thinnings from silviculture. A limited amount may derive from small dead trees or naturally fallen material collected in the logging or thinning area.

Commercial cutters hold licenses to take firewood that set maximum quantities for harvesting. Household or domestic cutters can obtain licences for small amounts. Collectors pay royalties, and are directed to cut firewood in specific areas. Most domestic firewood collectors prefer dead, fallen trees, and a limited amount of naturally-fallen wood is specifically licensed for collection from State forest, though such licences are being phased out. Commercial cutters mostly utilise silviculture thinnings which are cut green and allowed to dry on the forest floor until the next season. Neither commercial nor domestic firewood cutters are permitted to fall large dead standing trees.

Domestic collectors also value the recreational aspects of firewood collecting — opportunities for a family outing to

the bush, and for strenuous exercise. By its dispersed nature it is difficult to regulate (see Chapter 21).

## Other timber products

Box-ironbark forests also yield significant volumes of fencing timbers, and small quantities of sawlog and sleeper timbers. Markets for poles and heavy construction materials are now largely met by alternative products. The demand for quality sawn timbers is growing, however.

The attractiveness of these timbers and their potential for direction to high-value niche markets such as indoor and outdoor furniture, bench-tops, parquetry and decking is increasingly acknowledged. S M Collins Pty Ltd of Bairnsdale has pioneered the development of markets for kiln-dried value-added red ironbark to take advantage of these attributes. The major licensee for box-ironbark timbers in the study area, Risstrom Sawmills in Rushworth, has constructed seasoning kilns to process these timbers.

While about \$600 per cu.m can be obtained for unseasoned box and ironbark timbers, a three-fold potential increase may be achieved through kiln drying and selling into niche markets. This would significantly increase the current regional annual income of \$200 000 from timber processing.



*Sleeper cutting, Tarnagulla.*

Producing value-added timber is labour intensive. Accordingly, localised value-adding sawmills could provide regional employment opportunities. The emergence of several furniture manufacturers in the study area indicates potential for an increased contribution to the regional economy from value-added processing.

Commercial and domestic uses of other natural resources continue to varying degrees. The box-ironbark forests are a significant State-wide source of honey and eucalyptus oil, and a source of extractive materials such as road metal, clay and gravel, and some fodder.

## Production from individual Forest Management Areas

### Midlands FMA

Box-Ironbark forests in this FMA occur in the Pyrenees State Forest, Dunneworthy Forest near Ararat, and a small part of the Jim Crow Range near Hepburn. Commercial post cutters who operate in the Pyrenees State Forest also have allocations from the adjoining Bendigo FMA. Post allocations are based on work centre areas rather than FMAs (see Table 33).

The Pyrenees State Forest contributes about half of the Midlands FMA's total output of posts and poles, comprising both box-ironbark and mixed eucalypt species. Demand for these timber products has reached a stage where limits have been placed on annual harvest rates. The maximum annual harvest of posts and poles from all species in the Pyrenees and Dunneworthy State Forests is 25 000 pieces of roundwood, equivalent to about 3750 cu.m. Post and pole harvesting operations are located in areas where the potential for sawlog production can be improved by thinning. Green firewood production in the Dunneworthy State Forest is currently limited to Departmental felling for

domestic licensees or felling by commercial licensees. There is little current harvesting of any timber product in the Jim Crow Ranges due to the limited number of trees of suitable size and species.

### Bendigo FMA

About 109 000 ha of State forest in the Bendigo FMA is available and suitable for timber production and most of the timber harvested is box-ironbark. The legislated sustainable yield rate for all grades of sawlogs for this FMA is 800 cu.m a year. Current output of sawlogs totals about 650 cu.m a year. Firewood and fencing timbers are the main wood products from this area (Table 33).

Firewood production includes licensed non-commercial collection, but excludes wood sourced from private land. Commercial licensed firewood production accounts for some 62 per cent of production. Total revenue from timber production royalties for 1994/5 was \$450 788.

### Mid-Murray FMA

The main area of State forest supporting box-ironbark forest in this FMA is the Killawarra State Forest, of 2780 ha. Small areas of box-ironbark forest adjoin river red gum stands at the Barmah, Lower Goulburn and Lower Ovens forests. Although many of the stands in the Killawarra State Forest have developed to the stage when small sawlogs may be harvested, current operations concentrate on thinning. A maximum of 5000 pieces of fencing timber

**Table 33: Timber harvesting levels on public land in the Bendigo FMA by work-centre (1994/95)**

Work-centre	Product					
	Sawlogs (cu.m)	Fencing (pieces)	Sleepers (pieces)	Garden (cu.m)	Poles (lin. m)	Firewood (cu.m)
Bendigo		6 057			763	1 910
Castlemaine		2 439				4 326
Heathcote		14 325			2 577	3 480
Rushworth	641	17 724			220	1 562
Maryborough		10 192	404	53	370	7 347
Avoca		4 569		5	925	2 777
Dunolly		37 179	1 550		855	5 347
Inglewood		7 013	212		460	2 521
St Arnaud	12	3 468	131		1 005	2 994
<b>Totals — various units</b>	<b>653</b>	<b>102 966</b>	<b>2 297</b>	<b>58</b>	<b>7 175</b>	<b>32 264</b>
<b>Totals — cu.m 38 317</b>	<b>653</b>	<b>4857</b>	<b>383</b>	<b>58</b>	<b>102</b>	<b>32 264</b>

is harvested on an opportunistic basis each year during thinning operations. Two commercial post-cutters produce a total of 4000 pieces and local farmers harvest the rest.

#### Horsham FMA

Seven forest blocks in the Horsham FMA totalling some 6900 ha contain box-ironbark forest types. The legislated sustainable sawlog yield from Horsham FMA is 800 cu.m a year of all grades. Over the last five years, the nine forest blocks contributed about 11 per cent of this total (see Table 34).

While the North-east (Benalla/Mansfield and Wangaratta) and Central FMAs extend into the Box-Ironbark study area, the only appreciable State forest area is the Barambogic forest of 3049 ha.

**Table 34: Forest production — Horsham FMA**

Block Name	Sawlogs (cu.m)	Area harvested (ha)	Posts (number)	Firewood (cu.m)
Ledcourt	44	20	200	100
Lake Lonsdale			20	40
Blythewood	20	10	200	100
Illawarra	24	12	400	200
Jalluka			100	100
Morrl Morrl			40	1 000
Ironbarks			20	10
Devils Garden			20	60
Glenwyllyn			20	100
<b>TOTALS</b>	<b>88</b>	<b>42</b>	<b>1 020</b>	<b>1 710</b>

#### Notes:

1. This represents average production for the five years to 1995/96.
2. Block sizes are provided in Appendix XI.

**Table 35: Licensees and employees in the timber industry by work-centre, Bendigo FMA (1994/95)**

Work-centre	Timber licensees	Associated employees	Total
Bendigo	13	6	19
Castlemaine	19	8	27
Heathcote	22	9	31
Rushworth	16	17	33
Maryborough	35	5	40
Avoca	9	4	13
Dunolly	16	8	24
Inglewood	8	8	16
St Arnaud	9	5	14
<b>TOTALS</b>	<b>147</b>	<b>70</b>	<b>217</b>

This forest contains mainly Heathy Dry Forest and Grassy Dry Forest EVCs. No commercial timber-getting operations occur, although it supplies a limited amount of firewood for local cutters, and supports a low level of apiculture.

The sawlog yield of box-ironbark species from all FMAs in the study area currently totals less than 900 cu.m. For context, the total volume of wood produced annually from Bendigo FMA is 38 317 cu.m (Table 33).

#### Timber industry employment

The timber industry provides employment opportunities for local people, particularly within small rural communities, for example Inglewood, Dunolly,

Avoca, Heathcote and Rushworth in the Bendigo FMA. Many forest operators derive only part of their livelihood from the timber industry. Of the 147 commercial licensees in 1994/95, 45 were full-time, while 102 were part-time. All the associated employees would be considered part-time.

## FOREST MANAGEMENT

### Timber harvesting and regeneration systems

Timber harvesting may be by clear-felling, patch-felling, thinning, group selection or single-tree selection. The particular method used in any given situation depends upon forest structure and the regeneration requirements.

Forests containing mainly regrowth and semi-mature trees have replaced most of the original box-ironbark forests. Even-aged stands are a response to 19th century mining practices and the periodic harvesting of resulting regrowth. Even-spaced, even-aged areas are a result of early to mid 20th century silviculture. Overall there is a range of age classes, but few very old trees remain.



*Timber and foliage remaining after sleeper cutting, Bendigo area.*

The dense stands of young trees comprise both coppice and seedling stems. Thinning of the regrowth is directed towards increasing the average growth rates of the retained trees, accelerating both the recruitment of sawlog-sized trees and the maturing processes of the retained trees.

Most timber currently harvested from these forests is produced during thinning operations. Products are mainly fencing timbers and firewood, although limited single-tree

selection within suitable stands yields small quantities of sawlogs and railway sleepers.

Seedlings within box-ironbark forests will usually only develop on exposed ground following fire or artificial disturbances such as cultivation, and then only when conditions favour germination of the seed. As a result, most regeneration in these forests is by coppice from the cut stumps. Following timber harvesting, regeneration of the site is assessed and supplementary work to fulfil stocking objectives carried out where necessary.

The Forests Service's long-term goal in forest management is to optimise sawlog supplies and to meet other environmental and community requirements. This aims not only at maximising value-adding opportunities from timber outputs, but also at stands reaching a higher level of maturity. An intention of management is the retention of designated trees that are, or have the potential to be, hollow-bearing.

### Sustainable yield

Sustainable yield is the estimated rate of harvesting that can be maintained for a given period without impairing the long-term productivity of the land, taking into account the structure and condition of the forest. The sustainable yield of sawlogs from each of the 15 FMAs in Victoria is listed in a schedule to the *Forests Act 1958*, following the *Forest (Timber Harvesting) Act 1990*. The legislated yields do not stipulate the specific volumes of timber and wood other than sawlogs that may be harvested from the respective FMAs, nor do they differentiate between box-ironbark and other species.

### Box-Ironbark Timber Assessment

The Box-Ironbark Timber Assessment (BITA) project is generating timber resource and ecological data for all box-ironbark forests available for timber harvesting in the Bendigo FMA. Analysis of data from the project is expected to be completed during 1997.

The primary objective of the BITA project is to provide accurate and reliable timber resource data, including forest growth information, that will form the basis for determining medium- to long-term sustainable yields for all timber products. The assessment accounts for environmental measures and silvicultural requirements, as specified in current prescriptions and stand

management objectives, that affect the availability of timber products.

Secondary objectives of the project include identifying tree origin (coppice or seedling), regeneration levels, characteristics of habitat trees, values of dead wood, and site factors such as the presence of hollow-bearing trees.

### Timber harvesting prescriptions

Timber harvesting prescriptions outline restrictions placed on harvesting with the aim of protecting environmental and other values. They are based on the minimum standards in the *Code of Forest Practices for Timber Production* and management strategies in forest management plans. Within the Bendigo FMA, existing prescriptions specify areas to be excluded from timber harvesting. These include specific sites with certain rare, vulnerable or endangered species or communities of flora or fauna; land within a specified distance of designated permanent or temporary streams and wetlands; important recreation sites; and sites of historical or archaeological significance requiring protection. Appendix XIII has more detail.

The prescriptions also cover field marking, retained trees, tree felling, landings and log dumps, completion of operations, carting of forest produce, wet weather restrictions, fuel dumps and equipment servicing. The *Timber Harvesting Regulations 1989* provide formal enforcement mechanisms to facilitate the implementation of prescriptions.

### Protection of water production values

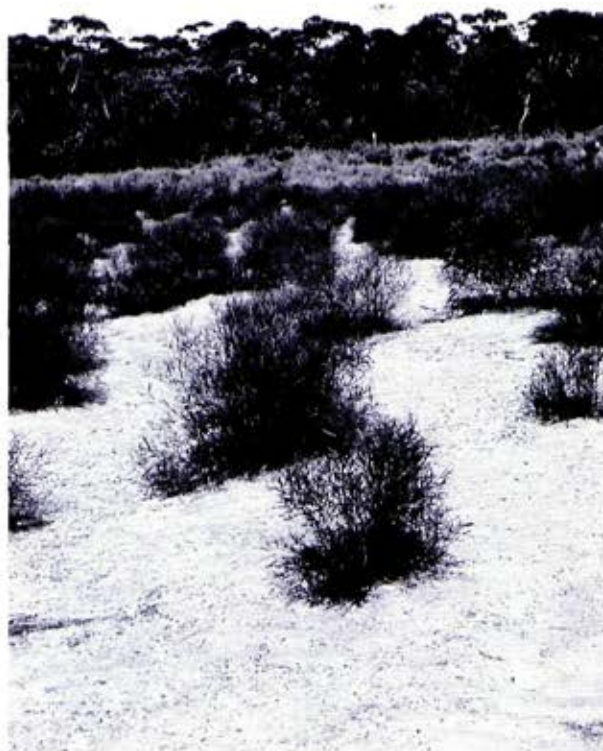
In accordance with previous LCC recommendations, public-land buffers around most of the reservoirs in the study area are controlled by the respective water-supply authorities. Small areas of State forest occur in some reservoir buffers, such as the Dunolly storage, and moderate areas around the margins of or in the catchments to lakes Eppalock, Cairn Curran and Laanecoorie, for example. Protection of water-quality values is also addressed in the Code of Forest Practices.

## OTHER FOREST USES

Recreation and tourism in forests are discussed in Chapter 12. Grazing of forest areas by domestic stock, and apiculture, are discussed in Chapter 15.

## Eucalyptus oil

The box-ironbark forests and woodlands of Victoria are significant at a State level as a source of eucalyptus oil, used in perfumes, medicinal products and industrial applications. Most production concentrates on the Gravelly-sediment Mallee EVC, and comes from stands of blue mallee and green mallee, and some bull mallee in the Bendigo, Inglewood and Wedderburn districts in the Bendigo FMA. This oil is of good quality with a high phenol content and is keenly sought after for use in industrial applications.



*Green mallee and blue mallee regenerating from recent harvesting, Inglewood.*

Australia is a net importer of eucalyptus oil despite its long history of production. Most imported oil is derived as a by-product of plantation woodlots in countries such as China and Brazil. These commonly consist of species such as blue gum, broad-leaved peppermint and lemon-scented gum. Oil produced from blue mallee is generally superior in quality to that produced from other eucalypts, however

the imported oil can be readily refined or blended with other oils.

The eucalypt branchlets were originally harvested by hand. Now, leaf is harvested using a unit comprising a tritter and a caged-trailer, towed by a tractor. Branches are mechanically cut close to ground level when plants reach a height of 0.5–0.75 m. The oil is extracted by forcing steam through the collected leaf. The resulting vaporised oil and water mixture is passed through a condenser. When the mixture cools and returns to a liquid state the oil floats to the surface and is skimmed off and placed in storage drums. The spent leaf is either used to fuel the boiler or sold to nurseries as garden mulch.

About 11 435 ha are specifically designated for eucalyptus oil harvesting; an additional 1055 ha are available within hardwood production areas. These 12 490 ha are part of

the total area of 19 000 ha of mallee communities remaining on public land in the study area.

A total of 2950 ha is actually used for harvesting at present (Table 36). On a two- to four-year cutting cycle, an average of approximately 1000 ha is harvested annually.

The industry is not a large employer in Victoria, providing direct employment for 15 people including the seven licensees. In 1994/95, \$21 807 in royalties were paid to the government from eucalyptus oil production in the Bendigo FMA. Oil production figures from the Bendigo FMA for the three years to 1996 are presented in Table 37.

NRE proposes to review eucalyptus oil harvesting management during 1997/98, before developing a management plan.

**Table 36: Eucalyptus harvesting areas by work-centre (1994/95)**

Locality	Area recommended for oil production		Area actually harvested	
	Area (ha)	Proportion of total (%)	Area (ha)	Proportion of total (%)
Bendigo	2 770	22	371	12
Inglewood/Wedderburn	8 100	65	2 103	71
St Arnaud	565	5	401	14
Other forests	1 055	8	78 <sup>1</sup>	3
TOTALS	12 490	100	2 953	100

Note: 1. Rushworth work centre.

**Table 37: Eucalyptus oil production 1993-94 to 1995-96, Bendigo FMA**

Year	Output in kg
1995-96	20 915
1994-95	32 548
1993-94	19 516

## Seed

Several commercial seed-collectors operate within the Bendigo FMA. These operators pay royalties to collect seed from native flora on public land. They are commonly under contract from mining or extractive industry companies who use the seed to meet rehabilitation requirements. The Forests Service and other NRE businesses collect seed to assist with mining or extractives site rehabilitation and to fulfil internal operational needs. A wide

variety of seed from tree, shrub and grass species is held within a Departmental seed store at Bendigo. Seed is also collected by the Catchment Management and Sustainable Agriculture Services and Landcare Groups for reforestation programs on private property.

During 1994/95 approximately 57 kg of seed was collected by the Forests Service within the Bendigo FMA. Of this, 27.9 kg was sold externally and returned approximately \$7500. Royalties from commercial seed collectors generally yield an additional \$500 annually in revenue.

## Public utilities

There are 44 sites in State forest occupied by various government agencies, across the Bendigo FMA. These include Telstra, local clubs and community groups, which altogether pay approximately \$48 000 in annual rent.

## Army exercises

In 1995/96, 21 Army exercises involving 2232 personnel were conducted, primarily within the Heathcote–Rushworth State Forest.

## MANAGEMENT FOR NATURE CONSERVATION IN STATE FOREST

State forest is the largest public land use category in the Box-Ironbark study area, and accordingly forests are important for biodiversity conservation. Protection is achieved through an integrated approach whereby measures in the General Management Zone (GMZ), Special Management Zone (SMZ) and Special Protection Zone (SPZ) progressively complement the permanent reserve system. The GMZ, although having timber production as a priority use, takes into consideration protection of biodiversity through the following:

- The single-tree or small group selection systems of harvesting and regeneration applied over time aim to produce a range of age classes throughout the timber-productive forests. This range, from regrowth to veteran trees and comprising both seedling and coppice, coupled with stumps with a range of sizes and conditions, provide structurally diverse habitat and food resources for a variety of animal species.
- Management prescriptions aim at ensuring existing hollow-bearing trees are retained. Further, a range of tree sizes is retained to allow for recruitment into the larger size classes over time. Stand thinning accelerates the maturing processes of the retained trees.
- About 50 per cent of the potential full stocking level (the number of trees per unit area) of a stand remains after thinning. Of this, about 15 per cent comprises trees retained for habitat and other purposes. The retention of understorey vegetation helps to maintain biological diversity throughout the forest, although some damage occurs through roading and vehicle operation.
- Areas of GMZ that are unsuitable for commercial timber production — in aggregate, some 45 000 ha in the Bendigo FMA — contribute substantially to conservation of particular forest types and their associated fauna. This is biased towards certain EVCs, however.

These areas may be used for apiculture or recreation or may supply small quantities of non-commercial wood products.

Whether or not a FMP is in place, the Code of Forest Practices establishes minimum levels of environmental protection. As well as matters outlined earlier, it includes provision for the retention of wildlife habitat (including habitat trees within coupes) and the protection of landscape values.

Management practices in State forest must account for approved action statements under the *Flora and Fauna Guarantee Act 1988*. Action statements provide guidelines for the conservation or control of flora and fauna and the management of potentially threatening processes; those relevant to the study area are listed in Chapter 9.

At the local level, protective measures for other particular values are established through prescriptions for timber harvesting, and recognised in wood utilisation plans and coupe plans. Because of their importance for the apiculture industry, for instance, all yellow box trees in box-ironbark forests are exempted from harvesting.

## Veteran and hollow-bearing trees

Although box-ironbark forests largely comprise dense stands of young forest of both coppice and seedling origin, there are also some scattered mature or veteran trees and many large stumps. The term 'veteran' is used to describe large trees (usually more than 80 cm in diameter) displaying features of senescence and in which the crowns are in visible decline and contain obvious hollows.

The number of veteran trees in a forest has an important influence on its habitat value. Although trees of all growth stages provide habitat for wildlife, live, hollow-bearing eucalypts are especially important, as their hollows provide nesting and roosting sites for birds and arboreal mammals. Dead trees, whether standing (stags) or fallen, and tree stumps are also valuable habitat, providing hollows, denning and basking sites and foraging substrates for a range of species.

The current scarcity of mature and senescent trees within box-ironbark forests and woodland areas is largely a consequence of the gold-rush era. The overall number of veteran trees is also declining across the freehold landscape.

The impact of this scarcity on hollow-dependent fauna is recognised in forest management. Existing or potential hollow-bearing, wide-crowned and other important habitat trees are excluded from timber-harvesting operations, and a major goal of State forest management is to provide more veteran trees.

To increase hollow-bearing and veteran trees throughout the timber-productive areas in the Bendigo FMA and Pyrenees State Forest, guidelines have been applied in all areas available for timber production. These guidelines — listed in Appendix XIII — aim to protect existing veteran trees and provide for the recruitment of new ones.

In the Bendigo FMA, between six and 14 habitat trees per hectare are currently identified for retention, depending on their availability. This range is brought about by compensating for a lack of trees in one or more of the three size classes.

Harvesting management across the timber-productive stands of State forest has as one of its aims the promotion of structural diversity. Single-tree and small group selection are the main harvesting and regeneration systems applied in box-ironbark forests and, together with strategies to protect and promote recruitment into the larger size classes, provide for a range of growth stages throughout the forest. Integrated management also seeks to retain or develop a mature component in timber-productive stands in the GMZ, and provide some habitat continuity with adjacent conservation reserves, SPZs, SMZs and other areas unavailable or unsuitable for harvesting.

## Habitat trees

Habitat trees are selected for retention, within each size class of retained trees, in accordance with the list of priorities in Appendix XIII.

Habitat trees are marked prior to selecting trees for harvesting, except:

- in firewood-only coupes where removal of only the small trees obviates this requirement, and
- in the Upper Loddon State Forest where ecologically mature trees are common.

Prescriptions specify other types of trees within coupes that are excluded from timber harvesting, including yellow box trees, registered significant trees, trees greater than 80 cm in diameter, and trees regularly used by gliders.

Additional trees retained on harvesting coupes are growing stock and dead standing trees of greater than or equal to 20 cm DBH (under the bark).

For the Bendigo FMA, it is estimated that about 15 per cent of the basal area of the timber-productive forests is occupied by trees retained for habitat and other purposes. Basal area per hectare is the sum of the cross-sectional area of tree stems at breast height (1.3 m).

In the Horsham FMA, management prescriptions exclude all yellow box trees from harvesting, and protect habitat trees in all forest types — generally averaging about two per hectare. In the 'community forests', about eight habitat trees are retained per hectare.

Following thinning operations, to ensure that long-term stand management objectives are met, the average retained basal area is required to be between 8 sq.m/ha and 10 sq.m/ha. This is equivalent to about 50 per cent of the basal area of most fully-stocked stands. Thinning concentrates the growth potential of a site on the retained trees, and with careful management is expected to accelerate their growth rate. This will benefit the timber industry, and in the long term should result in larger retained trees, also benefiting native flora and fauna.

## Protection of specific fauna habitat

Management of State forest addresses the habitat requirements of faunal species dependent on the box-ironbark forests in a number of ways:

- protecting a proportion of each EVC across the FMA;
- retention and planned recruitment of larger trees;
- removing only 50 per cent of the potential stocking of a stand during thinning; and
- ensuring that structural diversity is maintained across State forest.

These measures aim at providing suitable habitat for the regent honeyeater and swift parrot, for instance. Specific additional measures are taken to protect the habitats of endangered and threatened plants, plant associations and animals in the forests.

Other interim exclusion or restriction zones within State forest are currently being considered by NRE in response to results from:

- ongoing studies of the powerful owl, squirrel glider, swift parrot and brush-tailed phascogale in accordance with relevant Flora and Fauna Guarantee action statements; and
- Ecological Vegetation Class mapping.

**Squirrel glider**

The study area is the stronghold of Victoria's squirrel glider population (see Figure 6). The river red gum State forests along the lower Goulburn River are also important habitat for this species. In the Midlands FMA, strategies exclude timber harvesting from about 100 ha around confirmed populations in State forest. In the Horsham FMA, all trees regularly used by squirrel gliders for food are retained.

**Brush-tailed phascogale**

Much of the brush-tailed phascogale's range in Victoria overlaps the Bendigo and Midlands FMAs, but its distribution and abundance there are not well known. In the Mid-Murray FMA the species is found mainly in the

Killawarra State Forest. The main objective of management is to identify and protect preferred phascogale habitat and to undertake predator control.

**Spot-tailed quoll**

Spot-tailed quolls are high-order predators occupying large home ranges, possibly as large as 1000 ha. Dens are established in rocky outcrops and fallen timber. Pest-control activities using 1080 poison are believed to be a factor in the species' decline along with competition pressure from foxes and cats. Knowledge about the impact of forest management operations on the species is limited.

Although there have been recent records in the Chiltern-Wodonga area and north of Swan Hill, it is uncertain whether spot-tailed quolls are found in State forest in the Mid-Murray FMA. Nevertheless, a strategy to protect its habitat is proposed should it be found in the Killawarra State Forest, and is in place for the Midlands FMA. This strategy provides for the exclusion of harvesting from a zone 200 metres in radius around latrine and den sites in accordance with the Flora and Fauna Guarantee

**Table 38: Occurrences of Ecological Vegetation Classes in State forest in the study area**

EVC	Area (ha)	Substantial occurrences in State forest <sup>1,2</sup>
Box-Ironbark Forest	133 080	In 72 forest blocks
Heathy Dry Forest	25 160	In 34 forest blocks
Grassy Dry Forest	4 920	In 9 forest blocks
Heathy Woodland	2 126	Lake Lonsdale, Illawarra, Jalluka, G4 St Arnaud, Dunolly, Glenalbyn forest blocks
Metamorphic Slopes Shrubby Woodland	1 500	Mt Hooghly, Dunolly, Bealiba, Kingower forest blocks
Granitic Hills Woodland	201	Barambogie forest block
Rocky Outcrop Mosaic	132	Barambogie forest block
Sedge-rich Woodland	393	Illawarra forest block
Low Rises Grassy Woodland	343	Glenalbyn forest block
Creekline Grassy Woodland	472	Killawarra, Whroo-Costerfield forest blocks
Valley Grassy Forest	1 635	South St Arnaud Range, Denver-Guildford, Fryers Bridge, Barambogie forest blocks
Hillcrest Herb-rich Woodland	1 125	Bealiba, Kingower, Glenalbyn, West Brenanah forest blocks
Granitic Hills Herb-rich Woodland	0	—
Alluvial Terraces Herb-rich Woodland	2 204	Jalluka, Dunneworthy, Paddys Ranges forest blocks
Gravelly-sediment Mallee	9 931	Dunolly, G3 Inglewood, Kingower, G2 Wedderburn, Eaglehawk, G1, U2 Whipstick, Whroo-Costerfield forest blocks
Sandstone-rise Broombush	1 376	G3 Inglewood, G2 Wedderburn, G1, U2 Whipstick forest blocks
Northern Plains EVCs	—	Not mapped — see Table 15 for locations.

**Notes:**

1. Substantial occurrences are greater than 100 ha.
2. Includes eucalyptus oil production areas.

action statement, and additional measures surrounding this zone. The use of baits for pest control will be avoided or strictly controlled in known home ranges of this species.

### **Contribution to conservation of Ecological Vegetation Classes**

Protecting representative examples of each ecosystem across a FMA is an important feature of management for bio-logical diversity across the region and the State. Appendix XIII outlines current approaches to protection of examples of EVCs under State forest management. Table 38 summarises the occurrence of each EVC in State forest blocks.

To date, planned protection of surrogates of EVCs has been addressed in the Midlands FMA.

#### **Midlands FMA**

EVCs have not yet been described for the Pyrenees Forest, although they have for the small Dunneworthy Forest.

For the purposes of the Forest Management Plan an ecosystem classification, based on existing structural vegetation descriptions and mapping, has led to the target levels of protection of box-ironbark vegetation communities summarised in Appendix XIII.

#### **Bendigo FMA**

The EVC mapping project in the FMA has established the basis for a representative system of protected areas,

but these have not yet been identified. As an interim measure some 25 000 ha has been temporarily set aside from timber harvesting, of which 6098 ha is for drought refuge for native fauna and 13 859 ha is to protect older-aged stands. In addition, some 45 000 ha (25 per cent) of State forest is unsuitable for timber production.

#### **Horsham FMA**

EVCs in that part of the Box-Ironbark study area in Horsham FMA have been mapped, although they constitute a small part of the total FMA area. Ledcourt forest block has a large area of predominantly yellow box-dominated forest excluded from harvesting for squirrel gliders; additional habitat trees are retained elsewhere. Lake Lonsdale block has high plant community value. Jalluka block contains a large area of mature yellow box habitat trees. The block is maintained largely for conservation purposes. Morrl Morrl contains representation of all local vegetation communities. Ironbarks, adjoining Deep Lead nature conservation reserve, is dominated by red ironbark regrowth. Only light thinnings are carried out to maintain the health of the forest. It has important botanical values.

As well as excluding all yellow box trees from harvesting, habitat trees are protected in all forest types — generally averaging about two per hectare and, where they have been identified, trees used regularly by squirrel gliders for food are retained. Grazing has recently been excluded from all blocks to foster seedling regeneration.

## 17. EARTH RESOURCES

### INTRODUCTION

Mineral deposits of various types are widespread in the study area, hosted in the Palaeozoic bedrock of the highlands, and lowland Cainozoic rocks. Gold is undoubtedly the most important of the metallic minerals, in terms of past and present production and future prospects, and its provenance strongly overlaps the study area.

For other minerals of economic interest in recent times, known and potential resources mainly lie outside the study area. These include brown coal deposits in the north, and mineral sand resources to the west. Several commodities with a history of small-scale development have no present impact on box-ironbark vegetation, but may affect limited areas in future depending on new discoveries and markets. They include tin, antimony, kaolin, diatomite and dimension stone. Extraction of construction materials has been an ongoing small scale activity throughout the area, though these materials are widely available.

Victoria has separate legislation regulating minerals and stone. The *Mineral Resources Development Act 1990* deals with minerals. The *Extractive Industries Development Act 1995* covers the extraction of stone including all earth resource materials used for construction. The *Petroleum Act 1958* covers onshore exploration and development of petroleum in Victoria.

Map C shows the goldfields and mineral occurrences in the investigation area.

### METALLIC MINERALS

#### Gold

##### Production history

Victoria's gold provinces are of world-wide significance for their richness and output. With total recorded production of 2457 tonnes, valued today at \$34.2 billion, Victoria was Australia's foremost producer until Western Australia took over in the mid 1980s. About 1180 tonnes was from shallow alluvial deposits, 255 tonnes from deep leads, and 1022 tonnes from reefs (Table 39). Most was extracted in the last century. See Chapter 3 for a historical overview.

Table 39 gives recorded Victorian gold production, generally accepted to be significantly less than actual production. This is particularly so for early alluvial workings due to the paucity of government record keeping at the time.

About 1700 tonnes of gold valued today at \$23.7 billion was derived from goldfields overlapping current box-ironbark forests and woodlands, largely public land in the study area. This is 70 per cent of all recorded gold production in the State. Production from all goldfields in or overlapping the investigation area was 2075 tonnes, 84 per cent of the State total, and valued today at \$28.9 billion. The box-ironbark goldfields were very significant producers of reef and shallow alluvial gold. The Bendigo field alone produced about 53 per cent of Victoria's reef gold. A much lower proportion of Victoria's deep lead gold production is from Box-Ironbark country, as the large yielding Berry and Ballarat deep leads lie under basalt, and hence are outside the study area.

The historical significance of reef goldfields in the study area has important implications for present and future gold exploration in the State. Multiple episodes of alluvial mining exhausted the easily accessible deposits. Accordingly, primary gold deposits (bedrock-hosted) will attract greater interest in the future than alluvials. Areas of relatively high past production present the most obvious targets.

##### Primary gold

Most significant Victorian primary gold deposits worked to date have been fillings of rock fissures with gold bearing quartz, emplaced within faults, tension gashes or fold hinges. Gold-sulphide mineralisation occurred immediately following major deformation periods, including the Benambran and Tabberrabberan Deformations.

An understanding of structural controls on gold deposition is important to successful exploration and mining. Details of the structural settings are given in various reports, including those listed in the references.

The various primary gold producing centres have been grouped into provinces (Map 8), based on structural characteristics, mineral associations and metallogenesis.



Gold bearing quartz veins are clustered in north-south belts a few hundred metres wide, following regional fold and fault trends for many kilometres. Goldfields are typically separated by 20-30 km.

The Pyrenees Gold Province (Stawell Zone) is characterised by reefs along west-dipping fault zones, apparently reactivated and mineralised during the Tabberrabberan Deformation (380 million years). The Bendigo-Ballarat Province contains the largest goldfields, which on a regional scale tend to occur in the hanging wall of major faults. Mineralisation in the Ballarat Goldfield occurs in fault structures (see Figure 9) developed from the brittle failure of folds late in the Benambran Deformation (425 million years). In the Bendigo Goldfield, the interaction of bedding-concordant and bedding-discordant faults around the fold hinge zones has produced the classic saddle reef structures and associated bedded veins, neck reefs and vein arrays (spurs). This field produced about 540 tonnes, about half the Victorian production of primary reef gold.

The northern part of the Melbourne Gold Province experienced mineralisation at a higher crustal level than in

the Bendigo-Ballarat Province. It is characterised by a lower temperature, gold-antimony-quartz association hosted in Silurian to Devonian turbidites, for example at Costerfield and Nagambie.

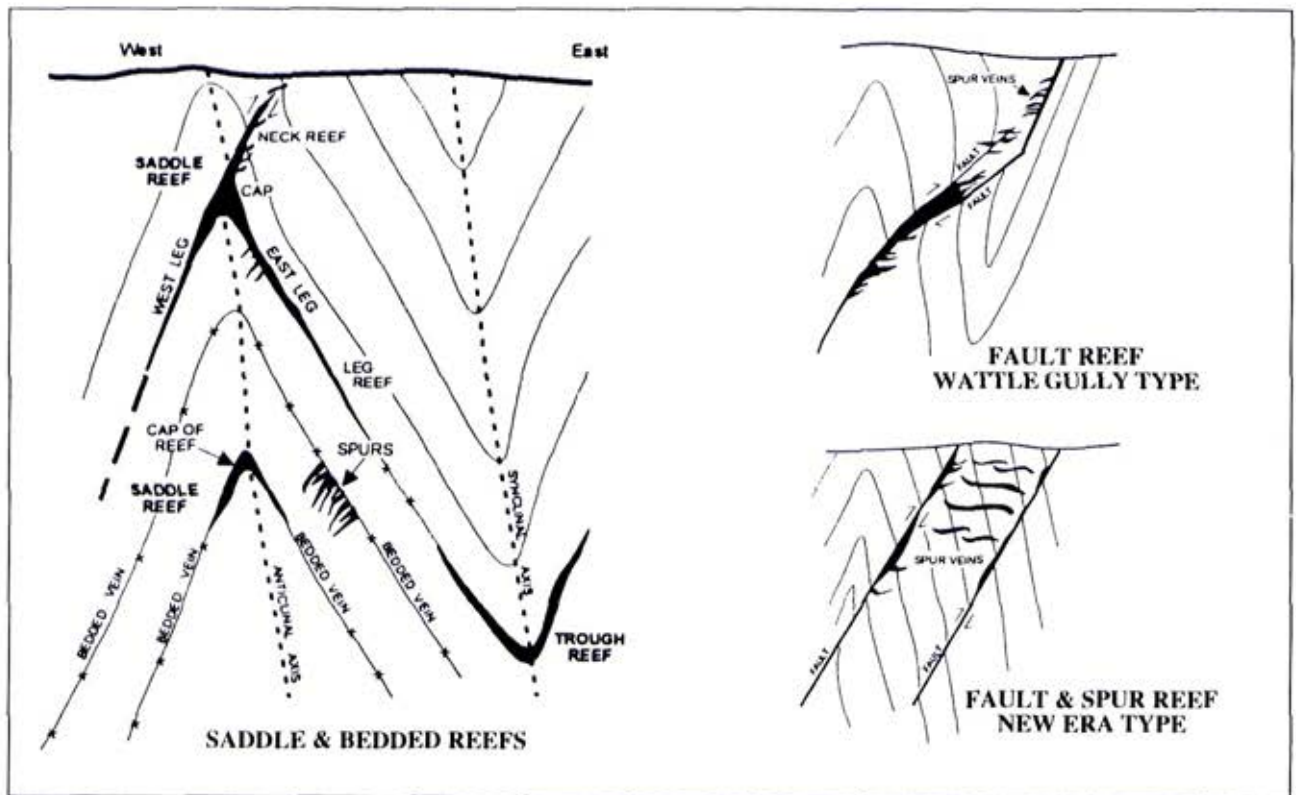
Secondary (alluvial) deposits

These can be subdivided into three types;

- shallow alluvial and eluvial deposits along modern drainage systems;
- shallow to deep lead deposits, formed in the Cainozoic period in ancient drainage systems, and later buried by alluvium or basalt; and
- high-level gravel deposits formed in ancient drainage systems, but later uplifted and eroded, leaving them as isolated remnants above present stream levels.

Prolonged erosion during Upper Palaeozoic and Mesozoic times (see Figure 3) exposed vast areas of gold bearing bedrock by the Tertiary period. Continued erosion, and concentration by fluvial processes have acted to produce the present alluvial gold deposits, generally close to the primary sources.

Figure 9: Types of mineralised structures



Shallow, very rich deposits were largely responsible for the 1850s gold rushes, and possibly more gold was won from them than from deep lead and reef mining combined. The most important fields were Castlemaine, Bendigo, Dunolly, Moliagul, Wedderburn, Tarnagulla and Inglewood. Mining involved the stripping of alluvium over large areas to depths from a few centimetres to 30 metres. This, together with the use of timber for shaft support and fueling boilers, resulted in widespread loss of soils and forests.

Mining of the buried alluvial gold deposits (deep leads) often commenced as shallow workings at valley and gully heads, and progressed downstream into leads with thick cover. Enormous groundwater volumes were pumped to enable mining to proceed. Major lead systems in the investigation area are those near Eldorado and Chiltern-Rutherglen.

High-level gold bearing gravels form hill cappings on the interfluvies between present streams across much of north-central Victoria. Mining occurred between Avoca and St Arnaud, near Tarnagulla, north-east of Moliagul and at Bendigo. Production has been intermittent and small.

## Antimony

Silurian to Lower Devonian sedimentary rocks of the Melbourne Zone host several antimony sulphide (stibnite) occurrences. They typically occur as quartz-stibnite fissure fillings, with minor pyrite, arsenopyrite, traces of lead, copper and zinc, and gold in variable amounts.

Antimony was produced mainly at Costerfield and South Costerfield during several mining phases, the main phases extending from 1865 to 1883, 1905 to 1925 and 1934 to 1952. Production from the Costerfield mines — about 22 400 tonnes of antimony metal — represents 92 per cent of total recorded State production. The gold content of the Costerfield ores was relatively high, leading to initial development of the field after discovery in 1860.

Minor veins and pods of stibnite have been observed, notably at Whroo, Bailieston, Redcastle, Nagambie, Reedy Creek, Doogalook and Merton. Stibnite is a minor constituent of gold bearing sulphide reefs in the Bendigo-Ballararat Province.

## Copper

A copper deposit at Mt Ararat has resources estimated at over 1 million tonnes with 2.7 per cent copper, 10 grams per tonne silver and 0.6 grams per tonne gold. Minor base

metal mineralisation has been found in greenstone belts at Mt Stavely, Dryden and Stawell. Copper has been recorded at Mt Camel near Heathcote and is associated with gold at a few other locations.

## Molybdenum

Several deposits of molybdenite are associated with granitic rocks, with significant production only from Everton. From 1917 to 1944, this mine produced 325 tonnes of concentrate — about 90 per cent molybdenite — from 21 936 tonnes of ore. Molybdenite at Mt Moliagul has been sporadically mined, but production was minor. Vein deposits of molybdenite also occur at McIntyre, Mt Kooyoora, Korong Vale and Nine Mile.

## Tin

Tin, as cassiterite, was recovered as an alluvial gold mining by-product in the Beechworth-Eldorado field, the State's largest producing tin field. Some 9180 tonnes of tin concentrates were produced by surface (including dredging) and underground mining.

## Other minerals

Massive sand resources of titanium-bearing minerals ilmenite, leucoxene, rutile, and zircon, monazite and xenotime are located in the north-west of the investigation area. Bismuth, lead, osmiridium, silver, tungsten, uranium and zinc occur in the investigation area, but have no history of mining. Although of little economic interest to date, they can assist exploration because of their geochemical associations. Their known locations are also shown on Map C.

## NON-METALLIC MINERALS AND PETROLEUM

### Brown coal

Extensive seams of brown coal, up to 40 m thick, and with overburden generally exceeding 100 m, have been identified in the southern Murray Basin. They belong to the Renmark Group, and appear to have formed from swamp deposits associated with the ancient Loddon and Murray rivers. Resources are estimated at 30 000 million tonnes but the high overburden to coal ratio and high ash content make the deposits uneconomic to mine. The largest deposits occur in the northern part of the

investigation area near Kerang-Cohuna and Torrumbarry-Tandarra.

## Diatomite

Diatomite is a light coloured, very porous rock composed of the siliceous shells of tiny aquatic organisms called diatoms. It is used primarily as a filter medium, as a filler, a carrier for hazardous materials, and a mild abrasive. Most of Victoria's large known deposits occur in the south of the investigation area, associated with basalts. Deposits have been worked by underground mining at Newham, Redesdale, Glengower and Moranding, and by open cut at Lillicur and Moranding. Accessible resources at Lillicur may be around 40 000 tonnes, while recent production has yielded a few thousand tonnes per year.

## Feldspar

Feldspar provides a source of alumina and alkalis for use in the glass and ceramics industries. Numerous pegmatite and other granitic bodies in the area have been explored, but most are economically insignificant. ACI Industrial Minerals is proceeding with a project designed to produce a glass grade feldspar from granite, about 5km west of Beechworth.

## Gemstones

Various precious and semi-precious stones, specimen rocks and minerals are found in scattered locations across the investigation area. There are no commercial operations in the State, but numerous occurrences in granites, pegmatites, quartz veins and alluvium are of interest to fossickers. Garnet, sapphire, zircon, ruby, topaz, tourmaline, coloured quartz and rare diamond have been recovered from Woolshed Valley stream gravels near Beechworth. Diamonds found in deep leads at Beechworth-Eldorado and Chiltern-Rutherglen, and at Carapooee, have stimulated exploration.

## Kaolin

The most important Victorian alluvial kaolin deposits are near Axedale. This plastic, pale-firing kaolin is highly valued for ceramic products such as whitewares, tiles and insulators. Production from the Axedale Ballclay pit and Osterfield pit (the latter on private land) has been around 60 000 to 80 000 tonnes/annum, and resources are sufficient for several years. There is scope for discovery of primary, relatively non-plastic kaolin in weathered granites, for

example east of Ararat, and secondary alluvial deposits similar to those at Axedale.

## Magnesite

Small magnesite deposits have been worked near Heathcote and Redesdale, and also recorded from the Whipstick, Maldon and Costerfield. Total Victorian production is about 4500 tonnes, of which 4020 tonnes were produced from Heathcote.

## Silica

The highest grade silica source in the State consists of quartz cobbles from deep lead mine dumps near Allendale. Selected material is crushed and milled for production of silica flour, used in the manufacture of whiteware, paints, ceramics, pottery and industrial fillers.

## Petroleum

There are no current petroleum titles, or exploration or development activities in the investigation area. However, the Box-Ironbark investigation area overlaps the southern margin of the Murray Basin, which has potential for hydrocarbons.

## CONSTRUCTION MATERIALS

### Rock, sand, gravel and clay

Across the study area in general, there is a good distribution of rock types that can be quarried and processed for construction use. Igneous and metamorphic rocks in sound, unweathered form are generally capable of yielding crushed rock products for many uses, including higher grades of aggregates for roadmaking and concrete manufacture. These include basalt, dolerite, granite, rhyodacite, hornfels and quartzite. The Palaeozoic sedimentary sandstones and shales are more widespread but limited in their applications because of their relatively low hardness, strength and durability. They can often be extracted by bulldozing and ripping to provide low cost road sub-base material.

Sand and gravel for roadmaking and building are obtained from numerous sources. Tertiary alluvial deposits contain extensive and thick sand and gravel sequences, and are commonly also gold bearing. Quaternary deposits are generally smaller, but ancestral streams containing channel

important sources for building and monumental purposes since 1859. Use expanded in the late 1980s reflecting growth in demand for decorative stone in buildings, but has since declined. Currently four quarries operate at Harcourt, producing 5516 tonnes in 1995/96. Numerous potential sources of granitic dimension stone have been identified in the investigation area. Low grade slate from the Castlemaine region has been used widely as a colourful paving material.

## EXPLORATION AND MINING INDUSTRIES

The mining industry is dominated by gold both in areal extent and the value of production, but also encompasses active mines for fine clays, gypsum and diatomite. Exploration activity is similarly dominated by gold searching, mostly over known goldfields.

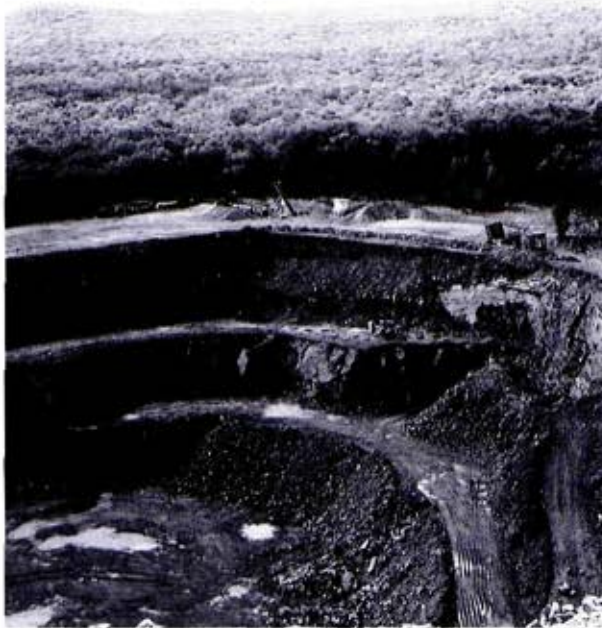
### Regulatory environment

The key legislation governing exploration for and development of minerals in Victoria is the *Mineral Resources Development Act 1990* (MRD Act), administered by the Department of Natural Resources and Environment (NRE). A 'mineral' under the MRD Act includes any naturally occurring substance of the earth's crust except water, stone or petroleum. Metallic and non-metallic minerals in the investigation area are described above. In general under the Act the Crown owns all minerals until they have been separated from the land in accordance with a mining licence. The MRD Act makes a clear distinction between exploration and mining.

An *exploration licence* authorises exploration activities such as geological, geochemical and geophysical surveys, drilling, trenching, bulk sampling and underground evaluation. Its term is up to two years, and may be renewed. No planning permit is required.

A *mining licence* applies to the commercial extraction and processing of ore for mineral production. The first stage, the grant of a Mining Licence, does not allow mining works; the second stage is an authority to commence work. The authority can only be granted once the licensee has:

- obtained all necessary consents (including planning permit or Environment Effects Statement);
- made compensation arrangements with or gained consent from landowners and occupiers;



Quarry adjacent to Chiltern Box-Ironbark National Park.

sands are common in the northern plains, and together with dune deposits are important construction sand sources. Other sand and gravel sources are colluvial deposits on granitic slopes, and mine tailings.

Deposits of clays suitable for bricks and other ceramic products are widespread, with brick making plants the largest consumers. Clays are commonly obtained from several sources and blended to achieve the required balance in plasticity, shrinkage and fired colour. Sources of residual clays and clay-shales from Palaeozoic sedimentary rocks are located close to plants at Bendigo, Ballarat, Stawell and Glenthompson. Cainozoic alluvial clays, commonly used to increase brick clay plasticity, have been obtained from Axedale. Various types of pottery ware have been produced at Bendigo and Ballarat.

### Dimension stone

Natural stone is cut to specific dimensions for use in building, construction and monumental industries. Granite quarries at Harcourt and Mt Alexander have been

- drafted a work plan (including rehabilitation plan) approved by NRE;
- lodged a rehabilitation bond set by NRE;
- given advance notice to owners and occupiers of land, and the chief mining inspector, of intention to commence work;
- obtained adequate public liability insurance cover.

Several State government departments and instrumentalities take part in the approval and control processes for mining operations, including:

- Department of Natural Resources and Environment
- Environment Protection Authority (EPA)
- municipal councils
- regional water authorities
- Department of Infrastructure (for Environment Effects Statements)

NRE is the key regulatory agency responsible for licensing, compliance with environmental, health and safety standards, and enforcement under the MRD Act. Through its Mines Inspectors and other officers, NRE is involved in statutory planning approvals, work plan assessment, conditioning operations, compliance auditing and assessment of post-mining rehabilitation. Environment Review Committees (ERCs) are established for all substantial mines. Each ERC includes representatives of government agencies and authorities, and the local community. It reviews the results of environmental monitoring programs and acts as a forum for problem resolution.

### Access to Land

The MRD Act classifies Crown land in three categories, with varying degrees of availability to mining and exploration. In the Box-Ironbark study area these are:

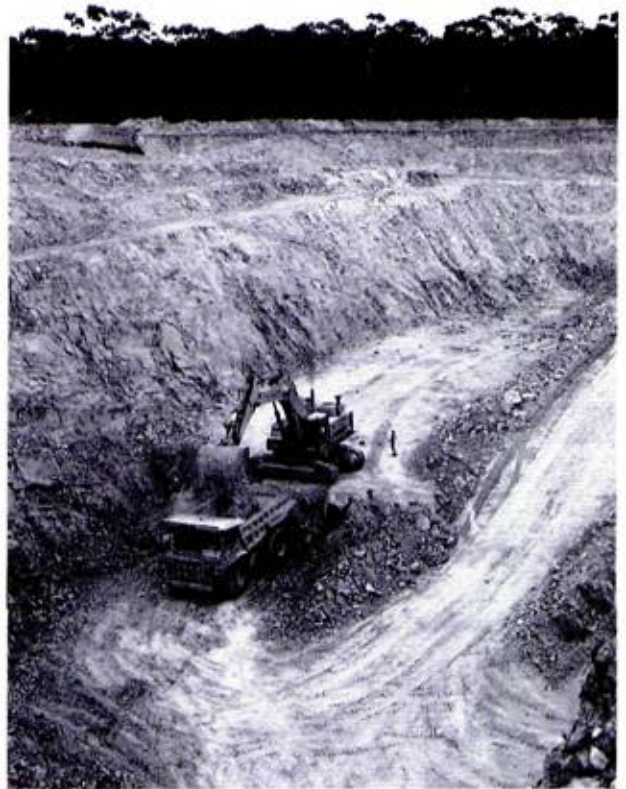
- Exempt — national and State parks, reference areas, and archaeological areas under the *Archaeological and Aboriginal Relics Preservation Act 1972*, or land containing registered relics. Granting new mining and exploration licences here is prohibited.
- Restricted Crown Land — regional parks, nature conservation reserves, natural features reserves, and historic and cultural features reserves. Access is subject to consent from the Minister for Conservation and Land Management.
- Unrestricted Crown Land — essentially all other Crown land. Access does not require the consent of the

Minister for Conservation and Land Management, though the Minister may recommend conditions to be imposed on the licence.

### Exploration

Exploration is the search for minerals. It does not involve commercial mining. Exploration methods include:

- Regional reconnaissance using remote sensing — satellite imagery, aerial photography — and regional mapping. Hundreds of square kilometres may be covered to identify areas for intensive exploration. Geological mapping involves the examination of rock outcrops and exposures. It is usually carried out on foot, with access via existing roads and vehicle tracks, and has minimal impact.
- Field sampling — geologists take small rock-chip, soil or stream sediment samples, by shovel, hand auger or hammer. More intensive sampling and localised mapping may be carried out using trenches (costeans) or



*Open cut mine, Fosterville.*

small pits. This may occur on a surveyed, marked grid. Minor vegetation removal may be involved, and rehabilitation of disturbed areas is required.

- Geophysics looks for anomalous physical properties indicating structures or mineralisation under the surface. The properties include magnetism, electrical conductivity, resistivity or capacitance, gravity, natural radioactivity or seismic behaviour. These surveys can be airborne for regional surveys, or ground based. The impact of ground surveys depends on the extent of grid and track development required for the equipment.

These methods are broad scale and provide information that builds up a picture of where mineralisation may occur. Drilling is the most economical way to assess in detail the presence of an ore body. Drilling, around 10 cm in diameter, is usually carried out by truck-mounted equipment and may yield samples as fine chips (rotary-percussion and auger) or as a solid rock core ('diamond' or core drilling). Samples are sent for mineralogical, chemical or metallurgical analysis, and the exploration company may require follow-up drilling if results are of interest. The impact of drilling on the environment depends on the openness of the vegetation, species present, topography, soil types, construction of track access and management of the operation. At the end of the drilling program, the drill holes are required to be capped (sub-surface) and the area returned to its natural landform and revegetated.

Detailed assessment of an ore body will require intensive drilling supplemented by bulk samples of several hundred tonnes or more. Bulk sampling gives a higher level of confidence in the drilling results, particularly when the gold is coarsely grained and not evenly dispersed. Large samples are needed to avoid misleading assessments. Samples are usually excavated from pits up to 5 m deep and 10 m square. The pit must be rehabilitated by backfilling, or battering.

Exploration programs may be conducted under Exploration Licence, with broad scale to intensive exploration, or Mining Licence, usually involving more intensive work building on broadly-defined mineralisation.

Mineral exploration expenditure in 1995/96 on Exploration and Mining Licences, recorded in statutory returns to NRE, is included in Tables 40 and 42. The extent of licences is shown in Map 11 (to November 1997). Total exploration expenditure for all titles affecting public land in the Box-Ironbark study area (Zone A, Tables 40 and 42)

amounted to \$17.9 million, about 52 per cent of the total for Victoria of about \$34.5 million. It is clear that a very significant part of exploration activity in Victoria is currently directed towards box-ironbark goldfields. The high level of exploration interest in the Box-Ironbark study area is also demonstrated by exploration licence coverage. Currently, most of the western Box-Ironbark study area public land is covered by exploration or mining licences or applications (Map 11). Historically, gold has been the most important mineral commodity to explorers, though target types have changed over the years. Prior to the 1980s, primary gold exploration focused on narrow vein styles of mineralisation, only amenable to underground mining. During the 1980s, large tonnage, low grade deposits which could be mined by open cut as well as underground, became attractive targets, due to increases in gold prices, and advances in mining and metallurgical processing techniques. Alluvial gold exploration has continued, with the recent resurgence of interest in deep lead gold, and primary gold beneath lead systems.

Exploration programs for other commodities have been carried out intermittently. In the 1980s and early 1990s, regional exploration for mineral sands was conducted north-west of the study area. Other programs include identification of sub-economic resources of brown coal in the north, and alluvial diamond occurrences in the east. Base metal prospects in bedrock areas have been investigated at various times, particularly when metal prices were high.

#### Government initiatives in exploration

Recently the Victorian Government has introduced initiatives aimed at improving the contribution of mining to the economy. The Victorian Initiative for Minerals and Petroleum (VIMP), a 3-year, \$16.5 million program, commenced in 1994. It provides state of the art geophysical data and regional scale maps of the most under-explored or prospective areas of the State.

VIMP products now include high quality airborne magnetic and radiometric data for about 72 per cent of the State, new generation geological maps for 30 per cent of important outcrop areas, Geographic Information Systems (GIS) data for 30 per cent of the State, and technical reports on geology, geophysics, prospectivity and mineral exploration history for specific areas. The objects are to establish Victoria's geological framework clearly, and to

provide an improved knowledge base for private exploration.

Partly as a result of VIMP, exploration expenditure has quadrupled since 1992/93. Total expenditure on exploration and mine development has risen dramatically from about \$14 million in 1990/91 to about \$108 million in 1995/96. Victoria currently has eight operating gold mines producing over 1000 oz. per annum and many encouraging prospects including several in the study area. The two tables in Appendix XIV provide information on the major mines, and an overview of the prospects.

## Mining

### Gold

Total gold production figures from 1986/87 to 1995/96, and for the 1995/96 year, are shown in Table 41.

In 1995/96 about 96 per cent of Victoria's gold production — 4651 kg valued at \$57.3 million — came from goldfields in or overlapping the Box-Ironbark study area. Two operations, the Stawell Gold Mines Pty Ltd mine at Stawell and the Perseverance Corporation Ltd mine at Fosterville, produced 87 per cent of that gold. Many operations including alluvial workings had very small outputs. There are numerous areas under mining title, some of which have had intensive exploration, for which no recent gold production has been recorded.

Table 42 indicates that a significant part of Victorian exploration and development expenditure relates to titles having at least some overlap with the Box-Ironbark study area. The total area of overlap between mining licences (including applications) and existing Box-Ironbark study area public land is about 7936 ha.

**Table 40: Exploration Licence statistics**

Zone	Current ELs				Applications for ELs		
	No.	Total area (sq.km)	Av. area (sq.km)	Expenditure (\$) in 1995/96*	No.	Total area (sq.km)	Av. area (sq.km)
A – study area	118	14 613	124	8 974 000	16	1 272	80
B – investigation area (outside study area)	77	10 766	140	2 408 000	31	3 400	110
<b>Total investigation area</b>	<b>195</b>	<b>25 379</b>	<b>130</b>	<b>11 382 000</b>	<b>47</b>	<b>4 672</b>	<b>99</b>
C – Rest of Victoria	110	19 814	180	5 484 000	36	6 456	179
<b>Victorian total</b>	<b>305</b>	<b>45 193</b>	<b>148</b>	<b>16 866 000</b>	<b>83</b>	<b>11 128</b>	<b>134</b>

**Notes:**

Current exploration licences and applications, February 1997  
Zones A, B and C as for Table 39.

Expenditure under ELs is reported for half year periods, which commence at the grant date of title, and which do not therefore, conform to halves of a financial year. The tabulated figures represent the totals for any half year reporting period whose end date occurs within the 1995/96 financial year.

Australian Bureau of Statistics exploration expenditure data varies from NRE data through categorisation and reporting differences. The ABS 1995/96 estimate was \$42.6 million.

**Table 41: Recent gold production**

Zone	Total production 1986/87–1995/96			Production 1995/96			
	Quantity (kg)	% of Vic. total	No. of producers	Quantity (kg)	% of Vic. total	Value (\$) @ \$12 320/kg	No. of producers
A – study area	28 880	84	47	4 651	96	57 300 320	18
B – investigation area (outside study area)	4 685	14	11	177	4	2 180 640	6
<b>Total investigation area</b>	<b>33 565</b>	<b>98</b>	<b>58</b>	<b>4 828</b>	<b>100</b>	<b>59 480 960</b>	<b>24</b>
C – rest of Victoria	633	2	25	9	0	110 880	8
<b>Total Victoria</b>	<b>34 198</b>	<b>100</b>	<b>83</b>	<b>4 837</b>	<b>100</b>	<b>59 591 840</b>	<b>32</b>

Zones A, B and C as for Table 39.

Map 11: Current exploration licences (to November 1997).

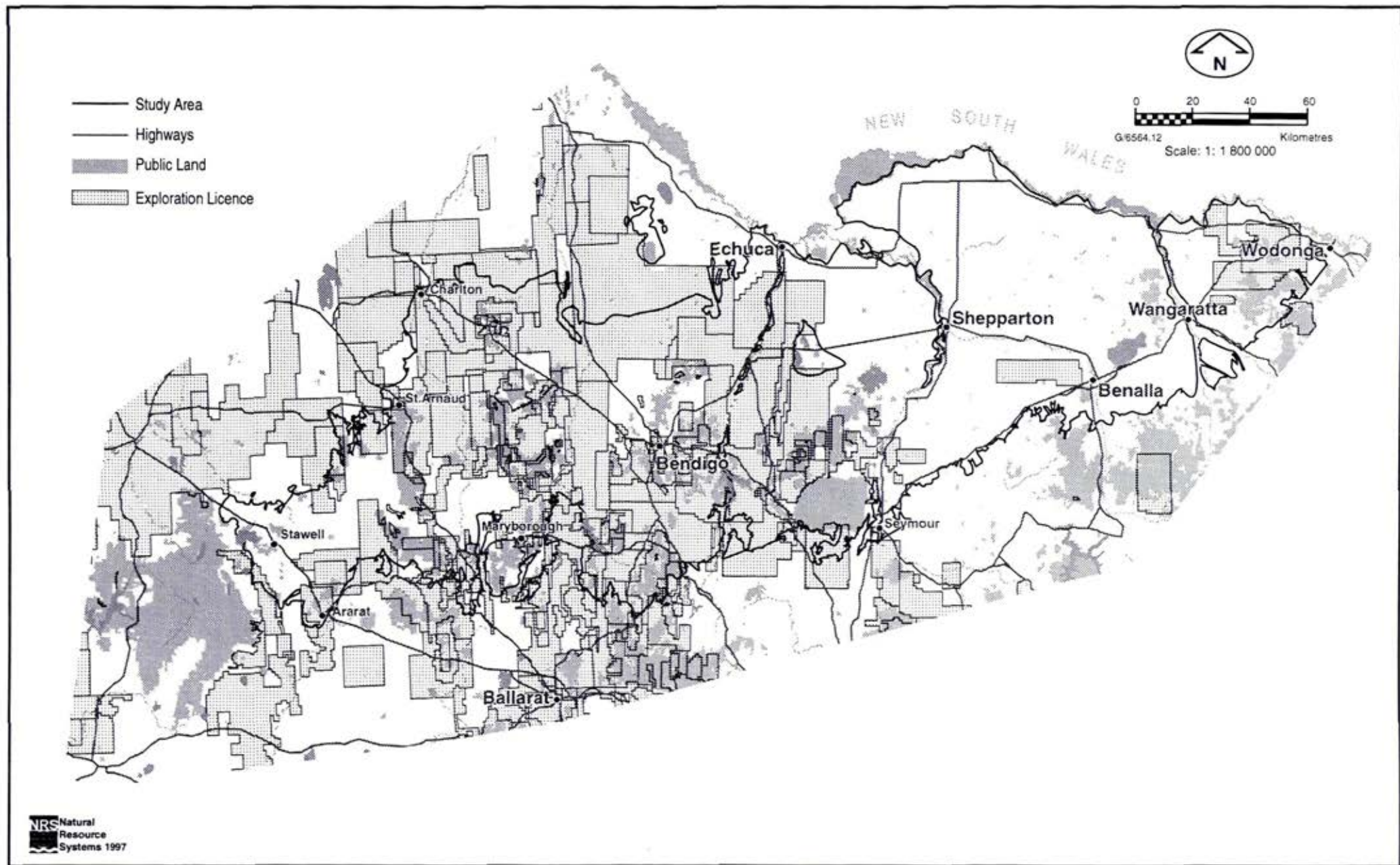


Table 42: Mining title statistics

Zone	Current titles			Expenditure 95/96 (\$)			Title applications		
	No. of titles	Total area (ha)	Av. area (ha)	Exploration	Other	Total	No. of titles	Total area (ha)	Av. area (ha)
A – study area	133	16 479	124	8 892 848	33 846 931	42 739 779	27	3 565	132
B – investigation area (outside study area)	117	8 631	74	4 929 881	11 551 974	16 481 855	20	729	36
<b>Total investigation area</b>	<b>250</b>	<b>25 110</b>	<b>100</b>	<b>13 822 729</b>	<b>45 398 905</b>	<b>59 221 634</b>	<b>47</b>	<b>4 294</b>	<b>91</b>
C – rest of Victoria	185	33 425	181	3 762 882	28 417 661	32 180 543	11	632	57
<b>Total Victoria</b>	<b>435</b>	<b>58 535</b>	<b>135(av)</b>	<b>17 585 611</b>	<b>73 816 566</b>	<b>91 402 177</b>	<b>58</b>	<b>4 926</b>	<b>85(av)</b>

**Notes:**

Titles include Mining Licences, Mineral Leases, Mining Area Licences and Miners Right Claims. Current titles include those current or under renewal application in February 1997.

Zones A, B and C as for Table 39.

**Other minerals**

Apart from gold, the only minerals produced recently in the investigation area are the industrial minerals diatomite and kaolin (as described above) and some gypsum. None of the current operations is on public land in the Box-Ironbark study area.

**Mining methods**

Mining methods applied in the study area are varied – from recreational metal detecting to large scale open pit mines.

**Prospecting**

A miner's right issued under the MRD Act allows the holder to search for minerals, most commonly gold nuggets. The miner's right allows for the use of metal detectors, but also limits search activities, and specifies that:

- only hand tools may be used for excavation;
- explosives may not be used;
- the search must not damage any tree or shrub;
- the search must not disturb any Aboriginal place or Aboriginal object;
- any damage arising from the search must be repaired, typically requiring backfilling of any holes and replacement of leaf litter; and
- the holder must have the consent of the owner or occupier before entering private land.

The holder of a miner's right cannot search within a current mining licence, or in exempt areas including State or national parks. However, under the *National Parks Act 1975*, the Minister for Conservation and Land Management

may designate areas in certain parks in which fossicking or prospecting is permitted. Such areas have been designated in Kamarooka and Whipstick State Parks, Beechworth Historic Park (fossicking only), and Kara Kara and Kooyoora State Parks (fossicking and prospecting). A miners right is valid for two years and approximately 9000 are currently in circulation. Holders range from weekend hobbyists to professionals.

**'Doze and detect'**

This type of mining involves the use of a bulldozer or backhoe (for earthmoving) and a metal detector for gold seeking. It requires a mining licence and is typically carried out by one or two people on a tenement of 5 ha or less. The mining method involves vegetation removal, stripping and stockpiling of topsoil, detection over the exposed surface, removal of another layer, detection over the newly exposed surface and so on. The total depth is commonly less than 1 m, but may be up to 6 m. Following detection, the licence requires the area to be rehabilitated and a new 'panel' opened up beside it. Mining proceeds around the licence area on this basis. The area 'open' at any one time is limited by licence conditions.

The MRD Act applies to 'doze and detect' with rehabilitation standards and bonds required (see 'Rehabilitation', below). Such licence areas are quickly worked out, usually in less than 18 months.

**Alluvial mining**

Alluvial mining is undertaken in mineralised gravels accumulated along current or ancient drainage lines. The largest alluvial mine in the State is at Amphitheatre, where



*Doze and detect mining, Kingower.*

about 300 000 cubic metres of gravels are treated each year. Alluvial mines can be small, but because of the low ore grade, economies of scale dictate that they be larger operations. Workings are usually less than 10 m deep and relatively coarse gold is sought and extracted by gravity methods without using chemicals. Tailings dams are usually required to store fine tailings resulting from gravel washing. Progressive backfilling and rehabilitation efforts are normal practice.

Alluvial mining has taken place in areas historically mined by shafts and small pits, such as around Moliagul and Maryborough. The areas were degraded as a result of earlier mining, where rehabilitation was not commonly undertaken.

### Open pit

Open pits have been established in the last two decades across the study area — from Nagambie to Stawell. Open pits for primary gold are usually linear excavations, typically less than 40 m deep and 100 m across. Pit length is

variable — the largest currently proposed in the study area will be at Fosterville Gold Project 20 km east of Bendigo, where pits 130 m deep, 250 m wide and 2000 m long are proposed. Excavations involve blasting, and large scale hydraulic excavators and haul trucks. Cyanide-based gold extraction techniques are used, such as heap leaching, carbon-in-pulp (CIP) or carbon-in-leach (CIL). The duration of mining is highly variable but a single pit is typically in operation for around two years.

### Underground

Underground mining is usually smaller scale than open cut and surface impacts are relatively smaller. There are reduced waste rock dumps, usually smaller areas occupied by the tailings dam or leach pad, and no open pit. Underground access is from an inclined tunnel (decline) or vertical shaft. It is more costly than open cut mining and needs higher ore grades and more selective mining. Waste rock is commonly used to backfill underground voids (stopes and drives) for ground support and reduced handling costs.

### Ore treatment

Once mined, ore needs treatment to remove minerals. Treatment methods utilise:

- gravity, relying on gold's high density to separate it from clay, quartz and rock particles;
- CIP/CIL methods using high pH cyanide solutions to dissolve the gold from a finely ground slurry pumped around a series of tanks, adsorption of gold-cyanide complex onto activated carbon, separation and recovery. The depleted slurry is deposited in a tailings dam; and
- heap leaching which involves heaping coarsely crushed rock on an impervious liner, with a weak cyanide solution circulated through it. Following depletion the cyanide is flushed out, and the heap landscaped and revegetated.

## EXTRACTIVE INDUSTRIES

'Stone' as defined in the *Extractive Industries Development Act 1995* (EID) includes high volume, low value rock; sand; clays (other than fine clays subject to the MRD Act); soils and earth. Rock types include sandstone, lime-stone, granite, hornfels and basalt. These commodities

are most commonly used in building and construction industries. The primary difference between stone and minerals is the emphasis on high volume, low value commodities. Stone operations accordingly are highly dependent on proximity to the consumer to be economic. Products such as sand and clay are relatively common, while others, such as quality hornfels for road bases, are relatively rare in some parts of the State.

## Regulatory environment

The EID Act is the key legislation governing exploration and development of stone. An extractive industry is defined as extraction or removal of stone from land if the main purpose is sale, commercial use, or use in construction, building, roads or manufacturing. As distinct from minerals, owners of land own the stone and therefore hold all rights to exploration or development. Extraction is carried out under regulations and a work authority issued by NRE. A work authority requires:

- consent of the landowner, including the public land manager for Crown land;
- planning approval under the *Planning and Environment Act 1987*;
- satisfactory work plans, including rehabilitation plans; and
- a rehabilitation bond.

NRE is the key regulatory agency for compliance with environmental, health and safety standards.

## Access to Land

Access to Crown land is similar to the provisions for exploration and mining described above. Consent for access to restricted Crown land is required from the Minister for Conservation and Land Management.

## Production

Quarry production under the EID Act, for the investigation area, is given in Table 43. There are many small pits producing road gravels for surfacing forest tracks, which in the past were exempted from legislative controls. Their production is not included in the table.

The total annual value of production of the above materials, about \$70 million, is about 16 per cent of the total value for Victoria of \$425 million. The aggregate area of current work authorities in the investigation area is

5500 ha, with 3570 ha applied for. Map C shows the major extractive operations.

There are currently over 90 quarry operations with work authorities under the EID Act in the investigation area. Most of these relate to areas licensed under the former *Extractive Industries Act 1966*. Many other operations, including shallow extractions, were excluded from licensing under the old Act, but will be brought under the EID Act. About 65 areas are under application for new work authorities.

Eight operations with EID Act work authorities affect public land in the study area. Two, the hard rock quarries near Chiltern and Talbot, are regionally significant.

## REHABILITATION

### Early Mining Techniques and Impacts

Many parts of the study area have been subject to mining disturbance several times. In some cases, areas first mined for shallow alluvials have later been subject to underground mining in search of deep lead or reef ore bodies. In others, later generations of miners have reworked the same ore bodies, for example, by strip mining shallow alluvial deposits.

Early mining was characterised by a complete lack of concern for its environmental impacts (see also Chapter 3). On alluvial fields, excavated material was usually left on the surface, topsoil was buried, understorey vegetation was stifled, watercourses were altered and erosion was initiated. Where deeper underground mining occurred, large quantities of timber were required for fuel and construction purposes, which resulted in the loss of a considerable amount of original forest cover. Extraction of gold from ore, using gravity separation and mercury amalgamation, resulted in tailings of finely ground sand containing mercury. Where gold mineralisation was associated with arsenic compounds, tailings were high in arsenic. Many streams in the goldfields were contaminated, and their clarity and salinity affected.

Later retreatment of tailings to recover remaining gold used cyanide solutions. While not persistent in the environment, cyanide compounds are toxic and, given the handling practices of the day, probably had serious

**Table 43: Quarry production under the *Extractive Industries Development Act 1995***

Rock Type	No. of operations	Production 1995/96 (tonnes)	Value of production (\$mil., approx.)
Hard rock types			
Basalt/dolerite	12	2 316 000	
Granite/rhyodacite	6	439 000	
Hornfels	9	737 000	
Sedimentary rock	16	559 000	
<b>Sub total — hard rock</b>	<b>43</b>	<b>4 051 000</b>	<b>56.0</b>
Clay and clay-shale	5	78 000	0.4
Sand and gravel	45	1 165 000	14.0
<b>Investigation area total</b>	<b>93</b>	<b>5 294 000</b>	<b>70.4</b>



*This mine tailings heap has been covered with topsoil prior to revegetation, Fosterville.*

short-term effects on aquatic fauna. This phase probably exacerbated the effects of underground mining by remobilising contaminated tailings and further degrading some streams.

Planned land rehabilitation was not a feature of the early phases of mining in Victoria. Fortunately, trees on remaining public land were in most cases coppiced rather than removed and so many regrew from stumps. Original soil profiles remained on non-gold bearing land between worked areas, retaining some understorey species. In some areas regeneration after mining was successful in restoring stability and re-establishing forest. Some areas now considered of relatively high conservation value were subject to at least one phase of mining, for example the Chiltern Box-Ironbark National Park.

### Modern Mining Impacts

The MRD Act seeks to limit the environmental effects of mining and provide for the rehabilitation of mined land.

Mining may only be undertaken in accordance with an approved work plan, incorporating a rehabilitation plan and environmental monitoring program. NRE holds a rehabilitation bond to ensure rehabilitation is completed in accordance with the plan. Rehabilitation requirements aim at reinstatement to the pre-mining condition as far as possible. Usually, this means re-establishing a forest community with overstorey and understorey plants appropriate to the area. Rehabilitated land must have appropriate land-forms, be stable, and not be subject to undue erosion. The Act allows retention of the rehabilitation bond for up to six years after licence expiry to ensure goals are met.

Modern day mining affects relatively small areas of land compared to the early diggings. It is estimated that current large mining projects have cleared 500 to 1000 ha of land with box-ironbark vegetation over the last 10–15 years. Rehabilitation will be undertaken on much of this land. New areas will be cleared as prospects are proved and mining is commenced. Other mining methods, such as ‘doze and detect’ and alluvial mining, as well as exploration, add to the total area affected.

Some elements of a mining site cannot be reinstated to original landform. Tailings dams must be covered and landscaped *in situ*, with sufficient cover to allow for revegetation. Backfilling open pits is not practical or desirable if underlying ore may become economic to mine. It is estimated that open pits in the study area, excavated in the last 10 years, occupy a total area of approximately 75 ha.

Rehabilitation plans and bonds are approved by Minerals and Petroleum Victoria (MPV) in consultation with NRE land managers. In addition, timber resources, flora and

fauna, cultural heritage sites and runoff water quality are considered, and the needs for supplementary surveys or information are identified. In some instances where forested Crown land is proposed for mining, an area of forested private land with similar values may be purchased and handed over to the Crown. Alternatively, cleared land may be purchased by the miner, and revegetated, as an offset for mining forested public land. Clearance of forested land overall is minimised.

## **EARTH RESOURCE POTENTIAL**

### **Prospectivity**

Potentially there are significant gold resources remaining in central Victoria. The extent of future development will be determined by the occurrence of gold, land access, economics, environmental standards and performance. It is generally the case that major mineral provinces experience repeated phases of mining, as economic grades of ore become lower. New exploration, mining and treatment technologies, geological models, more intensive exploration, improved environmental and safety management, and changing commodity prices can lead to the redevelopment of previously uneconomic deposits, and discovery of new deposits.

Current exploration interest in the Box-Ironbark investigation area is driven by a perceived high prospectivity for gold. This perception is based on the huge size of historical gold production and the limited application of modern exploration, mining and metallurgical techniques to date. Successful current projects, such as at Fosterville, provide some support for this view.

### **Potential scale of new developments**

Estimating future levels of mining activity is very difficult, because of uncertainty as to exploration success and economic circumstances. Victoria may follow the example of the West Australian goldfields, where the second wave of development is expected to yield more gold than the first.

There is also potential for discovery of other metallic and non-metallic mineral commodities in the area. This is evident from mineral records and past and present exploration, though active exploration for specific commodities is likely to be cyclical and related to market demand. However, much less exploration and development is likely for other minerals than for gold.

Most construction materials are widespread, so demand can generally be met from source areas outside box-ironbark forests and woodlands on public land.

# 18. WATER PRODUCTION AND USE

## INTRODUCTION

This chapter is concerned with the harvesting, storage, transport, and uses of water resources in the study area. The characteristics, distribution and condition of water resources in the study area are described in Chapter 5.



*Coliban Aqueduct, north of Harcourt.*

As noted in Chapter 5, substantial water flows are largely associated with drainage lines and other low-lying parts of the landscape. Major watercourses generally support wetland and riverine vegetation types that are not included in the definition of box-ironbark forests and woodlands. However, box-ironbark dominates the remnant vegetation on public land in many of the catchments used for water production in northern Victoria, extensive networks of channels and water storages lie within the study area, and most of the area used for irrigated agriculture in northern

Victoria also falls there. The implications of water production and use extend well beyond the immediate areas used for harvesting and storage.

Water production and transport in the Box-Ironbark study area contributes to much larger systems that include the Murray River to the north, storages in the mountains to the south-east, and the Wimmera stock and domestic supply system to the west, as well as smaller systems such as town supplies. The catchments and distribution systems of several town supplies are entirely in the study area. However, water production and volumes used in the study area, and indeed most of northern Victoria, are dominated by the irrigation developments of the Goulburn-Murray Irrigation District.

This chapter provides an overview of water production and use in the study area and relevant adjacent areas. More detailed information can be found in the annual reports of water authorities in the study area and, in particular, *Water Victoria. A Resource Handbook*, by the former Department of Water Resources Victoria (DWR 1989a).

## WATER SECTOR AGENCIES

As indicated in Chapter 3, water management in the Box-Ironbark study area has a long history of very diverse demands, from small-scale gold miners in the middle of the 19th century, domestic and industry supplies and irrigators, to modern hydro-electricity generation for the State-wide electricity grid. The history of administrative and institutional arrangements within the water sector has largely reflected this diversity of demands, with a large number and wide variety of agencies involved for much of this history.

In recent decades, there has been a number of rationalisations of these arrangements, leading to a complex series of changes since the completion of earlier LCC studies in the study area. These changes have resulted in the establishment of four Rural Water Authorities (successors to the Rural Water Corporation), 18 Regional Water Authorities (successors to town water boards and water-works trusts) and 18 Waterway Management Authorities across Victoria (Table 44). Three of the four Rural Water Authorities,

Map 12: Water sector authorities.

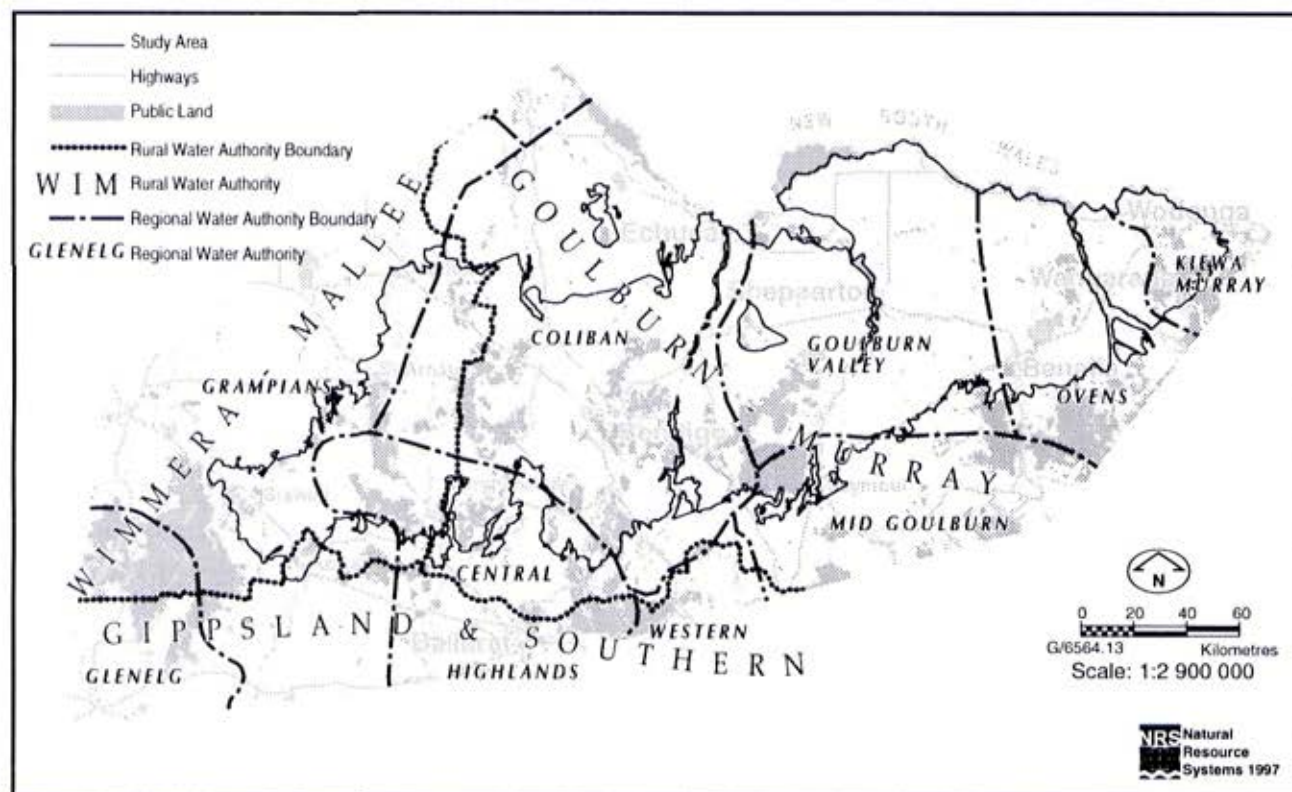


Table 44: Summary of water sector agencies in the Box-Ironbark study area

Agency type	Number within		History	Major roles
	Victoria	Study area <sup>1</sup>		
Rural Water Authorities	4	3	<ul style="list-style-type: none"> <li>Resulted from the partition of the (statewide) Rural Water Corporation in 1994, and the evolution of Rural Water Regions into Rural Water Authorities. The Rural Water Corporation evolved from the State Rivers and Water Supply Commission between 1984 and 1992.</li> </ul>	
Regional Water Authorities (also known as Non-Metropolitan Urban Authorities)	18	11	<ul style="list-style-type: none"> <li>Evolved from the restructure, between 1991 and 1995, of over 140 local water authorities throughout Victoria (including water services operated by local councils).</li> </ul>	<ul style="list-style-type: none"> <li>supply of town, rural, and some irrigation water</li> <li>collection, treatment, and disposal of domestic and most industrial waste water</li> </ul>
Waterway Management Authorities (Catchment Management Authorities)	24	7	<ul style="list-style-type: none"> <li>Most have evolved from the consolidation of local River Improvement Trusts.</li> </ul>	<ul style="list-style-type: none"> <li>local community-based coordination and implementation of on-ground works to maintain and enhance both the potential for sustained multiple use of waterways and their environmental values</li> </ul>

**Note:**

1. Includes several agencies that have relatively small areas within the Box-Ironbark study area.

seven of the 18 Regional Water Authorities, and seven of the 24 Waterway Management Authorities extend into the Box-Ironbark study area (Table 44), although some only barely so (Map 12).

**Rural Water Authorities** These are statutory authorities responsible to the Minister for Agriculture and Resources. They have a majority of water users on their boards. They are the Goulburn-Murray Rural Water Authority, which operates in the river basins north of the Divide from the Victorian Upper Murray catchment to the Loddon; Wimmera-Mallee Rural Water Authority, operating in the catchments of the Wimmera-Avon and most of the Avoca; Gippsland and Southern Rural Water Authority operating in all catchments south of the Divide, except around Rocklands Reservoir; and Sunraysia Rural Water Authority along the Lower Murray and northern Mallee areas. They use abbreviated names such as Wimmera-Mallee Water. Rural Water Authorities are responsible for the provision of bulk water supplies to large users: Irrigation Districts, Regional Water Authorities and some industries. They also provide irrigation water for some private diverters, 'stock and domestic' water — channelled or piped drinking water for stock and water for domestic use — to some rural consumers, and drainage services to irrigators. Accordingly, the Rural Water Authorities are responsible for the construction and maintenance of the infrastructure associated with these activities, most particularly the headworks — storages in the upper reaches of the major catchments. Thus, for example, Goulburn-Murray Water is Victoria's Constructing Authority for the Murray-Darling Basin Commission works. The Rural Water Authorities are also involved in some resource management activities related to their core business — salinity and water quality management for example.

**Regional Water Authorities** These are statutory authorities, with abbreviated names such as Coliban Water, responsible for supplying water to primarily urban consumers and the disposal of waste water from towns. The authorities, shown on Map 12, have largely evolved from the consolidation of numerous small local waterworks trusts, water boards and similar agencies such as units within municipal councils. For example, the Deakin Water Board, which supplied water and sewerage services to Tongala and Girgarre, was one of 14 organisations consolidated in 1994-96 to form the Goulburn Valley Regional Water Authority (Goulburn Valley Water).

Although the local agencies have been amalgamated, the physical means by which water, including waste water, is transported remains largely unchanged.

Regional Water Authorities harvest their own water, or purchase supplies from Rural Water Authorities. They then distribute and sell water to consumers in towns and stock and domestic supplies to consumers in rural areas. They are also responsible for collecting and treating waste water in sewered towns. These responsibilities entail a wide range of associated activities such as installing and maintaining pipes, channels, pumps, and sewage treatment plants.

**Waterway Management Authorities (WMA)** These differ from the water authorities described above in that their origins are largely non-government. They are derived from River Improvement Trusts which were first established, with rating powers, in the 1940s to 'protect' and 'improve' degraded sections of waterways affected by stream bed and bank erosion, and to expedite the passage of floodwater. Priorities tended to be the protection of valuable farmland which was either eroding, or affected by flooding. However in recent decades environmental considerations have become more prominent, in tandem with an increased recognition of the desirability of integrating whole-catchment planning with waterway management.

While earlier trusts concentrated on the watercourse, several were reconstituted under the *Water Act 1989* as whole-catchment boards in the late 1980s. Until recently, seven Waterway Management Authorities existed in the Box-Ironbark study area: Avoca River Management Board, Bullock Creek River Improvement Trust, Coliban Water (Bendigo Creek), Upper Goulburn Waterway Authority, Broken River Management Board, Lower Goulburn Waterway Management Authority, and Ovens River Management Board, also known as North East Waterways. Waterway Management Authorities, with salinity and Landcare groups, have been the major non-departmental agents implementing on-ground works in and adjoining streams.

The roles of the former Waterway Management Authorities have been taken on by the Catchment Management Authorities (see below). The Boards of the WMAs have been reconstituted as Implementation Committees of the Catchment Authorities.

In 1994, ten regionally based **Catchment and Land Protection (CALP) Boards** were established, with advisory and planning roles and responsibility for providing an overview of catchment management across the regions; for example, soil conservation and pest plant and animal control priorities.

Following a recent review of catchment management structures in Victoria, it was determined that **Catchment Management Authorities** would be established in nine of the ten CALP regions. The role of the Authorities is to integrate existing advisory mechanisms related to catchment management. They are also responsible for waterway and floodplain management, the coordination and management of rural drainage, and aspects of Crown frontage management. The CALP Board arrangements remain in place in the tenth region (Port Phillip), pending a special review of this region.

The complementary trends for stronger environmental and catchment-wide priorities in water management are also reflected at a larger scale in the transformation of the River Murray Commission into the Murray-Darling Basin Commission (MDBC) in 1988. The MDBC is an inter-governmental body equally responsible to the Commonwealth and the states of Victoria, South Australia, New South Wales and Queensland. The Commission coordinates and advises on the management of water and relevant land in the best interests of the basin as a whole. Its principal influences are in funding distribution, water allocation, research coordination and in developing policies and strategies which may be implemented by specific inter-government agreements.

## CATCHMENTS

Land use within catchments is a significant determinant of the quality and quantity of storage waters, a fact illustrated most dramatically by Laanecoorie Reservoir on the Loddon River which, since construction in 1884, has lost 12 000 ML of its original 20 000 ML storage capacity as a result of siltation. There are many such instances where inappropriate past activities — for example, some mining, agriculture, forestry, and recreational activities — in sensitive areas have adversely affected water quality and yields to the detriment of aquatic ecosystems and human users, according to the Department of Water Resources Victoria (DWR 1989a).



*Irrigation channel, south of Tatura.*

Water supply catchments in the Box-Ironbark study area incorporate both private and public land, the latter including land owned by water authorities. Some protection of storage water against inappropriate land use is provided by catchment measures under the *Catchment and Land Protection Act 1992*. The Act requires that water values be considered in planning and management decisions. The Catchment Management Authorities' regional catchment strategies (see Chapter 1) include procedures for achieving land and water resource quality objectives. The Act also provides two stages in the application of catchment controls:

1. **Declaration** of a special water supply catchment area emphasises the importance of an area as a source of water, and helps to ensure this is recognised when planning and management decisions are made. It is an essential precursor to the second stage. Catchments previously proclaimed under the *Soil Conservation and Land Utilisation Act 1958* are deemed to be declared special areas.

2. A **Special Area Plan** involves an investigation of the catchment to evaluate existing and potential land deterioration problems, including land uses and management practices which may conflict with water supply interests. The focus is particularly on the potential for soil erosion. Special Area Plans are recognised in various local government planning schemes. The previous equivalent was a Land Use Determination under the *Soil Conservation and Land Utilisation Act 1958*. Pre-existing determinations remain in force.

Occasionally, a **Land Use Notice** was used as an interim measure, after Proclamation but before a Land Use Determination, to require public authorities and landholders to consult with the Department of Natural Resources and Environment before making land use changes.

Not all water supply catchments in the study area are subject to controls; Table 45 lists the 16 that are declared. The land use determinations for the environs of Lake Eppalock and Cairn Curran, and Malakoff Creek, relate to limited areas within declared catchments.

## WATER STORAGE AND DELIVERY

The broad pattern of water production and use on the inland side of the Divide in south-eastern Australia is:

1. harvesting and storage mostly in the mountains to the south-east,
2. distribution, using natural waterways and artificial channels and pipes from the storages to users, and
3. use in areas where local rainfall is insufficient to provide for desired uses, mostly on the fertile plains and river valleys to the north-west.

Although there are many, generally small, pumps scattered throughout this system, for example pumps to supply water towers in many towns, the overwhelming majority of water transport in the system is by gravity, utilising the general slope from south-east to north-west.

Geographically, the Box-Ironbark study area straddles this system. Thus, although there are significant storages within the study area, most of the water delivered there is harvested and stored in the mountains south-east of the study area. While most of the water is used internally, a considerable amount passes through the study area

and is used to the north and west, in the extensive Wimmera-Mallee stock and domestic system, irrigation and other rural areas in southern New South Wales, and along the Murray Valley downstream of the study area.

Consequently, it is appropriate to include large upstream storages in Table 46, the list of major storages providing water to the Box-Ironbark study area. In terms of volume, three storages — Dartmouth, Eildon, and Hume — dominate the production of water delivered to the study area, and indeed, they dominate water production in the State: the capacity of the fourth largest storage in Victoria (Thomson Reservoir) is little more than one third of the capacity of Lake Hume, the third largest. Of the 39 storages listed in Table 46, only these three, Cairn Curran and Rocky Valley reservoirs are used for hydro-electricity generation.

Table 46 also includes Moora Moora and Rocklands reservoirs in the Grampians. Although these storages are in the catchment of the Glenelg River, which flows directly to the sea, water from them and upper Wannon River tributaries is diverted across the Divide and into the Wimmera catchment, mostly to supply the Wimmera-Mallee stock and domestic supply system. Water is also diverted into the Upper Murray River from the Snowy River via the Snowy Mountains Scheme. The Snowy catchment storages are not included in Table 46.

Comparatively small amounts of water are diverted north to south across the Divide: from Wallaby and Silver Creeks (Goulburn tributaries) near Kinglake into Toorourong Reservoir to supply Melbourne; from the Upper Wimmera River to supply Beaufort; and from Lake Fyans and Mt Cole Creek to supply Ararat.

As noted in Chapter 3 and outlined by Keating (1992), the development of water storages in Victoria is closely related to drought. As indicated in Table 46, an important function of many storages is to 'carry-over' water, that is, to hold large volumes from one season or year to the next in order to provide water to consumers in the event of an extended dry period. Security of supply is a major influence on the unit cost of water production and hence the cost to consumers, including industry, and on the amount of water that is available to consumers at a particular time. The Goulburn-Murray Irrigation District is operated to achieve 100 per cent supply of 'water right' in 97 years out of each 100.

Table 45: Status of water supply catchments in the Box-Ironbark investigation area

Catchment	Status <sup>1</sup>	Year of gazettal	Area <sup>2</sup> (sq.km)	Objective of protection <sup>3</sup>
<b>Within Box-Ironbark Study Area</b>				
Fifteen Mile Creek (Glenrowan)	D	1984	310	I, T, S, D
Diddah Diddah Creek (Springhurst)	D	1984	11	T
Ovens River (Wangaratta)	D	1988	3070	T
Barambogic Creek (Chiltern)	D	1990	11	T
Eppalock Reservoir	D	1960	2116	I,T
Eppalock (lake environs)	LUD	1985	258	I
Cairn Curran Reservoir	D	1962	1594	I
Cairn Curran (lake environs)	LUN	1972	55	I, T
Tullaroop Reservoir	D	1980	722	T
Laanecoorie Reservoir	D	1985	1830	I, T
Crusoe Group reservoirs (Bendigo)	D	1989	16	T
Spring Gully Reservoir (Bendigo)	D	1989	3	T
Avoca	LUD	1975	10	T
Bealiba	D	1981	6	T
Teddington Reservoir (Stuart Mill)	D	1989	27	T
Redbank Creek (Redbank)	D	1990	3	T
Forest Creek (Amphitheatre)	D	1990	3	T
Wimmera systems	D	1959	4386	S, D
Malakoff Creek (Landsborough)	LUD	1985	29	T
Picnic Road (Ararat)	D	1988	1	T
<b>Within Box-Ironbark Investigation Area</b>				
Lake Nillahcootie	D	1967	413	I, S, D
Ryans Creek	LUD	1974	78	T, In
Honeysuckle Creek (Violet Town)	D	1976	25	T
Upper Goulburn	D	1957	3807	I,T
Lake Eildon environs	LUD	1977	868	I
Seven and Mountain Hut creeks (Euroa)	D	1984	191	T
Mollison Creek (Pyalong)	D	1986	166	T
Nine Mile Creek (Longwood)	D	1990	4	T
Newham Parish (Eppalock catchment)	LUD	1962	14	T
Kyneton (Eppalock catchment)	LUD	1966	12	T
Creswick	D	1979	33	T
McCallum Creek	D	1982	188	T
Langi Ghiran Reservoir (Ararat)	D	1988	1	T
Fiery Creek tributaries (Beaufort)	D	1988	8	T
Musical Gully and Troy reservoirs (Beaufort)	D	1988	1	T
Trawalla Creek (Beaufort)	D	1963	108	S, D
Learmonth borefield (Learmonth)	D	1991	59	T
Rocklands Reservoir	D	1958	1342	I
Rocklands Reservoir environs	LUD	1959	160	I
Mason Creek (Willaura)	D	1989	16	T
Little Tea Tree Creek tributaries (Hamilton)	D	1989	4	T
Serra Range tributaries (Dunkeld)	D	1991	48	T
Wannon River tributaries (Lake Bellfield)	D	1989	2	T

**Notes:**

1. Status — D = Declared Special Area; LUN = Land Use Notice; LUD = Land Use Determination, equivalent to a Special Area Plan.
2. Area shown is total catchment area — not all is in the study area or investigation area.
3. Objective — I = Irrigation; T = Town Water; S = Stock; D = Domestic; In = Industrial.

## Box-ironbark vegetation associated with water production

Unlike catchments in mountainous parts of Victoria, large parts of the catchments in the Box-Ironbark area have been cleared of indigenous vegetation. In addition, because of the topographic position of most water storages, riverine forests typically dominate any indigenous vegetation which fringes the storage, for example at Goulburn Weir. Consequently, relatively few storages abut areas of box-ironbark vegetation; notable exceptions are Lake Eppalock and Lake Lonsdale, and numerous small storages associated with particular towns, such as Spring Gully Reservoir, on the southern edge of suburban Bendigo, and Barambogie Reservoir near Chiltern. Most of these are too small to be listed in Table 46. Several of the smaller storages are completely surrounded by box-ironbark vegetation.

## WATER USE

Most water production in the study area provides for three main uses:

1. **Irrigation** — mostly for dairy and beef cattle, orchards, vineyards, and horticultural crops. Irrigation in the study area is dominated by the Goulburn-Murray Irrigation District which covers the two large irrigation areas in the lower Goulburn and Campaspe valleys.
2. **Town Supply** — water to towns for domestic, industrial, and civic purposes.
3. **Stock and Domestic** — usually channel-delivered water to non-urban rural consumers (typically on farms not immediately adjacent to towns) for domestic and stock watering purposes.

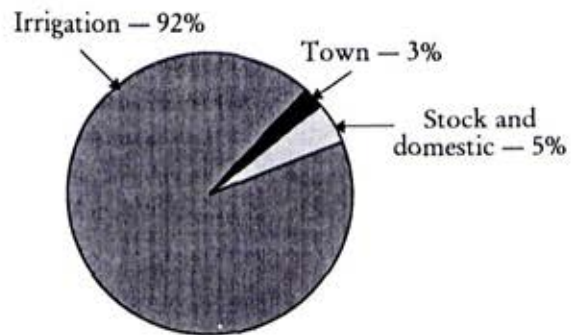
**Environmental Flows** — water flowing along waterways to maintain or restore natural in-stream and floodplain processes, including flooding of wetlands — is a fourth use of water in the study area.

Table 47 and Figure 10 show the dominance, in volumetric terms, of irrigation as a water use in the six river basins that cover most of the study area.

In some river basins, water use greatly exceeds stream-flow. In the Broken River basin for example, total water use in 1983/84 was 801 524 ML (Table 47), but average annual streamflow is only 325 000 ML (see Table 6 in Chapter 5). The difference, plus some extra to allow for

environmental flows, is made up by groundwater from within the basin and surface water imports from other sources. In the case of the Broken River basin, the latter dominates, supplying about 740 000 ML, compared to about 62 000 ML derived about equally from surface and groundwater sources within the basin (DWR 1989a).

Figure 10: Water use by volume (ML) in the Box-Ironbark study area



## GROUNDWATER

Groundwater use in the five main river basins in the study area is summarised in Table 48. This table lists the estimated total groundwater resource in each basin, as well as the divertible resource and the amount of the resource that is used. The divertible resource is the average annual volume of groundwater that could be removed on a sustainable basis, as opposed to the 'minor' sources, which are miscellaneous sources generally too small for major water supply development. Generally, the use of minor sources would not significantly diminish the volume of the divertible resource in a basin. Minor sources largely consist of isolated bores and wells in fractured aquifers. When the use of groundwater is greater than the divertible resource such as in the Ovens basin — see Table 48, the difference is made up by *minor sources*.

In total, groundwater comprises slightly more than 2 per cent of the total volume of water used in these basins, but there is considerable variation between basins in the relative contribution of groundwater to total water use (Table 48). Poor water quality, particularly high levels of salinity, is the major limitation to the utilisation of groundwater in many parts of the study area — the designation of a resource as divertible or minor makes no allowance for quality. Chapter 5 provides further information on the quality of groundwater in the study area.

**Table 46: Major water storages providing water to the Box-Ironbark investigation area**

River Basin	Storage	Capacity (ML)	Year of completion <sup>1</sup>	Primary purposes <sup>2</sup>	Watercourse <sup>3</sup>	Agency
<b>Within Box-Ironbark study area</b>						
Broken	Lake Mokoan	365 000	1971	I, O	ORS	Goulburn
Goulburn	Goulburn Weir	25 530	1890	I	Goulburn R	Murray Water
	Waranga Basin	411 000	1905 (1926)	I	ORS	
Campaspe	Malmsbury Reservoir*	17 800	1870 (1940)	T, I, O	Coliban R	Coliban Water
	Lake Eppalock*	312 000	1962	I, O	Campaspe R	Goulburn
	Campaspe Weir	2 700	1882	I	Campaspe R	Murray Water
Loddon	Cairn Curran Reservoir	148 000	1956	I, E, O	Loddon R	Goulburn
	Laanecoorie Reservoir	8 000	1891	I, O	Loddon R	Murray Water
	McCay Reservoir	1 400	1960	T	ORS	Coliban Water
	Barkers Ck Reservoir	2 700	1870	T, I	ORS	
	Crusoe Reservoir*	1 500	1871	T, I	ORS	
	Spring Gully Reservoir*	2 500	1869	T, I	ORS	
Wimmera-Avon	Lake Lonsdale*	65 500	1903	I, SD	Mt William Ck	Wimmera Mallee Water
<b>Within Box-Ironbark investigation area</b>						
Broken	Lake Nillahcootie	40 000	1968	I, O	Broken R	Goulburn
Ovens	Lake Mulwala	117 500	1939	T, I	Murray R	
Goulburn	Lake Eildon	3 390 000	1927 (1955)	I, E, O	Goulburn R	Murray Water
	Greens Lake	32 500	1968	I	ORS	
Campaspe	Upper Coliban Reservoir	37 500	1903 (1993)	T, I, O	Coliban R	Coliban Water
	Lauriston Reservoir	19 800	1941	T, I, O	Coliban R	
Loddon	Newlyn Reservoir	3 300	1871 (1961)	I, SD, O		Goulburn
	Hepburns Lagoon	3 000	1870 (1960)	I, SD		
	Tullaroop Reservoir	74 000	1959	I, O	Tullaroop Ck	
	Kow Swamp	51 000	1890 (1969)	I	Mt Hope Ck	
	Torumbarry Weir	35 600	1923 (1996)	I	Murray R	
Wimmera-Avon	Lake Bellfield	78 500	1966	I, SD, O	Fyans Ck	Wimmera Mallee Water
	Lake Fyans	21 000	1916	I, SD	ORS	
	Lake Wartook	29 500	1887	I, SD	McKenzie R	
	Pine Lake	64 000	1923	I, SD	ORS	
	Dock Lake	5 900	1935	I, SD	ORS	
	Green Lake	5 600	1935	I, SD	ORS	
	Taylors Lake	36 000	1923	I, SD	ORS	
	Lake Batyo Catyo	4 800	1916	SD	ORS	
Glenelg	Moora Moora Reservoir	6 300	1934	I, SD	Moora Moora Ck	
	Rocklands Reservoir	348 000	1954	I, SD, O	Glenelg R	
<b>Upstream of Box-Ironbark investigation area</b>						
Upper Murray	Lake Hume	3 038 000	1936 (1960)	T, I, E, O	Murray R	Murray Darling Basin Commission
	Lake Dartmouth	4 000 000	1980	I, E, O	Mitta Mitta R	
Kiewa	Rocky Valley Reservoir	28 000	1959	E	Rocky Valley Ck	Southern Hydro
Ovens	Lake Buffalo	24 000	1965	I	Buffalo R	Goulburn
	Lake William Hovell	13 500	1971	I	King R	Murray Water

**Notes:**

1. Brackets indicate the year in which the most recent enlargement was completed (refurbishment in the case of the Torumbarry Weir).
2. I = Irrigation, E = Electricity production, O = Over-year storage, SD = stock and domestic supply, T = Town supply.
3. ORS = Off River Storage
4. \* storages with substantial areas of box-ironbark vegetation in their immediate environs

## WATER QUALITY

All uses of water, including environmental 'uses', are dependent upon water of sufficient quality. In general, the quality requirements of the main uses decrease in the following order:

- domestic use (particularly drinking) and some industrial uses
- irrigation

- most industrial uses
- drinking water for stock (cattle are generally less tolerant of poor water quality than sheep).

Environmental 'uses' cannot be readily included in this list because some ecological processes, for example growth of many water plants, require water of the highest quality, while others such as reproduction of some bird species can persist in poor quality water.

**Table 47: Water use by volume (ML) in the six main river basins affecting the Box-Ironbark study area**

Catchment basins	Irrigation	Town <sup>1</sup>	Stock and domestic <sup>1</sup>	Total
Ovens	16 460	9 670	3 450	29 580
Broken	741 804	28 560	31 160	801 524
Goulburn	739 020	14 920	26 760	780 700
Campaspe	238 730	5 480	14 020	258 230
Loddon	1 275 200	28 610	32 960	1 336 770
Avoca	22 170	2 490	41 970	66 630
<b>Total:</b>	<b>3 033 384</b>	<b>89 730</b>	<b>150 320</b>	<b>3 273 434</b>
<b>Percentage of Total:</b>	<b>92%</b>	<b>3%</b>	<b>5%</b>	<b>100%</b>

**Notes:**

1. For consistency, the terms 'Town' and 'Stock and Domestic' have been used here to replace 'Urban and Industrial' and 'Rural' (respectively) used by Department of Water Resources Victoria (DWR 1989a).
2. Data from the 12 months 1983/84; surface and groundwater use combined.

Source: DWR (1989a)

**Table 48: Groundwater in the six main river basins in the Box-Ironbark study area**

Catchment basin	Total resource	Divertible	Use	No. of bores	Notes
Ovens	9 400	5 800	6 800	3 143	<ul style="list-style-type: none"> <li>• source of all stock and domestic water (3450 ML)</li> <li>• represents relatively high proportion (23 per cent) of total use</li> </ul>
Broken	27 000	22 500	22 500	10 649	<ul style="list-style-type: none"> <li>• mostly used for irrigation</li> </ul>
Goulburn	53 800	41 100	10 000	12 625	<ul style="list-style-type: none"> <li>• small component (1 per cent) of total water use in the basin</li> <li>• poor quality of water in aquifers below more fertile plains country is major limitation on use</li> </ul>
Campaspe	17 700	15 600	11 770	7 010	<ul style="list-style-type: none"> <li>• mostly used for irrigation</li> </ul>
Loddon	32 900	28 000	13 000	6 745	<ul style="list-style-type: none"> <li>• small component (1 per cent) of total water use in the basin</li> <li>• almost all used for irrigation</li> <li>• poor quality of water in aquifers below more fertile plains country is major limitation on use</li> </ul>
Avoca	4 900	4 100	670	1 828	<ul style="list-style-type: none"> <li>• small component (1 per cent) of total water use in the basin</li> <li>• mostly used for town supply</li> <li>• poor quality of water in aquifers below more fertile plains country is major limitation on use</li> </ul>
<b>Total:</b>	<b>145 700</b>	<b>117 100</b>	<b>73 240</b>	<b>42 000</b>	<ul style="list-style-type: none"> <li>• represents about 2 per cent of total water use in the five basins</li> </ul>

Source: DWR (1989a); data are annual averages.



*Inlet channel, Waranga Reservoir.*

The State Environment Protection Policy, 'Waters of Victoria', specifies the 'beneficial uses' of surface waters which require protection. The policy also specifies a number of water quality indicators, with accompanying objectives to be met such as concentration levels for various segments of the environment, for example parks and forests. The Environment Protection Authority's indicators include dissolved oxygen, bacteria (*E. coli*), temperature, toxicants, nutrients and biostimulants, total dissolved solids, suspended solids and settleable matter. The policy applies to private individuals and government agencies conducting activities on both public and private land.

Water quality is often considered in terms of two components: microbiological quality and physio-chemical quality. Microbiological quality is concerned with the prevalence of pathogenic (disease-causing) organisms in water. This quality is most critical when water is for consumption by animals, particularly humans. Common parameters for assessing physio-chemical quality are pH, salinity, suspended sediment, turbidity, and colour. Largely because of the input of often saline groundwater into water

supplies in northern Victoria, salinity is a particularly prominent element of physio-chemical quality in the Box-Ironbark study area.

Typically, there are two points in the water production process that are particularly important in terms of water quality: runoff in catchments; and treatment between storage and supply to consumers. The influence of catchment management on water quality is discussed above. Treatment of water is economically viable prior to delivery in reticulated systems, that is, town supplies. Information on the quality of drinking water in the study area is provided in Chapter 5.

## SEWERAGE

Waste water and sewage treatment facilities vary in scale and location depending on the level of treatment. The larger urban centres have sophisticated facilities providing treatment to the tertiary level. Smaller centres normally have secondary level treatment.

The majority of the waste water systems in the study area have evaporation lagoons with irrigated areas. This form of treatment system normally requires large areas to incorporate the holding basins, irrigation areas and EPA-recommended buffer distances. EPA licenses premises where the plant is designed to treat more than 5000 litres of sewage per day. This requirement also applies to private plants associated with industry.

Each authority has developed a long term program for up-grading some older treatment systems, and at unsewered townships to provide new sewerage systems. Several smaller towns with only septic tanks are experiencing pollution and contamination of groundwater.

# 19. UTILITIES AND OTHER LAND USES

## Introduction

The provision of public utilities throughout Victoria, including electricity, gas, water, sewerage, railways and roads, was formerly the sole domain of State government, government-controlled instrumentalities and local government. Until recently organisations such as the State Electricity Commission, Rural Water Corporation and V-Line were the sole providers of public utility services and facilities.

In recent years the State Government has undertaken an extensive program to restructure local government, and the electricity, gas and water industries. An object has been to emphasise the role of government as a buyer of services and reduce their direct provision by government agencies. The amalgamation of local water and sewerage boards into regional authorities has been completed, while a number of former public utility organisations have now been either corporatised or privatised. As a result, private industry now has responsibility for the delivery and maintenance of some traditional services.

At the Commonwealth level, the telecommunications industry has undergone a similar restructuring process. With the advent of mobile communications and deregulation, numerous telecommunication towers have been established throughout the study area to service the mobile network. The construction of towers is expected to continue as the field of the mobile network increases coverage.

The rationalisation of functions and landholdings, as a result of restructuring government organisations has led to the sale of some properties which were publicly owned. Some lands formerly held by public authorities, that were previously 'public land', are now held by companies.

## Local government

During 1994 local government underwent comprehensive restructuring and amalgamation. Within the Box-Ironbark investigation area, the number of local councils was reduced to 27 from over 70. Greater Bendigo, for example, contains the former municipalities of Bendigo,

Eaglehawk, Huntly, Strathfieldsaye, and parts of Marong, McIvor and Metcalfe. Many more townships are within each of the new municipalities, and some former council centres are now outposts.

Major municipalities within the study area are the City of Greater Bendigo (population 85 180), City of Greater Shepparton (54 730), Rural City of Wangaratta (25 100) and Rural City of Wodonga (31 180).

The operation of local government has substantially changed, with numerous functions subject to compulsory competitive tendering. Some functions of councils have been corporatised and subjected to the tendering process, and allocated to outside tenderers. Sewage treatment works, airfields and solid waste disposal sites are in some cases now operated by another provider or by private industry under contract.

## Planning schemes

Local government has responsibility for land-use planning and the development of planning schemes within their municipality. Until recently, some local planning schemes contained provisions that were inconsistent owing to the amalgamation of several old schemes.

*The Minister for Planning and Local Government*, aiming to achieve State-wide consistency and a more flexible planning system, introduced the Victoria Planning Provisions (VPP) in December 1996. This document contains the State Planning Policy Framework, standard State-wide zones and overlays, and standard provisions required for planning schemes.

In rural areas three zones — rural, environmental rural and rural living — are applied to private land, together with a series of overlays catering for such issues as vegetation, salinity management and erosion control. Public land is included under appropriate public use zones.

New planning schemes have been prepared in the VPP format and placed on exhibition. The new schemes are aimed at a strategic rather than detailed local level. Zoning is to reflect links to the Catchment Management Authorities' regional catchment strategies.

## Planning and mining

It is anticipated that the current high level of mineral exploration activity will result in some mining projects. Mining and exploration can no longer be prohibited in a planning scheme under the VPP. If a company wishes to proceed with a mine it has two options: to prepare an Environment Effects Statement, or to obtain a planning permit from the local municipality. Once approval has been obtained, the proponent seeks work plan approval from the Department of Natural Resources and Environment (NRE). An Environment Protection Authority (EPA) works approval may also be required. The main projects which have either received approval in recent years or are currently seeking approval are at Bendigo, Tarnagulla, Fosterville (extension), Costerfield and Ballarat.

## Waste disposal

Solid waste disposal sites catering for a population of 5000 or more are licensed by the EPA. Smaller operations require EPA works approval. Major disposal sites in the study area are located in the vicinity of large urban centres and most have recovery stations for waste recycling. With amalgamation of councils and privatisation of some waste disposal sites, some smaller, less appropriate sites have closed.

As the populations of urban centres increase, pressure to find environmentally suitable sites for waste disposal will become a major issue. The Commonwealth Government's policy on waste minimisation and more stringent environmental controls applied by the EPA will result in further rationalisation of solid waste sites.

## Water supply and sewerage authorities

The supply of water for urban domestic use, industry and agriculture is extremely important not only to the regional economy but also to Victoria and Australia. Water supply authorities are also responsible for the provision and maintenance of the sewerage network and sewage treatment facilities. Information on water production and sewerage is included in Chapter 18.

## Electricity supply authorities

The Victorian electricity industry restructure came into force in October 1994. The former supply areas of the State

Electricity Commission and municipal electricity supply areas have been restructured into five separate private distribution businesses. Within the Box-Ironbark investigation area there are two of these — Powercor, responsible for the western half of Victoria, and Eastern Energy, responsible for the east. Low and medium voltage lines, now owned by the individual power companies, are commonly located within existing road reserves, however some follow easements on private and public land.

Most electricity supplied to the study area is produced by coal-fired generating stations in Gippsland. A small amount of hydro-electric power generated during irrigation releases from Lake Cairn Curran supplements the State supply.

The main transmission supply lines are owned by Powernet, the State's electricity network. The transmission lines are mainly located adjacent to road reserves within defined easements. A major transmission line from Gippsland extends to Ballarat, from where lines continue via Horsham to Mildura and Bendigo to Mildura. Another major 500 kV line links Bendigo to Benalla and Dederang near Wodonga. Throughout the system numerous 330 kV, 220 kV and 66 kV lines distribute electricity to the domestic supply network. Major terminal stations are located at Ballarat, Horsham, Bendigo, Shepparton, Glenrowan, Kerang, and Dederang.



*Powerlines through forest, Chiltern Box-Ironbark National Park.*

In 1996, the Office of the Chief Electrical Inspector introduced the *Code of Practice for Powerline Clearance (Vegetation) 1996*. This code was developed from evidence gathered after the Ash Wednesday fires in 1983, and applies

to powerlines of 66 kV or less. The code specifies requirements relating to the clearance distances for vegetation from powerlines. While the code recognises the importance of preserving vegetation that is ecologically significant, its application could affect roadside vegetation under powerlines.

## Gas transmission

The Gas and Fuel Corporation, previously responsible for the distribution of natural gas throughout Victoria, was restructured in 1994 into gas transmission, and gas distribution and retail functions. The Gas Transmission Company owns and maintains the high pressure gas transmission pipelines. A proposed Gas Transmission System Operator is to be responsible for balancing the transmission system between distributors and large customers, and operating a gas market.

Two main pipeline routes cross the study area — Melbourne to Bendigo via Ballarat, and Melbourne to Albury via Seymour, Benalla and Wangaratta. Branch lines extend to Shepparton and Echuca, and Bendigo to Seymour. There are plans to extend this network with a major pipeline from Maryborough to Horsham, serving Ararat, Stawell and potentially the Wimmera Mineral Sands project.

Victorian gas distribution is now carried out by three businesses, of which Westar supplies the western part of the study area, and Stratus the east. Three new retailers provide gas to industries and consumers, with Kinetik Energy supplying areas west of Bendigo, and Energy 21 areas to the east.

The Government plans to privatise the Gas Transmission Company, gas distributors and retailers in 1998.

## Road network

The road network was initially established by early pioneers, Crown Lands officers and surveyors, and has been continually upgraded since that time.

The principal authority for major roads in the study area is VicRoads, a statutory corporation within the Department of Infrastructure. Public roads that do not fall under the domain of VicRoads are the responsibility of either local government or, in large public land blocks, NRE. Road reserves vary in width from about 20 m to

200 m depending on the classification of the road, highway or freeway.

VicRoads has four regions affecting the study area — South-Western Region based in Geelong, Western Region based in Ballarat, Northern Region based in Bendigo and North-Eastern Region based in Benalla.

Several major national transport routes radiating from Melbourne pass through the study area: the Hume Freeway; Calder Highway; Western Highway; Northern Highway; and Murray Valley Highway. A number of highways important for State transport also cross the study area.

VicRoads has a program to up-grade a number of these roads with the Calder Highway having highest priority. Where significant road proposals are contemplated, VicRoads has been required to prepare Environment Effects Statements to enable assessment of the issues and alternatives to be discussed in an open forum. The Albury-Wodonga By-pass project has been subject to an EES process. Smaller projects are normally subject to planning scheme amendments or planning permit applications.

In many parts of the study area, roadside conservation is extremely important as, on the northern plains in particular, road reserves may contain the only remnant indigenous vegetation in the locality. These roadsides provide some habitat and corridors for wildlife continuity, contributing to biodiversity maintenance. The Roadside Conservation Advisory Committee and various local committees have been established to assess the flora and fauna values and develop appropriate conservation strategies for roadside management.

## Rail network

The Public Transport Corporation is responsible for the rail network radiating from Melbourne. Previously an extensive web of steel lines supported on river red gum and box-ironbark sleepers traversed Victoria. Numerous lines remain, but most are used primarily for rail freight. Passenger lines extend from Melbourne through the study area to Echuca and Swan Hill via Bendigo, and Albury-Wodonga and Shepparton via Seymour. Table 49 lists the status of the rail network. Rail lines and associated facilities are commonly located in public land reserves similar to the road network. In places they retain

Table 49: Railway types and lines in the study area

	Railway types and lines	Length (km)
V/Line rail freight broad gauge lines	Ararat to Castlemaine via Maryborough	141.5
	Talbot to St Arnaud (Ballarat-Mildura line)	82.0
	Dunolly to Inglewood	41.0
	Korong Vale to Charlton (Kulwin line)	36.0
	Bendigo to Mysia (Robinvale line)	96.0
	Taradale to Pyramid Hill via Bendigo (Melbourne-Swan Hill/Piangil line)	140.5
	Bendigo to Echuca (Deniliquin/Moulamein lines)	87.5
	Toolamba to Echuca	67.0
	Mangalore to Tocumwal (NSW)	142.0
	Strathmerton to Cobram	15.0
	Shepparton to Dookie	27.5
	Tallarook to Barnawartha (Melbourne-Sydney line)	190.0
Benalla to Yarrawonga	59.0	
V/Line passenger broad gauge lines	Taradale to Pyramid Hill via Bendigo (Melbourne-Swan Hill/Piangil line)	140.5
	Bendigo to Echuca	87.5
	Tallarook to Barnawartha (Melbourne-Sydney line)	190.0
Private passenger broad gauge line	Tallarook to Shepparton (Melbourne-Shepparton line)	91.5
National rail freight standard gauge lines	Langi Logan to Glenorchy (Geelong-Horsham)	59.0
	Tallarook to Barnawartha (Melbourne-Sydney)	190.0
Rail Trails and proposals (all dismantled)	Bendigo to Axedale (Bendigo-Heathcote Junction line)	21.0
	Murchison-Rushworth-Girgarre	40.0
	Numurkah to Picola	33.5
	Dookie to Katamatite	27.5
	Bowser to Everton (Bowser-Bright line)	19.5
	Everton to Beechworth	16.5
Closed lines	Stawell to Fyans Creek (dismantled Grampians line)	17.5
	Joel to Navarre (dismantled Ben Nevis line)	20.0
	Wedderburn to Wedderburn Junction line (dismantled)	8.0
	Castlemaine to Maldon (tourist railway)	17.5
	Maldon to Shelbourne (dismantled)	16.5
	East Metcalfe to Redesdale (dismantled Redesdale junction line)	15.0
	Tooborac to Axedale (dismantled Bendigo-Heathcote Junction line)	42.5
	Elmore to Kotta (dismantled Cohuna line)	38.0
	Rushworth to Colbinabbin (dismantled)	20.5
	Benalla to Lima (dismantled Tatong line)	22.5
	Wangaratta to Docker (dismantled Whitfield line)	19.5
	Bowser to Peechelba (dismantled)	20.5
	Springhurst to Wahgunyah (disconnected)	7.5

important remnants of understorey vegetation, or structures of cultural heritage interest. In recent years there has been a rationalisation of the network and several lines have either been closed or downgraded from passenger to freight only. NRE is examining the disused rail lines to determine whether they should remain in public ownership as 'rail trails', or to protect other public land values. Where the lines have been closed for considerable periods, regrowth of some plants has

occurred, contributing to fauna habitat and remnant vegetation.

## Airfields

Public airfields in the study area are owned and operated by local government. Each major urban centre in the study area has an uncontrolled airfield catering for local light aircraft traffic, the largest being Drage's Aerodrome at Wangaratta and Mangalore airfield near Seymour.



*Telecommunications facility at Mt Alexander.*

Numerous private strips are located on farm properties throughout the study area.

### Telecommunication network

Site selection criteria for telecommunication towers require them to be located on prominent hills to enable maximum coverage, with road access and the capability for electricity supply. This has resulted in some instances in vegetation clearance to enable tower construction.

### Armed forces use

Defence uses public land other than Commonwealth-managed property for a wide variety of training for Regular and Reserve Army, cadet, RAAF and RAN personnel. The following types of activities are conducted in State forests and some parks in the study area:

- abseiling
- adventure training

- bivouacs
- communications training
- deployment
- driver and motorcycle training
- hiking
- infantry minor tactics
- mountain biking
- navigation exercises
- officer and leadership training, and
- water-based training

Access to these areas is subject to the same controls as general public access. Approval from the relevant managing authority is sought before the activity proceeds. None of the activities on public land involves the use of live ammunition. There were 85 activities in the period February to October 1996, ranging from as few as nine soldiers up to 1100 school cadets. Most activities include a base camp and a small number of vehicles, generally three to five 4-wheel drives and two or three light trucks.

### Other land uses

Within urban centres, the Government provides school, hospital and police services. Cemeteries, generally on public land, are often of heritage significance, and may contain remnant vegetation. Trigonometric stations and navigational beacons, normally located on prominent high ground, require small areas of public land. Radio station and television antennae are located on elevated sites near Bendigo, Castlemaine, Ararat, Maryborough, Ballarat, Horsham, Seymour and Shepparton.



*Armoured personnel carriers, Puckapunyal Military Area.*

## 20. LAND USE HAZARDS

### LAND AND SOIL DEGRADATION

To understand likely land degradation hazards it is first necessary to characterise the land. The main soil groups in the Box-Ironbark study area are introduced in Chapter 4, and Chapter 6 outlines the approach to inventory and *understanding the landscape using geomorphic units and land systems*.

Land in the **dissected East and West Central uplands**, which constitute much of the inland foothills, has relatively high soil degradation hazard because of soil types and land slope. Some past land-use practices have resulted in this hazard manifesting as sheet, rill and gully erosion, soil structure decline and acidification. There is a risk of soil mass movement in limited areas. Localised saline discharge and elevated stream salinity levels are relatively common. Areas of high groundwater recharge are considered to be major contributors to salinity problems in the adjacent riverine plains.

The **Murray Basin plains–riverine plains** unit, effectively the northern plains, includes most of the irrigated lands. Soils are susceptible to salinity, acidification and soil structure decline, and on isolated low hills, sheet erosion and gullyng.

#### Hazards associated with soil types

Some soils have either inherent characteristics that render them prone to land degradation, or physical and chemical limitations to plant growth that reduce their ability to maintain a protective cover of vegetation.

The *bleached duplex soils* have hard-setting, poorly structured slaking topsoils, and strongly sodic dispersible B horizons. For plant growth, physical limitations include low water-holding capacities, alternate waterlogging and cementing of the A2 horizon, and low permeability and penetrability of B horizons. Surface soils are acidic, exchange capacities and nitrogen, phosphate and calcium levels are low, hence natural fertility is poor.

These are the 'tin roof' soils; after clearing and compaction, much storm rainfall runs off without infiltrating far into the soil profile. In drainage lines, once the surface is

scoured, dispersible subsoils result in gully erosion being a serious problem. Seepage salting is also common on these soils.

The *red duplex soils* have poorly structured hard-setting topsoils, and sodic B horizons with a tendency to disperse, restricting available water storage to moderate levels. On freehold land red duplex soils are extensively used for wheat cropping. However, under cultivation they are prone to gully and sheet erosion on slopes of 1 to 5 per cent. Nearly two-thirds of the soil loss by water with extensive cropping in Victoria is from red-brown earths, the predominant red duplex soil, according to Gibbons and Rowan (1993).

*Shallow soils* usually occur on weathering parent rock where soil loss through natural erosion nearly equals the rate of soil formation. Under conditions of accelerated erosion there is not much depth of soil to lose. On steeper ridges parent Palaeozoic rock is often fractured, and this can allow groundwater recharge. The shallowness and stoniness of these soils mean the volume available for plant roots and moisture is restricted, causing low or very low average water storage. Shallow soils in the study area often have heathy understoreys, indicating low natural fertility.

Both the massive earths and gravelly duplex *poor loams and earths* have chemical limitations — low available nutrient level, resulting from either sandy and acidic or highly leached and gravelly parent material — and physical limitations — low available water storage — to plant growth. The massive earths erode when disturbed, particularly under cultivation.

*Salty soils* are the result of a land degradation process.

#### Land degradation

Soil is formed from parent materials at a very slow rate, of the order of 0.03 mm or about 0.04 tonnes per ha each year. Where soil is lost through erosion at a faster rate, land is degrading. A natural rate of erosion is part of ongoing geomorphic processes. The fact that a soil mantle exists suggests the natural rate of erosion has generally been less than the rate of soil formation. However erosion has frequently been accelerated by land-use practices, or following events such as wildfires. Office of the Commissioner for the Environment (OCE 1991) reported average Victorian

erosion rates of from 0 to 1 t/ha/yr from forested areas in normal conditions, 0.3 t/ha/yr from pasture, 1.5 t/ha/yr from winter crops and 8.1 t/ha/yr from summer crops. Erosion episodes are often intense, over limited areas and for short periods; the actual rate of soil loss from affected areas would be much greater than these average figures.

Table 10 in Chapter 6 lists the major land systems occurring on substantial public land parcels, the land degradation hazards that each land system is subject to under inappropriate management, and the corresponding Box-Ironbark EVCs. The hazards represent inherent characteristics of particular soils, or components of land systems — that is, the occurrence of a soil type in a certain part of the landscape. The indicated hazards are outlined in Appendix XV, except for salting, which is discussed later in this chapter.

## OCCURRENCE OF LAND DEGRADATION

The occurrence of degradation is closely related to land type and land management. Soil erosion has been significant in the foothills and dissected uplands of this area since the 1930s. Large-scale clearing, past gold-mining activities, inflexibility in dealing with climate variability, and inappropriate land management including overgrazing all contributed to the problem. Its rate of increase has markedly reduced since the 1940s and 1950s. Significant current soil erosion problems are associated with land disturbance activities for roads, excessive cultivation, land development, and streambank erosion.

### Land degradation on public land

Public lands across the study area predominantly have a medium inherent susceptibility to water erosion, according to Rowan (1991), with parts of the Pyrenees and St Arnaud Range, and areas around Wedderburn, being highly susceptible. The emphasis changes between land systems, but as expected with sodic soils on sloping land, water erosion is a widespread hazard. Parts of the Pyrenees, south St Arnaud Range and hills around Wodonga are susceptible to mass movement.

Structure decline susceptibility is 'high' on most of the northern plains and public lands around Bendigo, Maryborough and Dunolly, and 'medium' for the remaining public lands. Leaching of nutrients is evident on various



*Erosion gully in farmland moving into public forest.*

soil types, particularly shallow or poor stony soils in the St Arnaud and Fryers Ranges, and parts of the Deep Lead, Lonsdale and Illawarra forests near Stawell.

All of the inland slopes public lands have a 'high' susceptibility to soil acidification. Susceptibility to salting is at a 'medium' level in public lands around Dunolly, Maryborough, Bendigo and Heathcote–Rushworth Forest.

### Land degradation on private land

The study area contains substantial areas with a moderate to high degradation hazard when used for agricultural production, if land management activities are not appropriately matched to the capability of the land. The inland foothills of the Box-Ironbark study area are notable for the frequency and extent of gully erosion, and for the occurrence of tunnel erosion on hillsides with dispersible subsoils. The northern plains contain much cultivated and irrigated land, and expressions of associated structure decline and salinity hazards. Occurrences of observed land degradation on private land are noted in Appendix XV.

## CATCHMENT MANAGEMENT AUTHORITIES

The Catchment Management Authorities have the roles of the former Catchment and Land Protection Boards, river management authorities, salinity implementation groups, water quality groups and sustainable regional development committees. These Authorities aim at linking aspects of catchment management relating to pest plants and sustainable land management while incorporating floodplain management and rural drainage responsibilities.

The Authorities relevant to the Box-Ironbark study area are listed in Chapter 1, and their regions are shown in Map 4.

Final regional catchment strategies, recently released, identify areas of hazard, problems and priorities for each region. Programs and priorities for soil degradation control are listed for each Authority's area in Appendix XVI.

## SALINITY

### Dryland salinity

Secondary dryland salinity is brought about by excessive water mobilising stored salt and causing rises in groundwater levels, such that there is an accumulation of salt in surface soils and an associated rise in salt concentrations in surface waters. The excessive water is considered to come from a reduction in plant water use across the landscape in response to clearing and European-style land management.

The study area includes parts of the following dryland salinity provinces: 'highlands A' (local groundwater systems) and 'highlands B' (regional groundwater system), both on the inland hills; 'highland valleys' along the Loddon and Avoca Rivers; and 'riverine plain' (regional groundwater system) on the northern plains.

Discharge sites — where saline groundwater has come close to the soil surface and from where the water evaporates, leaving salted ground — occur mostly in the lower parts of the landscape, on flats and along drainage lines. There are no discharge points within the larger areas of tree cover. It is estimated that discharge sites are increasing at a rate of approximately 5 per cent per year.

Major discharge sites are at Bourkes Flat, Natte Yallock, Dunluce, Lexton, Eddington, Bears Lagoon, Nuggetty

(near Maldon), Leichhardt, Kamarooka, Ravenswood, sedimentary country south-east of Bendigo, Elphinstone, Knowsley, Mt Camel Range, west of Tooboorac and north of Violet Town. Dryland salting has caused scattered tree deaths on farms and roadsides in many areas, but damage to forested public land is not common.

While varying with seasonal and climatic conditions, surface water quality has reflected the long-term salt increase in local and regional groundwater, with the salinity levels being high in some cases. For example, Rural Water Corporation (RWC 1990) reported mean electrical conductivity ( $\mu\text{S}/\text{cm}$ ) in streams, using monthly data from 1976 to 1988. Tributaries with high salinities and a lower mainstream value over that period include:

- *Goulburn River tributaries* — Cornella Creek 2535, Wanalta Creek 1758, Major Creek 2136, Goulburn River at Seymour 102;
- *Campaspe River tributaries* — Axe Creek 3196, Mt Pleasant Creek 1567, Campaspe River at Eppalock 490;
- *Loddon River tributaries* — Bet Bet Creek 2967, McCallum Creek 1854, Picaninny Creek 1759, Loddon River at Laanecoorie 977.

A desirable limit for human consumption is 830 units, while the limit for apricots, grapes and peas is 1500 units, and for pears, apples and tomatoes is 3000 units.

### Irrigation salinity

In irrigation areas, rising regional groundwater levels resulting from clearing of highland and plains areas, and the large-scale introduction of applied water, bring salt to near the soil surface. In much of the irrigation areas watertables are now within 2 m of the surface, and a considerable proportion of the groundwater is saline. In some of these areas, salt is accumulating in the root zones, leading to the decline and death of vegetation. This threatens the productivity of the irrigated areas, and their local communities.

In 1990, more than 60 per cent of the Campaspe West irrigation area had watertables within 2 m of the soil surface, over 13 per cent was visibly salt-affected and an additional 23 per cent was producing below its potential. Approximately 43 per cent of the Shepparton irrigation area is underlain by a watertable within 2 m of the soil surface, although salt concentrations in subsoils and groundwater are lower here.

West of the Campaspe River, raised watertables, salting and inundation by drainage waters in irrigated areas have severely affected both forested public land and farm trees. Tree deaths have also occurred on roadsides and along watercourses where these form part of the water distribution or drainage networks.

## Salinity management plans

The Salt Action: Joint Action program (1988) set the State-wide framework for evaluation and amelioration of secondary salinity in Victoria. A recommended key action was the preparation of Salinity Management Plans. The study area incorporates parts of the areas subject to the following plans:

- Goulburn Dryland
- Campaspe Dryland
- Loddon Dryland
- Avoca Dryland
- Shepparton Irrigation Region
- Campaspe West Irrigation Area

and small sections of areas covered by plans for Glenelg and the Wimmera River.



*Farmland affected by salinity, Tatura.*

All salinity management plans were developed following intensive scientific and technical input, coupled with community consultation and participation. The plans propose community-led programs to improve productivity and environmental values in catchments and affected areas.

The plans outline activities including:

- treatment of saline discharge areas,
- property management plans,
- surface and sub-surface drainage projects,

- tree planting on high recharge areas and along channels,
- developing perennial pastures including lucerne,
- landforming,
- minimum tillage,
- protection of native vegetation,
- streamside fencing,
- research needs, and
- monitoring needs.

The salinity implementation role is now overseen by the Catchment Management Authorities.

## PEST PLANTS AND ANIMALS

### Background

Pest plants and animals threaten the values of natural ecosystems and reduce the productivity of agricultural land. Their control is recognised as a priority issue throughout the investigation area.

The *Catchment and Land Protection Act 1994* is the principal legislation concerned with the control or eradication of pest plants and animals. It sets procedures for their classification, and empowers the Catchment Management Authorities to prepare regional catchment strategies.

NRE has also established control programs throughout the study area. They are:

- Good Neighbour Program, which provides funding to manage pest plants and animals on public land, and supports cooperative programs addressing pest plant and animal issues arising on the boundaries of public and private lands;
- Rabbit Buster Strategy, which provides funding for rabbit control follow-up works, and predator control on private and public lands;
- Rabbit Action Program, which provides funding for incentives and facilitators for rabbit control works on private lands.

For pest animals, over 80 per cent are both economic and environmental threats. The proportion of the total number of pest plant species that are both is much lower.

### Pest plants

A wide range of pest plants occurs across the study area, including approximately 70 species of noxious weeds

declared under the Catchment and Land Protection Act, environmental weeds such as willows, and other weeds that have economic impacts such as bent grass and cape weed.

#### Catchment management authority priorities

Catchment Management Authority priorities are outlined in Appendix XVI. Major pest plants under the Catchment and Land Protection Act are, in order of priority, State Prohibited Weeds, Regionally Prohibited Weeds and Regionally Controlled Weeds. Chilean needle grass is a major emerging weed having both environmental and economic impacts.

- State prohibited weeds either do not occur in Victoria, or can reasonably be expected to be eradicated from the State — none has been identified within the study area.
- Regionally prohibited weeds are not widely distributed throughout a region, but are capable of spreading further, and can reasonably be expected to be eradicated from the region — nine have been identified within the study area.
- Regionally controlled weeds occur in the region and are capable of spreading further. They should be subject to ongoing control measures — 30 have been identified within the study area.

#### Environmental weeds

Environmental weeds are plants that have invaded native vegetation, including pasture grasses, pasture weeds and other introduced species such as native plants that do not occur naturally in the study area. Of the 1336 taxa recorded by Muir *et al.* (1995) in the inland hills, 322 (24 per cent) are weeds, and of these, 24 were encountered frequently during a flora survey of the area (see Table 50). Another 11 weeds were not as widespread in the inland hills but are known to be locally highly invasive (see Table 51). No systematic assessment of environmental weeds has been conducted across the northern plains.

The worst weed invasions occur in fertile areas, in areas where soil has been highly disturbed, and in forests sharing a large boundary with pasture land. The application of fertilisers, or the presence of manure from livestock, increases the fertility of an area and enhances weed invasion. Soil and vegetation disturbances that favour weeds include grazing, mining, rabbit activity, fire protection works, road construction, timber harvesting,

firewood collection and recreational activities. Severe weed invasions are often closely correlated with areas that have had a long history of sheep grazing. Weeds are spread in droppings and carried in wool, and their establishment is favoured by the increase in soil fertility and reduction in native species cover caused by sheep. The hard hooves of sheep also cause soil compaction, which impedes the growth of local native plants.

Vehicles can gain easy off-track access to many areas of gentle terrain and open forest and woodland in the study area, contributing to the introduction of weeds and creating suitably disturbed environments for their establishment. Because of the fragmented nature of the forests and woodlands in the study area, many of the remnants adjoin rural pastures, which are the source of most weed invasions.

Once established, weeds crowd out many native species that cannot compete effectively for light, nutrients or water. For example Toowoomba canary-grass (*Phalaris aquatica*) forms extremely tall, dense swards in some areas, preventing the regeneration of most plants, including overstorey trees. In the more fertile vegetation communities it is likely that weed invasion has caused localised losses of indigenous plant species. Weed invasions also affect fauna habitat, particularly that used by ground-dwelling animals that forage in leaf and branch litter. The grey-crowned babbler, a threatened bird of the study area, has lost access to valuable foraging areas where canary-grasses have invaded.



*Phalaris invading roadside vegetation from adjacent farmland.*

All Box-Ironbark EVCs are affected by weed invasion, but those on the most fertile soils are more vulnerable, for example Low Rises Grassy Woodland, Creekline Grassy Woodland, Alluvial Terraces Herb-rich Woodland and

**Table 50: Environmental weed taxa widespread in box-ironbark forests and woodlands**

<i>Aira cupaniana</i>	small hair-grass
* <i>Aira elegans</i>	elegant hair-grass
* <i>Anagallis arvensis</i>	pimpernel
* <i>Arctotheca calendula</i>	Cape weed
* <i>Briza maxima</i>	large quaking-grass
<i>Briza minor</i>	lesser quaking-grass
* <i>Bromus diandrus</i>	great brome
* <i>Bromus hordeaceus</i> ssp. <i>hordeaceus</i>	soft brome
* <i>Bromus rubens</i>	red brome
* <i>Cerastium glomeratum</i>	common mouse-ear chickweed
* <i>Cirsium vulgare</i>	spear thistle
<i>Galium murale</i>	small bedstraw
* <i>Hypochoeris glabra</i>	smooth cat's ear
* <i>Hypochoeris radicata</i>	cat's ear
<i>Juncus capitatus</i>	dwarf rush
<i>Parentucellia latifolia</i> ssp. <i>latifolia</i>	common bartsia
<i>Petrorhagia velutina</i>	hairy pink
* <i>Romulea rosea</i> var. <i>australis</i>	common onion-grass
* <i>Sonchus asper</i> s.l.	rough sow-thistle
* <i>Sonchus oleraceus</i>	sow-thistle
* <i>Trifolium arvense</i>	hare's-foot clover
* <i>Trifolium campestre</i>	hop clover
* <i>Vulpia bromoides</i>	squirrel-tail fescue
* <i>Vulpia myuros</i>	rat's-tail fescue
* Species considered by Carr <i>et al.</i> (1992) to be serious or very serious threats to one or more vegetation formations in Victoria.	

Source: Muir *et al.* (1995).

**Table 51: Environmental weed taxa not widespread in box-ironbark forests and woodlands but locally highly invasive**

<i>Acacia baileyana</i>	Cootamundra wattle
<i>Genista linifolia</i>	flax-leaf broom
<i>Genista monspessulana</i>	Montpellier broom
<i>Chrysanthemoides monilifera</i>	boneseed
<i>Lycium ferocissimum</i>	African box-thorn
<i>Chamaecytisus palmensis</i>	tree lucerne
<i>Myrsiphyllum asparagoides</i>	bridal creeper
<i>Cortaderia seloana</i>	pampas grass
<i>Juncus acutus</i>	spiny rush
<i>Hypericum perforatum</i>	St John's wort
<i>Phalaris aquatica</i>	Toowoomba canary-grass

All species in this table were considered by Carr *et al.* (1992) to be serious or very serious threats to one or more vegetation formations in Victoria.

Source: Muir *et al.* (1995).

Valley Grassy Forest (see Tables 14 and 15, Chapter 8, for further details). Granitic EVCs are also quite susceptible to weed invasion with St John's wort having a severe effect in the north-east of the study area, and just beginning to invade similar areas such as Mt Kooyoora. Drainage lines in many parts of the study area have been severely affected by Toowoomba canary-grass because the seed washes down from sown pasture on the surrounding slopes.



*St John's wort displacing native vegetation near Mt Pilot.*

The species in Table 50 are typically annual grasses or other ground species that have been introduced for horticultural or agricultural purposes, or have been accidentally introduced. In some areas weeds have a lowcover and do not appear to affect the natural ecological processes in the vegetation community. At sites where soil fertility and water availability are greater, especially on granitic soils, weeds can become the dominant ground cover, leading to the depletion and loss of native species.

#### Management of pest plants on public land

The main pest plant species subject to control programs on public land in the study area are furze, blackberries and St John's wort. Other programs aim to control wheel cactus (or wheel pear), artichoke thistle, bridal creeper, golden dodder, coffee bush (or drooping cassinia), Cootamundra wattle, spiny rush, Cape tulip and horehound. Scientific names for these plants are provided in Appendix VI.

The most common control methods for pest plants utilise chemicals, although mechanical removal is used in some instances, especially along watercourses. Biological control is also being investigated for blackberries, horehound and bridal creeper.

NRE maintains a computerised database, called the Pest Management Information System (PMIS), which:

- facilitates the planning of pest management programs on public land;
- allocates resources to implement such programs; and
- monitors procedures to ascertain their effectiveness.

The Good Neighbour Program is mentioned above. Each year the Forests Service allocates approximately 20 per cent of its forest management funding within the Bendigo FMA to the Good Neighbour Program and other pest plant and animal works.

Private land-holders are responsible for controlling weeds on roadsides adjoining their properties, and on public land areas over which they hold a licence.

## Pest animals

The most common pest animal species across the investigation area are rabbits, wild dogs, foxes, feral goats, feral pigs, feral cats, and eight species of fish including European carp. In some situations native species such as wallabies, kangaroos and cockatoos are also recognised as becoming a nuisance.

Feral bees are considered separately in Chapter 21. Invertebrate pests of horticulture are also not considered here, as they are not a significant issue for public land areas.

### Priorities

Major pest animals in order of priority are rabbits, foxes, feral pigs, feral goats and feral cats. Wild dogs are also a priority in the north-east of the investigation area. In some situations management of nuisance wildlife is also a priority.

### Impacts

Virtually all pest animals have negative impacts on indigenous biota wherever they occur, but some species — dogs, goats and pigs — are usually localised, and some effects are not significant. In Box-Ironbark forests and woodlands there are negligible impacts of indigenous

animals, such as excessive numbers of a species, on other indigenous biota. Among the fish, negative effects are known for carp, brown trout and rainbow trout, and mosquito fish.

All except feral cats have negative impacts on economic values wherever they occur. The impacts of some species (again, dogs, goats and pigs) tend to be localised. Kangaroos, parrots and cockatoos are sometimes economic pests; among the fish, negative effects are well known only for carp.

### Management of pest animals on public land

The principal pest animals within the Bendigo FMA are rabbits and foxes, but there are also feral animals such as goats and pigs. In conjunction with Landcare groups, annual poisoning campaigns are undertaken to eradicate rabbits and foxes on public and private land. Since the diminishing effectiveness of Myxomatosis has become apparent, 1080 poisoned bait is the standard control method for rabbits. The Rabbit Calicivirus Disease (RCD) is also having a significant impact on rabbit numbers in some areas.

Foxes are controlled using Fox-off bait. At Puckapunyal, the fox control program using monitored baiting has been successful, with an initial kill of over 90 per cent.

In order to measure the effectiveness of each campaign, numbers of pest animal are surveyed before and after poisoning. These assessments consist of nightly transects by spotlight, during which the numbers of rabbits and foxes sighted are recorded on a per-kilometre basis.

Feral pigs and goats are usually enticed with free feed into enclosure traps. Despite, or perhaps because of, their low numbers they are difficult to eradicate.

Conservation reserves are sometimes perceived as major sources of pests for surrounding agricultural lands. The reverse is just as true. Pest animals seek out natural habitats for shelter, in close proximity to the agricultural lands where food sources are available. Their numbers would decrease if either component was removed.

## 21. ISSUES

### MINING AND EXPLORATION

In 1995/96, the goldfields of the study area produced gold valued at approximately \$66.5 million, or 96 per cent of total Victorian production (Chapter 17). It is difficult to predict future production levels due to the uncertainties of mining and the vagaries of the international gold market, but investment in exploration has been at record levels in recent years. Although gold dominates mining in the study area, other minerals have been mined — including some in recent years — and further prospects remain (see Chapter 17). Map C indicates that many of the study area's known earth resources overlap with the public land estate. As a result, there are a number of issues associated with mining and exploration.

- Availability of public land for mining. Access to public land for exploration and mining is a key issue for large and small miners. Access has generally been available for exploration and mining on most public land, predominantly State forests. National and State parks are generally exempted from exploration and mining under the *Mineral Resources Development Act 1990* and the *National Parks Act 1975*. These parks total about six per cent of the public land in the study area. Recreational prospecting is allowed in principle in several State parks, and the relevant park management plans have defined limited areas where fossicking is permitted.
- Environmental effects of exploration. The impacts of mineral exploration on the environment can vary widely, according to the techniques used and the attention given to minimising impacts. By their nature, certain methods, such as aerial geophysical surveys and surface sampling of loose rock, can have little impact. Others can be intrusive and difficult to reclaim — for example, conventional diamond drilling can leave lasting impacts if vegetation is removed for access, drilling plant is sited poorly, extracted material is treated or disposed of inappropriately, or fuel, oil, or drilling fluid is spilled. In the Deep Lead Flora and Fauna Reserve in 1990, however, Western Mining Corporation carried out exploration using existing

tracks, duckboards to reduce compaction by drilling plant, impermeable sheeting, and care to prevent spillage and leaks of materials brought in, resulting in a low impact.

- Environmental effects of mining. Recreational metal detecting and other prospecting with hand tools generally have significant impacts only at sites of high environmental sensitivity, such as those where populations of rare plants, particularly orchids, have been diminished or eliminated.

The effects of larger commercial operations can be more severe. In the first instance, indigenous vegetation is cleared from the site — the size of the affected area generally being a function of whether mining is by open pit, 'doze and detect', or underground shafts. This effect may be temporary — up to several decades — if the site is successfully rehabilitated, although there are issues associated with rehabilitation (see below). However, with open pits, current practice is not to backfill excavated areas, because of the cost and the possibility of future economic resource extraction. The resulting landscape permanently retains deep holes, usually filled with groundwater, and 'hills' of overburden and treated ore. This needs to be seen in the context of the limited total area affected by such operations (see Chapter 17).

- The cumulative effect of successive operations at the landscape scale. A modest total area is likely to be mined by open pits, and underground company mining may also cause only limited surface disturbance. However the aggregate effect of numerous small mining, 'doze and detect' and exploration operations, where they involve vegetation clearing, together with the large mines, can over time disturb appreciable areas. For example a series of 13 operations from 1984 to 1994 by small companies in the Craigie Forest near Maryborough resulted in four per cent of the total forest area being cleared. These are not the only activities disturbing the vegetation. Because the public land estate is highly divided, clearing of relatively small areas can have a disproportionate fragmenting effect, particularly in these slow-growing forests.

- Disturbance of historic tailings and mullock dumps. Following the recent State-wide project to assess historic gold mining sites, a number of historic tailings and mullock dumps have been identified. Removal of material for retreatment or local road-making, a common practice, can damage the historic nature of such sites. Potential sources of stone are relatively common (see below).
- Long term decline in the availability of shallow gold. Although technological advances are continuing to provide new opportunities for large companies to exploit gold reserves, shallow alluvial and hillside nugget discovery is likely to decline. Improvements in metal detectors have temporarily reversed this decline and may continue to do so. Ultimately, however, the shallow gold resource is finite and will decline to the point that fossicking and prospecting will become increasingly unrewarding, regardless of land use decisions.
- Improved site management and rehabilitation. Permanent effects of some past mining include: unvegetated treated tailings dumps resulting from earlier chemical treatment methods; hydraulic sluiced and dredged streams; sheet eroded hillsides; gullied watercourses; disturbed soil profiles in alluvial diggings; and declines in biodiversity. Large-scale mining in the past also had off-site effects on water quality and siltation — for example, the silt deposits in Laanecoorie Reservoir. Responsible current operators, on the other hand, seek to minimise initial and operating impacts, and reclaim sites where practicable, re-establishing indigenous vegetation. Where reclamation is not possible, alternatives are to purchase freehold land containing native bushland for land exchange, and to contribute to wider revegetation programs. Bonds are retained for reclamation, and works are planned and carried out in conjunction with NRE.



*Mineral exploration, Tarnagulla.*

- Fulfilment of obligations for site rehabilitation after mining has ceased. Rehabilitation can be an expensive and difficult proposition at a time when activity and interest at the mine site may be in decline. Although in recent years more attention has been given to miners' obligations for rehabilitation, the efficacy of post-mining rehabilitation remains an issue. A related issue is the tension between the long-term loss of indigenous vegetation and visual amenity and the practice of not backfilling excavated areas because of the possibility of future resource extraction.
- Use of indigenous plants in rehabilitation. In a region where native vegetation has been greatly depleted, there is general recognition of the merits of re-establishing indigenous vegetation after mining. However, in box-ironbark forests and woodlands, indigenous revegetation has commenced only in the last few years, and it may take many years of monitoring and refinement to develop and assess adequate revegetation techniques. Consequently, the extent to which revegetation can ameliorate the long-term effects of mining remains to be demonstrated, although it is clear that it will be many decades before some natural values — such as large hollow-bearing trees — return, and some impacts may be permanent.

## STONE EXTRACTION

Unlike minerals, stone resources are widely available across the study area, and are sought by a range of users. Extracted stone is mostly used for local road-making, and building and construction. Over 90 quarries in the study area occupy approximately 5500 ha, and produce about \$70 million dollars of materials annually — 16 per cent of the Victorian total. In recent times, stone extraction has been less well planned and coordinated than mining, raising a number of issues.

- Rationalisation of operations. Extraction is often spread across a large number of shallow sites, when a small number of deeper sites could provide the same volume of rock with fewer adverse impacts (see below). Similarly, it is common for several sites in an area to be 'open' — operating, temporarily dormant, or exhausted and disused — at one time, when exhausting and reclaiming sites before initiating new ones would decrease adverse impacts. Finally, progressive reclamation of operating sites and full reclamation of used sites (including long-disused sites), and the provision of adequate resources for reclamation of old sites would also decrease adverse impacts.
- Site location planning. Poorly planned and located excavations can affect surrounding lands through noise, dust, unsightliness, and erosion, and can diminish the value of the land — stone extraction typically involves the movement of large volumes of rock. Also, since broad areas are suitable and generally available for extraction, planning is necessary to exclude extraction from places of greater value for other purposes, including aesthetic or nature conservation values.
- Water supply catchments. Many stone sites are located in declared special water supply catchment areas, where particular care is necessary to avoid compromising water quality.
- Extraction at highly erodible sites. The potential adverse impacts of extraction in highly erodible situations such as streambeds and granitic sands are severe, and specific measures to ameliorate these impacts may be desirable.

Issues associated with the removal of indigenous vegetation, the cumulative effects of successive extraction, the use of stone from mullock dumps, and rehabilitation are

much the same for stone extraction as for mining and exploration (see above).

Some extractors and managing agencies, for example VicRoads, have addressed particular instances of some issues, but they remain generally applicable.

## APICULTURE AND FERAL BEES

Prolifically flowering eucalypts which produce large volumes of nectar are a distinctive feature of box-ironbark forests and woodlands, as are the diverse nectarivorous fauna and valuable apicultural industry which they support. Conflicts could be anticipated between the apicultural use and the natural values associated with this resource.

- Chapter 15 presented some estimates of the size of the apiculture industry in the study area. It is clear that box-ironbark forests and woodlands are the pre-eminent vegetation type for apiculture in Victoria, in terms of quality and quantity of honey and of other products. Bee-sites — where licensees can operate hives — are located throughout most of the public land in the study area. They are specifically excluded only from (1) reference areas and a surrounding 'buffer' zone of 2 km, (2) areas of intensive recreational use, and (3) some ecologically significant and sensitive areas. However, many of these exceptions may be accessed by bees from hives on nearby private land, where they can be located with the landholder's permission. An important issue for beekeepers is their continued access to the public box-ironbark nectar and pollen resource.
- Potential impacts of introduced honey bees and apiculture on nature conservation values can be considered under four headings.
  - (a) Competition for nectar and pollen. Both feral and 'managed' bees are highly efficient consumers of nectar and pollen from a wide range of indigenous plants — possibly to the detriment of native nectarivores, including native bees.
  - (b) Disruption of plant-pollinator systems. Most plant-pollinator systems are composed of a myriad of complex relationships that have evolved over thousands of years. As major consumers of nectar from indigenous plants, honey bees may

significantly disrupt this component of the ecology of box-ironbark forests and woodlands.

- (c) Competition for tree hollows. Feral hives in tree hollows are frequently encountered in box-ironbark forests and woodlands, and there are documented accounts of feral honey bees displacing native fauna (including threatened species in some instances) from tree hollows and nest boxes.
- (d) Physical damage to habitats (including the dispersal of pathogens) as a result of beekeepers travelling to their hives. This is less likely to have substantial adverse effects on native biota than other potential impacts.

Technical obstacles have been a major constraint to the assessment of the first two of these impacts, despite a significant body of research, while relatively little research has addressed competition for tree hollows in the study area. While there is relatively little evidence which unambiguously demonstrates that honey bees have a substantial negative impact on native flora and fauna, Schwarz and Hurst (1997) summed up the issue as follows:

*Even without any clear evidence to suggest that honey bees are having a negative impact on native bee fauna it is difficult to imagine, given so many other Australian examples of the effect of introduced species, that honey bees do not impact on our ecosystems.*

Other potential issues associated with honey bees are:

- bee stings are a hazard for all users of public land, and may compromise existing or potential recreational values, in particular; and
- as exotic animals, honey bees may be considered intrinsically out of place in conservation reserves, regardless of the nature of their effects on indigenous biota.

## RESERVE SYSTEM DESIGN

Landscapes where the depletion of native vegetation has been severe and where remaining vegetation is highly fragmented present special problems for nature conservation. In recent years, major research programs, including a considerable body of work on the northern plains, have addressed these problems. Conclusions from this research

raise some important issues for nature conservation in the study area.

- Size of reserves. Larger vegetation remnants make a much more substantial contribution to nature conservation than smaller ones, both absolutely and relative to unit area. Smaller remnants may not be ecologically viable in the long term, as the effects of cumulative pressures become apparent (see below). In some parts of the study area there is insufficient remnant vegetation to create large reserves, while in other areas the creation of large reserves may leave little public land for some other uses.
- Links between remnants. Linear strips of indigenous vegetation between small remnants (such as along roads and streams) can enhance the operation of ecological processes between the remnants, and hence enhance their ecological viability. However, linear strips are also difficult and expensive to manage for conservation, and in some areas have potentially conflicting uses — for example, streambanks are often required for stock watering.



*Powerful owls have large territories and may not survive in small reserves.*

- Delayed impacts of land-use change. Ongoing declines in biodiversity have been recorded many decades after clearing has ceased, raising the possibility that existing vegetation remnants, both collectively and in some cases individually, may not be sufficient to maintain ecological viability.
- Climate change. In the longer term, as climatic zones shift, habitat fragmentation may prevent plant and animal species from shifting with the climatic zone to

which they are adapted. These species may then become locally extinct. These problems further complicate public land-use planning and management decisions in the study area.

- **The role of revegetation.** Revegetation with indigenous plants has commenced in some areas, and is often promoted as a solution to the preceding problems. However, a significant contribution by revegetated areas to mitigating regional biodiversity declines remains to be demonstrated and, in terms of providing large old trees for instance, will be limited for several decades at least. Revegetation is also extremely expensive compared to retaining existing indigenous vegetation or allowing it to regenerate with relatively little management input. However, targeted revegetation programs may be useful for achieving specific objectives, such as enhancing the viability of small reserves.
- **Fragmentation.** The above issues are most pertinent in those parts of the study area where depletion and fragmentation of indigenous vegetation have been most severe — that is, across the northern plains and in smaller areas in the inland hills involving those Ecological Vegetation Classes (EVCs) that occur on more fertile soils. Table 13 provides an indication of the severity of depletion in some of these areas. The public land estate in these areas is also comparatively small, limiting opportunities for nature conservation by reservation in precisely the areas where it may be most required.
- **Reserve management structures.** Currently, the difficult task of managing nature conservation in the severely depleted ecosystems of the study area is being undertaken by a range of land managers (agencies and individuals), operating across a variety of land tenures and land use categories. In addition, nature conservation is often not their primary management objective. While there are clear areas of responsibility — NRE on most public land, and Trust for Nature working cooperatively with some private landholders, for instance — there is no clear coordination of nature conservation across the range of managers, categories and tenures. The need for coordination is most acute in regions where the loss of native vegetation has been most severe. Researchers such as Thiele and Prober (in prep.) have begun exploring innovative administrative frameworks to address this issue.



*Network of roadside vegetation corridors connecting larger remnants, Mt Korong.*

## CAR RESERVE SYSTEM

Reserve system targets have been set under the JANIS (1997) reserve criteria and adopted by the Commonwealth and State governments for the purposes of Regional Forest Agreements. A target of at least 15 per cent of the pre-1750 extent of each vegetation type for representation in a comprehensive, adequate and representative (CAR) reserve system is proposed under the criteria (see Chapter 11 for further details). The ECC has not yet considered the appropriateness of this target for box-ironbark. Factors to be taken into account include:

- **Extent of the box-ironbark reserve system.** Given the considerable extent of clearing of native vegetation which has occurred in the study area, the extent to which such a target can be met for each of the vegetation types (EVCs or BVTs) in the study area, and appropriate alternative reservation levels remain to be resolved.

- Public land planning process. In attempting to resolve this issue, the Council's process, and the Commonwealth-State Regional Forest Agreement process are both using the best technical information in the area of public land uses as well as in biological, recreational, cultural heritage and other values. In addition, in seeking balanced public land use and development the ECC will consider other relevant factors, including social and economic impacts of recommended land use changes, and public consultation, in developing its conclusions.

## RECREATION

A study of recreational uses and values conducted for the Box-Ironbark Investigation identified the following issues.

- Access to public land. The availability of suitable areas is important for all recreational users, particularly near towns and in the most favoured areas for specific types of recreation — for example, sites where shallow gold is found, in the case of metal-detectors and fossickers.
- Effects of timber harvesting and mining operations. These activities largely occur in State forests, although they may occur in other land use categories. The noise, vehicular traffic and other human activity, and resultant disturbed landscapes that are associated with these activities may affect a broad range of recreational activities, such as fossicking and prospecting, natural history study, and orienteering, where the relative quietness, solitude and absence of recent severe disturbance are important components. Noise and human activity can be more conspicuous in box-ironbark forests and woodlands than in denser forests with steeper terrain.

## FIRE

The role of fire in the ecology of box-ironbark forests and woodlands is generally poorly understood. There is evidence to suggest that box-ironbark eucalypts have become adapted to fire events, but the intensity, seasonality and frequency of these events are not known.

Chapter 5 describes some of the possible effects of fire on box-ironbark ecosystems, as presently understood. They include fire frequency requirements for seed germination,

and factors influencing eucalypt seedling regeneration and the general scarcity of seedlings and saplings in box-ironbark forests and woodlands. Adverse fire effects can include the local extinction of particular species; impacts on the abundance of habitat features (such as fallen timber, leaf litter, dead trees and hollow-bearing trees); and impacts on the status and distribution of fauna.

Some research into the role of fire in selected ecological components is likely to be of great value for the long-term conservation of box-ironbark forests and woodlands (see Chapter 5). The most appropriate use and management of fire for the protection of the box-ironbark vegetation types, either through regular controlled burning or allowing forest litter to build up, remains to be determined.

Low-intensity prescribed, or planned, fires are used regularly in Victorian forests to reduce fuel hazard levels, though only a small proportion of public land in the Box-Ironbark study area is deliberately fuel-reduced in any year.

The localised impacts of fire suppression and protection may include increased numbers of some fauna, such as eastern grey kangaroos and feral honey bees, associated with the introduction of fire dams; disturbed soil and vegetation, and enhanced opportunities for weed invasion, related to fire protection works; transport of cinnamon fungus (*Phytophthora cinnamomi*) into areas through fire-break machinery; and adverse effects on certain biological values and the killing of young regrowth resulting from previous fires or timber harvesting, through frequent fuel-reduction burns.

## WOOD PRODUCTION

As described in Chapter 16, firewood is one of the highest volume products from Victorian forests, and accounts for over 80 per cent by volume of the licensed timber output of the study area. Firewood production from public land in the study area accounts for about half of the total Victorian production. Other timber products from the study area include posts and poles, sawlogs and sleepers. State forest — where wood production is the primary objective — occupies about 47 per cent of the public land in the study area (including 11 440 ha for eucalyptus oil production). The following issues are associated with wood production in the Box-Ironbark study area.

- Access to timber resources. Continued access to large areas of forest, particularly close to towns will be necessary if wood product harvesting is to be maintained at current levels.
- Sustainability. The sustainability of harvesting of the main forest products — firewood, posts, poles, sawlogs and sleepers — is an issue.
- The development of large trees. Past timber harvesting practices have eliminated large, hollow-bearing trees from extensive areas. The very large trees that are required by hollow-dependent fauna, for instance, may not necessarily be produced or retained under current practices (see State forest, under Public land management, below).
- Removal of habitat in firewood collection. Dead hollow-bearing trees, standing or fallen, and fallen limbs provide valuable habitat, particularly for fauna. Forest litter provides shelter, breeding, refuge and foraging sites for many ground-dwelling animals such as reptiles, skinks and frogs, as well as bird and mammal species (see Chapter 9). The litter may also provide a microclimate for germinating plants.
- Fallen timber. Fallen timber is the main source of firewood collected for domestic use, but it is an important ecological component of box-ironbark forests and woodlands. However, reduced removal of fallen timber could potentially exacerbate the wildfire risk. There is a need for a clear prescription to address the contention associated with fallen timber.
- Illegal firewood collection, from all public land categories — unlicensed collection, taking greater than a licensed amount, collecting in contravention of land-use objectives, and taking types of material not authorised to be taken. In a fragmented public land estate, it is difficult to regulate such use effectively.
- Public attitudes. Many domestic wood collectors regard firewood collecting on public land as a long-established right. This may contribute to regulation difficulties.
- Protection of roadsides. Habitat provided by roadside vegetation is particularly vulnerable, especially in areas where there is little other public land with tree cover.
- Use of plantations. Some areas of cleared public land occur on land systems which elsewhere carry

box-ironbark vegetation. These areas may be appropriate locations for the establishment of plantations to alleviate pressures resulting from the continued extraction of firewood and other products from existing forests and woodlands with important natural and recreational values. However, plantations can have a long lead time before production, and current wood product harvesters may be reluctant to shift into plantations.

Other issues relating to forest management are included elsewhere in this chapter under Public land management, Reserve system design, Eucalyptus oil harvesting, and Fire.

## EUCALYPTUS OIL HARVESTING

The Box-Ironbark study area is the major centre of high quality eucalyptus oil production in Victoria, because it is the Victorian stronghold of blue mallee — the species most preferred for the production of high quality oil. On average, around 25 tonnes of eucalyptus oil are produced annually. Issues associated with eucalyptus oil harvesting include the following.

- Concentration of harvesting on Gravelly-sediment Mallee EVC. This vegetation class is of considerable botanical, biogeographic and palaeoclimatic interest, and is limited in extent. Further, some species which occur in this EVC, such as blue mallee and the nationally endangered pink-tailed worm-lizard, are poorly represented in conservation reserves.
- Continued availability of areas designated for eucalyptus oil harvesting but not previously harvested. Within the areas that have been set aside for eucalyptus oil harvesting, there are presently sites which have not been previously harvested and support a mature mallee eucalypt canopy. The removal of a this canopy through harvesting (as opposed to the repeated harvesting of cutting regrowth on short rotations) can result in soil erosion and changes in microclimatic conditions, which in turn impact on the diversity of understorey flora and fauna. Dramatic declines in most species of birds, ground mammals, reptiles and invertebrates have been recorded in areas of intensive activity, compared with unharvested areas. The loss of botanical diversity

is evident: a low shrubland dominated by regrowth of one or two mallee eucalypts remains, while the litter layer and ground vegetation disappear. Harvesting also reduces the nutrients being cycled back into the ecosystem.

- Likelihood of harvested areas regenerating fully if harvesting were to cease. It is yet to be demonstrated that indigenous biota can fully recover from repeated cutting of mallee eucalypts. The loss of highly erodible soils, in particular, may preclude the re-establishment (after harvesting ceases) of some species for many decades, and perhaps permanently.

## PUBLIC LAND GRAZING

Public land grazing in the study area occurs mainly (1) in small parcels (for example, water frontages and unused roads), and (2) across broad areas of State forests. Grazing is not a major land use in the study area because most State forests are located in the inland hills where the intensity and extent is limited by less fertile soils than those of the riverine forests and woodlands, such as Barmah forest, and along the Goulburn and Ovens Rivers. Grazing in small blocks in the study area mostly occurs where soils are relatively fertile and slopes are more gentle — it is widespread on the northern plains and in valleys and alluvial terraces in the inland hills. Issues associated with public land grazing by domestic stock include the appropriateness of this use of public land and the environmental effects of grazing.

- Economic value. A study carried out for the LCC Murray Valley study revealed that public land grazing was important to individual licensees, where it is an integral part of their farming enterprise. However, it also found that public land grazing is not of great significance in the economy of the grazing industry in Murray Valley region, even with the inclusion of the Barmah and Gunbower forests — both of which are outside the Box–Ironbark study area. Recommendations for the Murray Valley and North Central areas are contained in Appendix XVII.
- Ecological effects. In a high proportion of the small public land blocks in the study area, grazing has reduced nature conservation values. In many cases these impacts are ongoing, or grazing continues to pose a

significant threat to natural and recreational values. A number of adverse effects has been recorded as a result of grazing *per se*, trampling by stock, and weed invasion. Weed invasion is often a consequence of soil disturbance, introduction of weed seeds in faeces, and concentration of nutrients at points where stock congregate. Adverse effects include loss of existing native vegetation, particularly ground and shrub layer vegetation; prevention of regeneration of all vegetation layers; soil compaction and loss of leaf litter; increased soil disturbance and hence erosion; reduced viability of flora and fauna populations; and off-site effects, such as reduced water quality and increased groundwater recharge.

- Effects on recreational values. The presence of domestic animals and their signs can also compromise recreational values.
- Control of existing weeds. There are many examples of weeds proliferating following the removal of domestic stock from public land. The circumstances under which the environmental benefits of continued stock grazing exceed those of stock removal is a poorly understood issue. A related benefit of timely grazing is that it may also reduce the fuel available for local grassfires.

## PUBLIC LAND MANAGEMENT

Box–Ironbark forests and woodlands have a range of management objectives. Key components of the public land — the parks, State forests, conservation reserves, reference areas, and water supply areas — and relevant issues, are outlined below.

### Parks

The various national and State parks have similar management aims, expressed in recent management plans. These are summarised in Chapter 11. Issues arising in parks include:

- Non-conforming uses. Specific non-conforming uses have been recommended in response to particular local issues. They represent departures from conventional park use, and could conflict with the basic aims of parks. Where such uses continue, they need to be

managed to minimise adverse effects and allow retention, as far as possible, of park values in those areas.

- The shortage of mature trees. Parks and reserves are generally dominated by regrowth forests from past use (see Chapters 3 and 16). Whereas in State forests silvicultural thinning is used on the basis that it will increase average tree size by increasing the growth rate of those trees that are retained, this practice has generally not occurred in parks and reserves. At issue for parks managers is whether this technique is appropriate in parks to assist in meeting conservation objectives — for hollow-dependent fauna, for example — or whether trees should be allowed to develop without intervention.

### State forests

State forest management is explained in Chapter 16. Particular issues in box-ironbark forests include:

- Retention and development of large trees and particularly hollow-bearing trees. Timber harvesting prescriptions specify the number and size of trees per hectare, both living and dead, to be retained for habitat purposes. Silvicultural thinning as practised at present is intended to increase the average size of trees in the existing regrowth forests to produce more sawlogs. It remains to be demonstrated that these prescriptions, marking, and current thinning practices, will lead to the generation of very large trees in the long term.
- Pathogens, and pest plants and animals. While this issue relates to all public land, some characteristics of the management of wood product harvesting may exacerbate particular weed or vermin problems — for example, use of heavy machinery off main tracks and greater penetration of sunlight to the forest floor as a result of tree removal.

### Conservation reserves

- The degree of implementation of LCC recommendations for smaller reserves, including 38 nature conservation and various natural features reserves. Implementation of past recommendations usually involves reservation, management planning, and appropriate on-ground management.
- Permitted uses in conservation reserves. LCC recommendations permitted honey production and, in some instances, prospecting.

### Reference areas

- Proclamation of the Sandhurst reference area. Other recommended reference areas have been proclaimed under the *Reference Areas Act 1978*. Sandhurst is located on public land held by Coliban Water near Bendigo, and its future is to be considered in this Investigation. It represents land system 2.1/Ss4.2, typical of metamorphic aureoles, in this case around the Mt Alexander granitic intrusion. The representation of other modified land systems in reference areas will be reviewed in this Investigation.

### Water supply

Within the study area, moderate volumes of water are harvested in multiple-use catchments. As described in Chapter 18, much of the water used in the study area is harvested in the mountains to the east, and used for irrigation. In brief, issues relating to water supply are:

- use of waterways — including some smaller waterways such as the Broken Creek — for transmitting large volumes of water out of season;
- seepage and salinisation associated with channels; and
- use and management in sensitive parts of water supply catchments — particularly those used for urban domestic supplies — which can adversely affect water quality or quantity.

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## Appendix I

### RELEVANT EXTRACTS FROM THE *ENVIRONMENT CONSERVATION COUNCIL ACT 1997*

#### Public land

Section 3.

'Public land' means —

- (a) any unalienated land of the Crown, including, land temporarily or permanently reserved under the *Crown Land (Reserves) Act 1978*;
- (b) state forest within the meaning of the *Forests Act 1958*.
- (c) park, within the meaning of the *National Parks Act 1975*;
- (d) land under the management and control of Melbourne Parks and Waterways, established under the *Water Industry Act 1994*;
- (e) land vested in any public authority, other than —
  - (i) a municipal council; or
  - (ii) an Authority under the *Water Act 1989*, to the extent that the land vested in the Authority is within a sewerage district listed in column 3 of Schedule 12 of the Act.

#### Functions

Section 6.

The functions of the Council are to —

- (a) carry out those investigation that are requested by the Minister into the balanced use or development of public land or any flora, fauna or minerals on above or under that land or water flowing over that land; and
- (b) carry out any other functions conferred on the Council by this or any other Act.

#### Minister to require investigation

Section 17.

- (1) The Minister may require the Council to carry out an investigation into the balanced use or development of public land or any flora, fauna or minerals on, above or under that land or water flowing over that land.
- (2) A request must be in writing and must specify the time within which the Council is to report on the request.
- (3) The Minister may, at any time during the course of an investigation —
  - (a) direct the Council on any matters it is to take into consideration;
  - (b) withdraw or amend a request.

#### Matters to be taken into account in investigations

Section 20.

In carrying out an investigations the Council must have regard to —

- (a) the ability of any existing or proposed development or use of the land or resources to be ecologically sustainable and economically viable;
- (b) the economic and social value of any existing or proposed development or use of the land or resources;

- (c) the existence of and the need to conserve and protect any areas of ecological, historical, cultural or recreational value or areas of landscape significance on the land;
- (d) the need for the creation and preservation of a comprehensive, adequate and representative system of parks and reserves within the State;
- (e) any international obligations entered into by the Commonwealth and any national agreements entered into with or obligations undertaken in conjunction with the Commonwealth and other States and Territories which relate to the subject matter of the investigation;
- (f) the need to protect and conserve biodiversity.

### Notice

Section 21.

- (1) The Council must cause notice of an investigation to be published in a newspaper circulating generally throughout the State.
- (2) If, at any time during the course of an investigation, the Council proposes to hear further submissions on the investigation, the Council must cause notice that it is to hear further submissions on the investigation to be published in a newspaper circulating generally throughout the State.
- (3) A notice under sub-section (1) or (2) —
  - (a) must include a statement of the subject of the investigation; and
  - (b) set out an address where a copy of the Minister's request may be obtained; and
  - (c) must state the fact that submissions may be made; and
  - (d) set out the time within which submissions must be made and form and the manner in which they may be made.

### Submissions

Section 22.

- (1) Any person or body may make submissions on an investigation to the Council.
- (2) A submission must be made —
  - (a) within 60 days of the publication of a notice under section 21; or
  - (b) if another time is specified in the notice, the time specified in the notice; or
  - (c) in the case of a submission made by a person or class of persons for which the Council allows and extension of time, within the time allowed by the Council.
- (3) A submission must be made in the form and manner specified in the notice.

### Report on the investigation

Section 23.

- (1) The Council must present a written report on the outcome of its investigation to the Minister on or before the date specified as the date on which the report is to be made.
- (2) The report must specify all the proposals made in submissions to the Council and the reasons for which the Council had accepted, rejected or modified those proposals.
- (3) The Minister must cause a copy of the report to be laid before each House of Parliament, within 7 sitting days after the report has been presented to the Minister.

## Appendix II

### RELEVANT COMMONWEALTH LEGISLATION AND AGREEMENTS

#### Commonwealth legislation and the Regional Forest Agreement (RFA) process

The *Endangered Species Protection Act 1992* provides a legislative basis for Commonwealth responsibilities with regard to the conservation of endangered and vulnerable flora and fauna, endangered ecological communities and key threatening processes. The *Endangered Species Protection Act 1992* has schedules of species, ecological communities and key threatening processes that are required to be taken into account in Commonwealth actions and decisions.

The *Environment Protection (Impact of Proposals) Act 1974* provides for environmental impact assessment, by requiring Commonwealth actions and decisions likely to be *environmentally significant* to be referred to the Minister for the Environment. The Regional Forest Agreement process has been designated as *environmentally significant* and referred under this legislation.

The *Australian Heritage Commission Act 1975* establishes the Australian Heritage Commission with the statutory responsibility to identify the National Estate, and obliges the Commonwealth to take into account the effect of its actions on the National Estate. The Regional Forest Agreement process provides the opportunity for National Estate values in a region to be systematically identified.

The *Export Control Act 1992* includes regulations that control the export of woodchips. As woodchips are not sourced from box-ironbark forests this legislation will not affect box-ironbark forests and woodlands.

#### Agreements and Legislation

##### International Agreements

- Convention on Biological Diversity;
- Australia-Japan Agreement for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (1974) (JAMBA);
- Australia-China Agreement for the Protection of Migratory Birds and their Environment (1986) (CAMBA);
- Convention for the Protection of the World Cultural and Natural Heritage (1972) (World Heritage Convention);
- Convention on Wetlands of International Importance especially as Waterfowl Habitat (1975) (Ramsar Convention), including the 1986 and 1994 amendments;
- Convention on the Conservation of Migratory Species of Wild Animals (1979) (Bonn Convention). Australia is required to protect endangered species of migratory animals and animals which have an unfavourable conservation status due to habitat depletion or reduction in range.

##### Commonwealth Legislation

- *Environment Protection (Impact of Proposals) Act 1974*
- *Australian Heritage Commission Act 1975*
- *National Environment Protection Council Act 1994*
- *Endangered Species Protection Act 1992*, and *Endangered Species (Consequential Amendments) Act 1992*
- *National Parks and Wildlife Conservation Act 1975*
- *Natural Resources Management (Financial Assistance) Act 1992*

- *World Heritage Properties Conservation Act 1983*
- *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*
- *Defence Act 1903*

#### Government Agreements

- National Strategy for Ecologically Sustainable Development (NSESD) and the National Greenhouse Response Strategy (NGRS)
- Environment and Heritage Policy in Defence
- National Strategy for the Conservation of Australia's Biological Diversity
- Intergovernmental Agreement on the Environment

### **Commonwealth Policies**

In addition to the Acts and conventions listed above, the Commonwealth Government, usually in co-operation with the States, has developed strategies and established a number of initiatives in relation to environmental protection. For instance, a range of projects can be funded under programs delivered through the Natural Heritage Trust. These include:

- National Vegetation Initiative (or Bushcare)
- National Landcare Program
- National Rivercare Initiative
- National Weeds Strategy
- National Reserve System Program
- Farm Forestry Program
- Endangered Species Program
- National Wetlands Program
- National Feral Animal Control Strategy

Broader strategies developed at national, State and regional level, which are also supported by the Natural Heritage Trust, include:

- National Strategy for Ecologically Sustainable Development
- Decade of Landcare Plan
- National Strategy for the Conservation of Australia's Biological Diversity
- National Water Quality Management Strategy
- National Greenhouse Response Strategy
- Council of Australian Governments water reform framework
- National Strategy for the Conservation of Australian Species and Ecological Communities Threatened with Extinction

### **Defence Instructions**

Environmental management on Defence land is also governed by Defence Instructions:

- Department of Defence. 1990. Environment and heritage protection. Defence Instruction (General), Administration, 40-1. DI(G) ADMIN 40-1.
- Department of Defence. 1994. Environmental management. Draft Defence Instruction (General), Administration, 40-2. DI(G) ADMIN, 40-2 (draft)

## Appendix III

 SELECTED HISTORIC PLACES ON PUBLIC LAND IN  
 THE BOX-IRONBARK STUDY AREA

Forest management			
Forests office	Beechworth	Chiltern Valley tramway	Chiltern
Harcourt oak plantation	Castlemaine	Wallaces lead	Chiltern
Balt camp	Graytown	Costerfield cyanide works	Costerfield
Mount Tarrengower firetower	Maldon	Costerfield main shaft/Bombay mine	Costerfield
Warby Ranges firetower	Peechelba	Minerva mine	Costerfield
Carapooee West boys camp	Stuart Mill	Hand in Hand cyanide works	Deep Lead
Charcoal production		Four Post diggings	Deep Lead
Kamarooka charcoal kilns	Bagshot North	Glasgow Reef workings	Diamond Hill
Barkly track charcoal pits	Barkly	New Chum goldfields sites	Diamond Hill
Bailieston Track charcoal pits	Graytown	Almedia Reef	Dunolly
Teal Track charcoal pits	Rostron	Wild Duck lead puddler	Dunolly
Eucalyptus oil production		Bet Bet lead puddler	Dunolly
Charlies steam house	Clunes	Catherine Reef workings	Eaglehawk
Ruedins eucalyptus distillery	Kamarooka	New Moon mine	Eaglehawk
Battery Dam eucalyptus distillery	Maryborough	Specimen Hill sites (various)	Eaglehawk
Eucalyptus distillery	Waanyarra	South New Moon Co.	Eaglehawk
Timber production		New Napoleon mine	Golden Square
Kilns	Mt Samaria	Chinese camp and diggings, Hard Hill	Great Western
Gold mining *		Sawpit Gully puddlers	Heathcote
Long Gully shallow lead	Armstrong	Pink Cliffs	Heathcote
Castlemaine Flagging Co.	Barkers Creek	Eaglehawk Gully puddlers	Inglewood
Specimen Gully Q.M. Co.	Barkers Creek	Beehive Company mine	Maldon
Tunstall's diggings	Bealiba	South German Co.	Maldon
No. 7 reservoir	Bendigo	North German Co.	Maldon
Ballerstedt's mine	Bendigo	State battery	Maldon
Central Deborah tourist mine	Bendigo	Lisle's Reef workings	Maldon
Deborah Co.	Bendigo	Tarrengower Creek workings	Maldon
Lansells 180 mine	Bendigo	Mt Tarrengower Tunnelling Co.	Maldon
Golcondah Co.	Bendigo	Grand Junction Co.	Maldon
Old Tom mine puddler	Bendigo	North British Co.	Maldon
Spargos pyrites works	Bendigo	Caledonian crushing works	Maldon
North Deborah mine	Bendigo	Swedes and German gullies puddlers	Moliagul
Forest Creek tourist mine	Castlemaine	Albert Company mine	Muckleford
Garfield water wheel site	Chewton	Frenchman's Gully alluvial workings	Muckleford
Central Wattle Gully mine	Chewton	Frenchman's Reef quartz workings	Muckleford
Expedition Pass reservoir	Chewton	Smiths Reef workings	Muckleford
Golden Point water race	Chewton	Thornhill Co. Mine	Muckleford
Cobblers Gully sites (various)	Chewton-Fryerstown	Raggedy lead diggings	Percydale
South Spring Gully	Chewton-Fryerstown	Welcome Reef puddler	Redcastle
Spring Gully sites (various)	Chewton-Fryerstown	Specimen Hill open cut	Rushworth
Eureka Reef and mine sites (various)	Chewton-Fryerstown	White Hills puddler	Rushworth
		Lloyd's whip shaft	Stuart Mill
		Pickpocket cement workings	Strangways
		Grand Duke Co.	Timor
		Nine Mile Co.	Wedderburn
		Phillips Gully alluvial workings	Whipstick
		Jib Horse Gully puddler	Whipstick

Main/Balaclava Gully cyanide works	Whroo
Reconstructed puddler	Whroo
Balaclava Hill	Whroo
<b>Transport and communication</b>	
Bridge	Amherst
Stone culvert, McIvor Highway	Axedale
Railway bridge	Barkers Creek
Newtown Bridge, Spring Creek	Beechworth
Railway embankment and bridges	Beechworth
Bridge, Bet Bet Creek	Bung Bong
Railway station complex	Castlemaine
Old coach road and paddock	Chewton
Railway station complex	Chiltern
Railway station complex	Dunolly
Railway station complex	Echuca
Wharf precinct	Echuca
Railway tunnel	Elphinstone
Railway station complex	Elphinstone
Russell's Bridge, Campaspe River	Fosterville
Railway bridge	Harcourt
Railway station complex	Kangaroo Flat
Janevale Monier bridge	Laanecoorie
Railway station complex	Maldon
Railway station complex	Maryborough
Mia Mia iron bridge	Redesdale
Old coach road and paddock	Spring Gully
Railway station complex	St Arnaud
Railway viaduct	Taradale
Railway station complex	Taradale
Seymour-Tocumwal railway bridges	Toolamba
Stone bridge	Waanyarra
<b>Settlement</b>	
Childrens cemetery, Pennyweight Flat	Castlemaine
Settlement site, Trapps or Sailors Gully	Chewton
Welsh Village	Chewton
Old Chiltern Cemetery	Chiltern
Bartley's brewery site	Chiltern Park
Township site	Fosterville
Cemetery	Graytown
Old Kurting township site	Kurting
Cemetery	Murchison
Stony Creek school	Talbot
Tunnel Hill garden beds	Talbot
Township site	Tarnagulla
Township site	Wehla
Cemetery	White Hills

Cemetery	Whroo
Township site	Whroo
<b>Water supply</b>	
Water supply system	Coliban
Pumping station	Echuca
Weir	Goulburn
Barkers Creek reservoir	Harcourt North
Weir	Laanecoorie
Water trust pump site	Murchison
Well	Rheola
Water reserve and dam	Rheola
Syphon, catch drain, tunnel and main channel	Taradale
Reservoir and recreation reserve	Tarnagulla
Weir	Wanalta
Cattanach Channel	Waranga
Stuart Murray Canal	Waranga
Waranga Basin, weir wall, borrow pits and tramway	Waranga
Western Channel, regulator, pumping station and bridge	Waranga
<b>Exploration</b>	
Burke and Wills camp site and cairn	Barnadown
Major Mitchell camp site and cairn, Expedition Pass	Chewton
<b>Military operations</b>	
RAAF camp and airfield	Benalla
Army camp and airfield	Mangalore
Army base and associated features	Puckapunyal
Dysart Siding	Seymour
<b>Miscellaneous</b>	
Mt Pilot lookout, firetower and cairn	Chiltern
Mt Glenrowan tower and Morgan's Lookout	Glenrowan
Township site and internment camp	Graytown
Mount Alexander silkworm farm	Harcourt
Blind Creek ochre mill	Kingower
Prestons hut	Kingower
John Flynn memorial	Moliagul
Welcome Stranger monument	Moliagul
Mt Franklin and reserve	Mt Franklin
Woolshed Falls	Reids Creek
Mudbrick structure, Devonshire Gully	Stuart Mill
Recreation reserve and reservoir	Tarnagulla
Kelly's Caves/bushrangers' hideout	Woolshed

**Note:**

\* Source for gold mining sites: NPS (1996) - see references for Chapter 3.

## Appendix IV

## SITES OF GEOLOGICAL AND GEOMORPHOLOGICAL SIGNIFICANCE IN THE BOX-IRONBARK STUDY AREA

No.	Map	Significance	Location	Description
1	7423	Regional	Stawell Railway cutting	Exposure of faulted and folded Ordovician rocks
2	7524	Regional	3 km north-east of St. Arnaud	Occurrence of unusual silver-lead minerals
3	7524	State	Hard Hills, north-east of St Arnaud	Early Tertiary weathering surface
4	7525	Local	Yawong Hill, north-east of St Arnaud	Hill with granite tors
5	7525	Regional	Barrakee Creek—Lake Marmal	Lake and lunette
6	7623	State	Amherst Reef, west of Talbot	Large dyke of quartz forming ridge
7	7623	Local	5 km east of Campbelltown	Small exposure of Permian glacial rocks
8	7625	Regional	Wedderburn	Anticlinal fold in sedimentary rocks
9	7624	Local	Bealiba Range	Metamorphic ridge is contact aureole
10	7624	Regional	Mt Moliagul	Metamorphic ridge is contact aureole
11	7625	Local	Mt Egbert, north-east of Wedderburn	Granite tors
12	7624	State	Melville Caves—Mt Kooyoora	Excellent examples of pseudokarst weathering in granitic rocks
13	7624	Local	Tylers Flat, Rheola	Aplite dykes intruding gabbro
14	7625	Regional	Mt Korong	Substantial granite monadnock with colluvial fan deposits
15	7724	Regional	Mt Tarrengower, Maldon	Prominent ridge is contact aureole of Harcourt Batholith
16	7723	Regional	Old Nuggety Gully, Yandoit	Unusual plant fossils
17	7724	International	Nuggety Reef, Maldon	Type locality of rare mineral (Maldonite)
18	7725	Regional	Pyramid Hill	Extensive, isolated granite outcrop
19	7725	Regional	Mt Terrick Terrick	Prominent isolated granite hill
20	7725	Local	Regal Rocks, Mitiamo	Large granitic tors
21	7723	Local	Vaughan Springs, Vaughan	Mineral spring, unconformity.
22	7724	Regional	Fogarty's Gap, Harcourt	Excellent example of intrusive contact
23	7723	Regional	Lyttleton Street, Castlemaine	Clear exposure of small anticline
24	7723	Local	Red Cliffs, Vaughan	Tertiary gravels overlying Ordovician rocks
25	7723	Local	Moyston Street, Castlemaine	Clear example of small syncline
26	7723	Local	Campbells Creek—Irishtown Road cutting, Irishtown	Exposures of Lower Ordovician folded sediments
27	7724	Regional	Big Hill, south of Bendigo	Prominent ridge is contact aureole of Harcourt Batholith
28	7724	Regional	Kangaroo Gully, Kangaroo Flat	Unusual volcanic feature of Jurassic age
29	7724	Regional	Lightning Hill, Eaglehawk	Remnant of once extensive quartz ridge features
30	7724	State	Victoria Hill, Bendigo	Excellent example of plunging anticline
31	7723	Local	Chewton—Fryerstown Road cuttings, Fryerstown	Exposures of Lower Ordovician folded sediments
32	7723	Local	Forest Creek, Chewton	Good exposure of structures in Ordovician rocks
33	7724	State	Spring Gully, Bendigo	Excellent graptolite fossil locality

No.	Map	Significance	Location	Description
34	7723	Regional	Chewton railway cutting, Chewton	Excellent example of folded and faulted Ordovician rocks
35	7724	Regional	Eaglehawk	Excellent example of anticline
36	7724	Local	Paddys Gully, Spring Gully	Good example of anticlinal fold
37	7723	Regional	Expedition Pass, Faraday	Contact metamorphism and folded Ordovician sediments
38	7724	Regional	Dixons Quarry, Mandurang	Important graptolite fossil locality
39	7724	Local	One Tree Hill, Bendigo	Good example of synclinal fold
40	7724	Regional	White Hills, Bendigo	Good outcrops of Ordovician sediments and Tertiary gravels
41	7724	National	Harcourt	Type locality of rare mineral (babingtonite)
42	7724	Regional	Mt Alexander *	Abundant outcrop and large tors
43	7723	Local	Dog Rocks, Harcourt	Granite tors and slabs
44	7723	Regional	Elphinstone tunnel, Elphinstone	Excellent example of folded and faulted Ordovician rocks
45	7723	State	Coliban Falls, Redesdale	Cascades and giant potholes in Coliban River
46	7724	Regional	Sugarloaf Range, Fosterville *	Prominent strike ridge in Ordovician sandstone
47	7824	International	Moorabbee, eastern shore of Lake Eppalock *	Excellent exposure of striated glacial pavement
48	7824	International	Hills glaciated pavement, eastern shore of Lake Eppalock	Excellent example of glacial pavement
49	7824	International	Derrinal cutting	Exposure of Permian glacial deposits
50	7824	Regional	Heathcote	Unusual mineral and rock formation
51	7824	Regional	Pink Cliffs, Heathcote	Deeply weathered Cambrian granodiorite
52	7824	State	Heathcote	Exposures of various Cambrian rocks
53	7824	Regional	Mt Ida	Prominent ridge and fossiliferous sandstone
54	7824	State	Lady Pass, Heathcote	Excellent exposure of folded Cambrian rocks
55	7923	Regional	Hume Highway cuttings, Seymour	Folded Siluro—Devonian sediments
56	7924	Regional	Reedy Lake, Nagambie	Abandoned meander and small lunette
57	7924	Local	Kirwans Bridge, Nagambie	Folded Siluro—Devonian sedimentary beds
58	7924	Local	Goulburn Weir	Good exposure of folded Siluro—Devonian sedimentary beds
59	8025	Regional	Mt Major	Outcrops of varied Cambrian rocks
60	8125	State	Warby Ranges *	Complex faulted granites and dykes
61	8125	Regional	Springhurst	Exposures of Permian glacial deposits
62	8225	Regional	Byawatha, north-east of Wangaratta	Extensive aplite dyke system
63	8225	Regional	Native Dog Peak, Beechworth	Domed granite outcrop with tors
64	8225	Local	Woolshed Falls, Beechworth	Falls and gorge in granite
65	8225	Local	East of Beechworth	Ridge at contact metamorphic aureole
66	8225	Regional	Barnawartha	Pegmatite dykes intruding granite
67	8225	International	Wooragee	Exposures of Permian glacial deposits
68	8225	Local	Indigo Upper	Exposure of crushed zone on fault
69	8225	Local	Barnawartha South	High grade metamorphic rocks

**Notes:**

\* Indicates sites larger than 50 ha.

Site numbers correspond to those on Map C.

## Appendix V

ECOLOGICAL VEGETATION CLASSES, LANDSCAPE,  
SOILS AND LAND SYSTEMS

EVCs	Landform, Geology, Soils and Land Systems
Box-Ironbark Forest	<p>On undulating to rolling hills on Ordovician sedimentary parent rock, with slopes generally less than 8 per cent</p> <p>Red duplex soils, red or yellowish-red stony gradational soils, poor gravelly duplex soils; usually well- or moderately-drained, without strongly bleached A2 or mottled B horizons; found on soils with relatively low fertility; the gravelly duplex soils have ironstone in the profile</p> <p>Land Systems 2.1/Gs4.2, Gs4.6, Gs5.3, Gs5.4, Gs5.5, Gs6.2, Gs6.4; 1.1/Gs4.1, Gs5.1</p>
Heathy Dry Forest	<p>Slopes on Palaeozoic sediments and granite, generally steeper than Box-Ironbark Forests (above 10 per cent slopes), rocky crests of rolling hills, and extending to lower slopes of major ranges; on steep slopes on metamorphic aureoles; major occurrence south of Castlemaine; on exposed aspects in the south St Arnaud Range; also widespread in the north-east</p> <p>Uniform stony loam soils on steep slopes, often shallow; bleached red or yellow gradational soils on broader crests; some red duplex soils on gentle lower slopes</p> <p>Land Systems 2.1/Ss4.2, Ss4.3, Ss6.1 (north aspects), Ss6.4, Ss7.6; 1.1/Gs6.2 (part)</p>
Grassy Dry Forest	<p>Palaeozoic sediments, generally steeper than Box-Ironbark Forests (above 10 per cent slopes), and at higher elevations; major occurrence at Mt Pilot; on sheltered aspects in the south St Arnaud Range</p> <p>Shallow stony uniform loam soils; stony red duplex soils</p> <p>Land Systems 2.1/Ss5.2, Ss6.1 (south aspects); 1.1/Gs6.2 (part), Sg7.2 (part)</p>
Heathy Woodland	<p>Small occurrences on Palaeozoic sediments north of Dunolly, and on plains south of Glenalbyn, and near Stawell; from undulating plains to low hills</p> <p>Various soil types with poor nutrient status and low water holding capacity, for example on sands or localised areas with shallow soils over hardpans that limit plant roots, on Tertiary sands and gravels</p> <p>Land Systems 2.1/Gs4.2, Pf4.17</p>
Metamorphic Slopes Shrubby Woodland	<p>On steep metamorphic ridges around Rheola, Kingower, Wedderburn</p> <p>Shallow stony uniform soils, with low water holding capacity, low natural fertility, excessive site drainage; bleached red or yellow gradational soils</p> <p>Land System 2.1/Sg4.1</p>
Granitic Hills Herb-rich Woodland	<p>Granitic hills, particularly at Mt Kooyoora</p> <p>Shallow brown coarse sand soils</p> <p>Land Systems 2.1/Sg4.1, Gg4</p>
Granitic Hills Woodland	<p>Warby Ranges, Mt Pilot</p> <p>Shallow brown coarse sands; pale massive gradational soils</p> <p>Land System 1.1/Sg6.4</p>
Rocky Outcrop Mosaic	<p>Mt Pilot, Warby Range</p> <p>Shallow sands with much outcropping granitic rock</p> <p>Land System 1.1/Sg6.4</p>

EVCs	Landform, Geology, Soils and Land Systems
Sedge-rich Woodland	Deep Lead, Illawarra Sands, where localised clay subsoil causes seasonal inundation; clay loams Land System 2.1/Pf5.2
Low Rises Grassy Woodland	Kamarooka, south of Glenalbyn, Tottington Bleached yellow duplex soils Land Systems 2.1/Gs4.2 (Kamarooka), Pf4.17 (south of Glenalbyn) and in mosaics with Alluvial Terraces Herb-rich Woodland in 2.1/Pf4.8, 4.9, 5.2 (Tottington)
Creekline Grassy Woodland	Many drainage lines without permanent flow Various including bleached mottled yellow duplex soils, sandy alluvial soils Drainage line components in various land systems except where too dry
Valley Grassy Forest	Gentle foot-slopes and creek flats in dissected hills - south St Arnaud Range, Fryers Range, Mt Pilot Various soils including bleached yellow-grey duplex soils Land Systems 2.1/Ss7.6, Ss6.4, in valleys
Hillcrest Herb-rich Woodland	Broad ridgetops and upper slopes of rolling hills at Wedderburn Junction, Bolangum, Mt Brenanah, Mt Moliagul, Mt Tarrengower Shallow uniform stony loam soils, copious fragmented stone Land Systems 2.1/Ss4.1, Ss4.3, Ss5.4
Alluvial Terraces Herb-rich Woodland	Lower slopes, drainage lines and old alluvial plains in gently sloping terrain - south St Arnaud Range, Fryers Range, Mt Pilot Various soils including bleached yellow to brown mottled sodic duplex soils, bleached red and yellow gradational soils, structured alluvial earths Land Systems 2.1/Ss7.6, Ss6.4, in valleys
Gravelly-sediment Mallee	Undulating rises on Ordovician sediments, some contact metamorphosed, around Wedderburn, Inglewood and south of Rushworth Bleached red duplex soils, often shallow and stony, with quartz or ironstone gravel; shallow stony red or yellow gradational soils Land Systems 2.1/Gs4.1 (Wedderburn), Gs4.3 (Inglewood); 1.1/Gs4.2 (Rushworth)
Sandstone-rise Broombush	Tops of gentle rises with lateritic remnants and Ordovician rock around Inglewood, Wedderburn, Bendigo, adjoining Gravelly-Sediment Mallee occurrences Shallow stony soils over lateritic or siliceous hard-pans Land Systems 2.1/Gs4.1 (Wedderburn), Gs4.3 (Inglewood, Bendigo)
Northern plains EVCs	These vegetation communities are broadly located in geomorphic unit 4.2 Riverine Plain — older alluvial plain. There has generally been insufficient vegetation mapping to associate them with individual land systems.
West and Central Riverine Grey Box Grassy Woodlands, Eastern Riverine Grassland	Riverine plain, sandy to clay loam surface soil textures
West Riverine Grey Box Shrubby Woodland	Margin of geomorphic unit 2.1 — dissected uplands on Palaeozoic sediments
Terrick Terrick Cypress-pine Grassy Woodland	Lower slopes of granitic hills Land system 2.1/Gg3
Eastern Low Rises Grassy Woodland	Outwash from geomorphic unit 1.1 — granitic and sedimentary hills

## Appendix VI

### COMMON AND SCIENTIFIC NAMES OF VASCULAR PLANTS

*artichoke thistle	<i>Cynara cardunculus</i>	dense mint-bush	<i>Prostanthera decussata</i>
Audas' spider-orchid	<i>Caladenia audasii</i>	dense spear-grass	<i>Austrostipa densiflora</i>
Ausfeld's wattle	<i>Acacia ausfeldii</i>	dodder-laurel	<i>Cassytha</i> spp.
austral carrot	<i>Daucus glochidiatus</i>	Dookie daisy	<i>Brachyscome gracilis</i>
austral cranesbill	<i>Geranium solenderi</i>	downy Swainson-pea	<i>Swainsona swainsonioides</i>
bald-tip beard-orchid	<i>Calochilus richiae</i>	drooping cassinia	<i>Cassinia arcuata</i>
bear's-ears	<i>Cymbonotus lawsonianus</i>	drooping sheoke	<i>Allocasuarina verticillata</i>
bitter cryptandra	<i>Cryptandra amara</i> var. <i>longiflora</i>	dwarf bluebush	<i>Maireana humillima</i>
Black's goodenia	<i>Goodenia blackiana</i>	erect pepper-cress	<i>Lepidium pseudopapillosum</i>
black bristle-sedge	<i>Chorizandra enodis</i>	Euroa guinea-flower	<i>Hibbertia humifusa</i> ssp. <i>erigens</i>
black-anther flax-lily	<i>Dianella revoluta</i>	feather spear-grass	<i>Digitaria divaricatissima</i>
*blackberry	<i>Rubus</i> spp.	finger panic grass	<i>Prasophyllum fitzgeraldii</i>
blue burr-daisy	<i>Calotis cuneifolia</i>	Fitzgerald's leek-orchid	<i>Astroloma conostephioides</i>
blue devil	<i>Eryngium ovinum</i>	flame heath	<i>Ulex europaeus</i>
blue finger-flower	<i>Cheiranthra cyanea</i>	*furze	<i>Vittadinia cuneata</i>
blue mallee	<i>Eucalyptus polybractea</i>	fuzzy New Holland daisy	<i>Sclerolaena birchii</i>
blue squill	<i>Chamaescilla corymbosa</i>	galvanised burr	<i>Acacia acinacea</i>
bluish bulbine-lily	<i>Bulbine glauca</i>	gold-dust wattle	<i>Cuscuta tasmanica</i>
Boorman's greenhood	<i>Pterostylis boormanii</i>	golden dodder	<i>Glischrocaryon behrii</i>
bottle bluebush	<i>Maireana excavata</i>	golden pennants	<i>Acacia pycnantha</i>
*bridal creeper	<i>Myrsiphyllum asparagoides</i>	golden wattle	<i>Daviesia ulicifolia</i>
bristly greenhood	<i>Pterostylis setifera</i>	gorse bitter-pea	<i>Caladenia versicolor</i>
bristly wallaby-grass	<i>Danthonia setacea</i>	Grampians spider-orchid	<i>Eragrostis molybdea</i>
broom bitter-pea	<i>Daviesia genistifolia</i>	granite love-grass	<i>Oxalis perennans</i>
broombush	<i>Melaleuca uncinata</i>	grassland wood-sorrel	<i>Convolvulus remotus</i>
brush heath	<i>Brachyloma ericioides</i>	grassy bindweed	<i>Prasophyllum lindleyanum</i>
bull mallee	<i>Eucalyptus bebriana</i>	green leek-orchid	<i>Eucalyptus viridis</i>
buloke	<i>Allocasuarina luehmannii</i>	green mallee	<i>Cheilanthes austrotenuifolia</i>
buloke mistletoe	<i>Amyema linophyllum</i> ssp. <i>orientale</i>	green rock fern	<i>Eucalyptus microcarpa</i>
cane spear-grass	<i>Austrostipa breviglumis</i>	grey box	<i>Ozothamnus obcordatus</i>
cane wire-grass	<i>Aristida ramosa</i>	grey everlasting	<i>Hibbertia obtusifolia</i>
*Cape tulip	<i>Homeria</i> sp.	grey guinea-flower	<i>Podolepis canescens</i>
cat's claws grevillea	<i>Grevillea alpina</i>	grey podolepis	<i>Poa sieberiana</i>
cattle-bush	<i>Alectryon oleifolius</i> ssp. <i>canescens</i>	grey tussock-grass	<i>Dodonaea boroniifolia</i>
chocolate-lily	<i>Arthropodium strictum</i>	hairy hop-bush	<i>Levenhookia dubia</i>
clover glycine	<i>Glycine latrobeana</i>	hairy stylewort	<i>Ptilotus erubescens</i>
club-hair New Holland daisy	<i>Vittadinia condyloides</i>	hairy-tails	<i>Austrostipa hemipogon</i>
common bog-sedge	<i>Schoenus apogon</i>	half-bearded spear-grass	<i>Brachyscome lineariloba</i>
common early nancy	<i>Wurmbea dioica</i>	hard-head daisy	<i>Acacia paradoxa</i>
common everlasting	<i>Chrysocephalum apiculatum</i>	hedge wattle	<i>Eucalyptus blakelyi</i>
common fringe-myrtle	<i>Calytrix tetragona</i>	hill red gum	<i>Danthonia eriantha</i>
common hovea	<i>Hovea linearis</i>	hill wallaby-grass	<i>Hakea tephrosperma</i>
common lagenifera	<i>Lagenifera stipitata</i>	hooked needlewood	<i>Marrubium vulgare</i>
common onion-orchid	<i>Microtis unifolia</i>	*horehound	<i>Pomaderris paniculosa</i> ssp. <i>paniculosa</i>
common raspwort	<i>Gonocarpus tetragynus</i>	inland pomaderris	<i>Aristida jerochensis</i> var. <i>subspinulifera</i>
common rice-flower	<i>Pimelea humilis</i>	Jericho wire-grass	<i>Eucalyptus froggattii</i>
common sunray	<i>Triptilodiscus pygmaeus</i>	Kamarooka mallee	<i>Themeda triandra</i>
common wallaby-grass	<i>Danthonia caespitosa</i>	kangaroo grass	<i>Leptorhynchos elongatus</i>
common wheat-grass	<i>Elymus scabrus</i>	lanky buttons	<i>Senecio macrocarpus</i>
common woodrush	<i>Luzula meridionalis</i>	large-fruit groundsel	<i>Templetonia stenophylla</i>
*Cootamundra wattle	<i>Acacia baileyana</i>	leafy templetonia	<i>Bulbine bulbosa</i>
corkscrew spear-grass	<i>Austrostipa setacea</i>	leek lily	<i>Prasophyllum</i> sp. aff. <i>validum</i>
cotton fireweed	<i>Senecio quadridentatus</i>	leek-orchid	<i>Calocephalus citreus</i>
cranberry heath	<i>Astroloma humifusum</i>	lemon beauty-heads	<i>Eucalyptus goniocalyx</i>
creamy candles	<i>Stackhousia monogyna</i>	long-leaf box	<i>Pterostylis woolsii</i>
curved/silky rice-flower	<i>Pimelea curviflora/micrantha</i>	long-tail greenhood	<i>Pterostylis despectans</i>
cut-leaf goodenia	<i>Goodenia pinmatifida</i>	lowly greenhood	<i>Pelargonium rodneyanum</i>
dainty phebalium	<i>Phebalium obcordatum</i>	magenta stork's-bill	<i>Acacia notabilis</i>
daphne heath	<i>Brachyloma daphnoides</i>	mallee golden wattle	<i>Poa lowanensis</i>
Deane's wattle	<i>Acacia deanei</i> ssp. <i>deanei</i>	mallee tussock-grass	<i>Acacia montana</i>
delicate love-grass	<i>Eragrostis tenellula</i>	mallee wattle	<i>Lomandra multiflora</i>
dense crassula	<i>Crassula colorata</i>	many-flowered mat-rush	

maroon spider-orchid	<i>Caladenia concolor</i>	spider-orchid	<i>Caladenia magnifica</i>
milkmaids	<i>Burchardia umbellata</i>	spider-orchid	<i>Caladenia xanthochila</i>
mountain Swainson-pea	<i>Swainsona recta</i>	spiky guinea-flower	<i>Hibbertia exutiacies</i>
Mueller daisy	<i>Brachyscome muelleroides</i>	*spiny rush	<i>Juncus acutus</i>
mugga ironbark	<i>Eucalyptus sideroxylon</i>	spoon cudweed	<i>Stuartina muelleri</i>
Murray Swainson-pea	<i>Swainsona murrayana</i>	spotted emu-bush	<i>Eremophila maculata</i>
myall	<i>Acacia melvillei</i>	spreading eutaxia	<i>Eutaxia diffusa</i>
narrow goodenia	<i>Goodenia macbarronii</i>	spur-wing wattle	<i>Acacia triptera</i>
narrow-leaf bitter-pea	<i>Daviesia leptophylla</i>	spurred spear-grass	<i>Austrostipa gibbosa</i>
narrow-leaf emu-bush	<i>Eremophila sturtii</i>	*St John's wort	<i>Hypericum perforatum</i>
needle greenhood	<i>Pterostylis aciculiformis</i>	sticky hop-bush	<i>Dodonaea viscosa</i>
nodding blue-lily	<i>Stypandra glauca</i>	sticky sword-sedge	<i>Lepidosperma viscidum</i>
nodding chocolate-lily	<i>Arthropodium fimbriatum</i>	stinking pennywort	<i>Hydrocotyle laxiflora</i>
nodding saltbush	<i>Einadia nutans</i>	straw wallaby-grass	<i>Danthonia richardsonii</i>
northern sandalwood	<i>Santalum lanceolatum</i>	streaked wattle	<i>Acacia lineata</i>
paper sunray	<i>Rhodanthe corymbiflora</i>	swamp diuris	<i>Diuris palustris</i>
*Paterson's curse	<i>Echium plantagineum</i>	sweet bursaria	<i>Bursaria spinosa</i>
peppermint box	<i>Eucalyptus odorata</i>	sweet quandong	<i>Santalum acuminatum</i>
pink bindweed	<i>Convolvulus erubescens</i>	tall bluebell	<i>Wahlenbergia stricta</i> ssp. <i>stricta</i>
plains leek-orchid	<i>Prasophyllum campestre</i>	tall raspwort	<i>Gonocarpus elatus</i>
Pomonal leek-orchid	<i>Prasophyllum subbisectum</i>	tall sedge	<i>Carex appressa</i>
purple diuris	<i>Diuris punctata</i>	tall sundew	<i>Drosera peltata</i>
pygmy sunray	<i>Rhodanthe pygmaea</i>	three-nerve wattle	<i>Acacia trineura</i>
quinetia	<i>Quinetia urvillei</i>	tick indigo	<i>Indigofera adesmiifolia</i>
Reader's daisy	<i>Brachyscome readeri</i>	*Toowoomba canary-grass	<i>Phalaris aquatica</i>
red box	<i>Eucalyptus polyanthemus</i> ssp. <i>vestita</i>	totem-poles	<i>Melaleuca decussata</i>
red ironbark	<i>Eucalyptus tricarpa</i>	turkey-bush	<i>Eremophila deserti</i>
red stringybark	<i>Eucalyptus macrorhyncha</i> ssp. <i>macrorhyncha</i>	turnip bassia	<i>Sclerolaena napiformis</i>
rising star guinea-flower	<i>Hibbertia humifusa</i> ssp. <i>humifusa</i>	twiggy bush-pea	<i>Pultenaea largiflorens</i>
river red gum	<i>Eucalyptus camaldulensis</i>	twin-leaf emu-bush	<i>Eremophila oppositifolia</i>
rock isotome	<i>Isotoma axillaris</i>	umbrella wattle	<i>Acacia oswaldii</i>
Rohrlach's bluebush	<i>Maireana rohrlachii</i>	urn heath	<i>Melichrus urceolatus</i>
rough spear-grass	<i>Austrostipa scabra</i>	variable sida	<i>Sida corrugata</i>
rough-barked honey-myrtle	<i>Melaleuca parvistaminea</i>	varnish wattle	<i>Acacia verniciflua</i>
rush species	<i>Juncus</i> spp.	veined caladenia	<i>Caladenia reticulata</i>
rye beetle-grass	<i>Tripogon loliiiformis</i>	veined pepper-cress	<i>Lepidium phlebopetalum</i>
saloop saltbush	<i>Einadia hastata</i>	velvet daisy-bush	<i>Olearia pannosa</i> ssp. <i>cardiophylla</i>
scaly buttons	<i>Leptorhynchus squamatus</i>	wallaby-grass	<i>Danthonia</i> spp., <i>Rytidosperma</i> spp., <i>Notodanthonia</i> spp., <i>Joycea</i> spp.
scaly greenhood	<i>Pterostylis hamata</i>	wallowa	<i>Acacia calamifolia</i>
scented bush-pea	<i>Pultenaea graveolens</i>	waterbush	<i>Myoporum montanum</i>
scented mat-rush	<i>Lomandra effusa</i>	wattle mat-rush	<i>Lomandra filiformis</i>
scented sundew	<i>Drosera whittakeri</i>	wax-lip orchid	<i>Glossodia major</i>
sheep's burr	<i>Acaena echinata</i>	weak daisy	<i>Brachyscome debilis</i>
shiny everlasting	<i>Bracteantha viscosa</i>	weeping grass	<i>Microlaena stipoides</i>
short-hair plume-grass	<i>Dichelachme micrantha</i>	weeping myall	<i>Acacia pendula</i>
shrubby dampiera	<i>Dampiera dysantha</i>	western golden-tip	<i>Goodia medicaginea</i>
silky umbrella-grass	<i>Digitaria ammophila</i>	western silver wattle	<i>Acacia decora</i>
silver needlewood	<i>Hakea leucoptera</i>	*wheel pear	<i>Opuntia robusta</i>
silver wattle	<i>Acacia dealbata</i>	Whipstick westringia	<i>Westringia crassifolia</i>
silvertop wallaby-grass	<i>Chionochloa pallida</i>	white box	<i>Eucalyptus albens</i>
slaty leek-orchid	<i>Prasophyllum frenchii</i>	white cypress-pine	<i>Callitris glaucophylla</i>
slaty sheoke	<i>Allocasuarina muelleriana</i> ssp. <i>muelleriana</i>	whorled zieria	<i>Zieria aspalathoides</i>
slender club-sedge	<i>Isolepis congrua</i>	Williamson's wattle	<i>Acacia williamsonii</i>
slender rice-flower	<i>Pimelea linifolia</i>	winged New Holland daisy	<i>Vittadinia pterochaeta</i>
slender sun-orchid	<i>Thelymitra pauciflora</i>	winged pepper-cress	<i>Lepidium monoplacoides</i>
slender sunray	<i>Rhodanthe stricta</i>	wingless bluebush	<i>Maireana enchylaenoides</i>
slender tick-trefoil	<i>Desmodium varians</i>	wirilda	<i>Acacia retinodes</i>
small loosestrife	<i>Lythrum hyssopifolia</i>	woolly New Holland daisy	<i>Vittadinia gracilis</i>
small milkwort	<i>Comesperma polygaloides</i>	woolly cloak-fern	<i>Cheilanthes lasiophylla</i>
small poranthera	<i>Poranthera microphylla</i>	woolly plover-daisy	<i>Ixiolaena tomentosa</i>
small St John's wort	<i>Hypericum gramineum</i>	yam-daisy	<i>Microseris scapigera</i>
small-leaf goodenia	<i>Goodenia pusilliflora</i>	yellow box	<i>Eucalyptus melliodora</i>
small-leaf wax-flower	<i>Eriostemon difformis</i> ssp. <i>difformis</i>	yellow bulbine-lily	<i>Bulbine bulbosa</i>
smooth minuria	<i>Minuria integerrima</i>	yellow gum	<i>Eucalyptus leucoxydon</i>
spear-grass	<i>Austrostipa</i> spp.	yellow hyacinth orchid	<i>Dipodium hamiltonianum</i>
spider grass	<i>Enteropogon acicularis</i>	yellow rush-lily	<i>Tricoryne elatior</i>
spider-orchid	<i>Caladenia fulva</i>	yellow-tongue daisy	<i>Brachyscome chrysoglossa</i>
		yellowish bluebell	<i>Wahlenbergia luteola</i>

\* Introduced species.

## Appendix VII

### VERTEBRATE FAUNA OF THE BOX-IRONBARK STUDY AREA

Distribution of species across faunal habitat types, ecological vegetation classes (inland hills) and floristic communities (northern plains).

The occurrence of species in relation to habitats is presented at two levels.

1. The occurrence of species in the nine faunal habitat types (denoted in upper case in the heading) is shown by an 'X' (for records derived from site-specific localities) or 'A' (for records derived by mapping).
2. The occurrence of species in EVCs (lower case in the heading) within each faunal habitat type is shown by a '+' or 'A', where information is available. Not all species could be allocated to specific EVCs or floristic communities: species which no longer occur in the study area; or those for which the Atlas records only general locality information, for example. EVCs have not been sampled with equal intensity, and hence the species lists are not equally complete. Those EVCs limited in area (e.g. Rocky Outcrop Mosaic) have received little attention and the number of species recorded from them is likely to be an underestimate. The absence of a species from the list for a particular faunal habitat type, EVC or floristic community does not necessarily mean that it does not occur there, only that it has not been recorded.

Information on habitat use by fauna has been derived in two ways:

- from field surveys at site-specific localities which have been allocated accurately to particular EVCs (shown as '+'); and
- from records in the Atlas of Victorian Wildlife, which have been allocated to an EVC using location data and EVC mapping. These records (shown as 'A') provide additional records for some faunal habitat types, especially those with little site-specific data. However, they may come from a mixture of habitats, and should be taken as indicative only.

Note that Box-Ironbark Forest and Heathy Dry Forest contain only one EVC, of the same name, so are listed as a single column.

Common and scientific names follow Menkhorst (1995)<sup>1</sup> for mammals, with the exception of *Myotis* which follows Kitchener *et al.* (1995); Christidis and Boles (1994) for birds; Cogger (1994) for reptiles and amphibians; and Koehn and O'Connor (1990) for freshwater fish.

Asterisks (\*) indicate introduced species.

<sup>1</sup> For full citations see references for Chapter 9.

SPECIES		FAUNAL HABITAT TYPES & EVCs: (GW = Grassy Woodland)													
Common Name	Scientific Name	BOX-IRONBARK FOREST	MALLEE SHRUBLANDS	HEATHY WOODLANDS	INTERFACE WOODLANDS	HEATHY DRY FOREST	GRASSY DRY FORESTS	ELEVATED WOODLANDS	GRANITIC HILLS WOODLANDS	NORTHERN PLAINS GRASSY WOODLANDS	Terrick Terrick Cypress-pine Grassy Woodland	West Riverine Grey Box GW/Shrubby Woodland	Central Riverine Grey Box Grassy Woodland	East Riverine Grassland / Eastern Low Rises GW	
<b>Mammals</b>															
1 platypus	<i>Ornithorhynchus anatinus</i>														
2 short-beaked echidna	<i>Tachyglossus aculeatus</i>	X	X	+	X	+	X	+	+	X					
3 yellow-footed antechinus	<i>Antechinus flavipes</i>	X	X		X		X			X					
4 spot-tailed quoll	<i>Dasyurus maculatus</i>														
5 eastern quoll (extinct)	<i>Dasyurus vivax</i>														
6 brush-tailed phascogale	<i>Phascogale tapoatafa</i>	X													
7 fat-tailed dunnart	<i>Sminthopsis crassicaudata</i>	A	X	+						X					
8 common dunnart	<i>Sminthopsis murina</i>	X	X	+						X					
9 southern brown bandicoot	<i>Isodon obesulus</i>						X								
10 long-nosed bandicoot	<i>Perameles nasuta</i>							X	A						
11 common wombat	<i>Vombatus ursinus</i>									X				A	
12 koala	<i>Phascolarctos cinereus</i>	X			X	+	X	X	A	X				A	
13 common brushtail possum	<i>Trichosurus vulpecula</i>	X			X	+	X	X	A	X				A	
14 eastern pygmy-possum	<i>Cercartetus nanus</i>	X			X	+	+	X	A	X				A	
15 yellow-bellied glider	<i>Petaurus australis</i>														
16 sugar glider	<i>Petaurus breviceps</i>	X													
17 squirrel glider	<i>Petaurus norfolcensis</i>	X													
18 common ringtail possum	<i>Pseudocheirus peregrinus</i>	X	X	+	A		X	X	A	A					
19 feathertail glider	<i>Acrobates pygmaeus</i>	X													
20 rufous bettong (extinct)	<i>Aepyprymnus rufescens</i>														
21 eastern hare-wallaby (extinct)	<i>Lagorchestes leporides</i>														
22 western grey kangaroo	<i>Macropus fuliginosus</i>	X	X		A	X	+								
23 eastern grey kangaroo	<i>Macropus giganteus</i>	X	X	+	+	X	+	+							
24 bridled nailtail wallaby (extinct)	<i>Onychogalea fraenata</i>														
25 black wallaby	<i>Wallabia bicolor</i>	X	X	+	+	X	+	+							
26 grey-headed flying-fox	<i>Pteropus poliocephalus</i>														
27 little red flying-fox	<i>Pteropus scapulatus</i>	A													
28 southern freetail bat (lp)	<i>Mormopterus planiceps</i>	X	X												
29 southern freetail bat (east. for)	<i>Mormopterus sp.</i>	A													
30 white-striped freetail bat	<i>Tadarida australis</i>	X	X	+	+	X	+	+							
31 Gould's wattled bat	<i>Chalinolobus gouldii</i>	X	X	+	+	X	+	+							
32 chocolate wattled bat	<i>Chalinolobus morio</i>	X	X	+	+	X	+	+							
33 large-footed myotis	<i>Myotis macropus</i>														
34 lesser long-eared bat	<i>Nyctophilus geoffroyi</i>	X	X	+	+	X	+	+							
35 Gould's long-eared bat	<i>Nyctophilus gouldi</i>	X													
36 greater long-eared bat	<i>Nyctophilus timoriensis</i>														
37 inland broad-nosed bat	<i>Scotorepens batstoni</i>	X													
38 large forest bat	<i>Vespadelus darlingtoni</i>	X													
39 southern forest bat	<i>Vespadelus regulus</i>														
40 little forest bat	<i>Vespadelus vulturinus</i>	X	X	+	+	X	+	+							
41 white-footed rabbit-rat (extinct)	<i>Conilurus albiges</i>														
42 water rat	<i>Hydromys chrysogaster</i>														
43 dingo (extinct)	<i>Canis familiaris dingo</i>														
44 house mouse*	<i>Mus musculus</i>	X	X	+											
45 bush rat	<i>Rattus fuscipes</i>														
46 brown rat*	<i>Rattus norvegicus</i>														
47 black rat*	<i>Rattus rattus</i>	A	X		A										
48 feral dog*	<i>Canis familiaris</i>	X	X	+	X	+									
49 red fox*	<i>Canis vulpes</i>	X	X	+	+	X	+	+							
50 cat*	<i>Felis catus</i>	A	A												
51 goat*	<i>Capra hircus</i>	X													
52 pig*	<i>Sus scrofa</i>	A	X		A										
53 brown hare*	<i>Lepus capensis</i>	A													
54 European rabbit*	<i>Oryctolagus cuniculus</i>	X	X	+	+	X	+	+							
<b>Birds</b>															
1 emu	<i>Dromaius novaehollandiae</i>	A			X	+	+	X	A						
2 malleefowl	<i>Leipoa ocellata</i>	A	X	+											
3 stubble quail	<i>Coturnix pectoralis</i>	A													
4 brown quail	<i>Coturnix ypsilophora</i>	X													
5 plumed whistling-duck	<i>Dendrocygna eytoni</i>														
6 Australian shelduck	<i>Tadorna tadornoides</i>		X	+											
7 Australian wood duck	<i>Chenonetta jubata</i>														
8 Pacific black duck	<i>Anas superciliosa</i>														
9 little pied cormorant	<i>Phalacrocorax melanoleucos</i>	X													
10 white-faced heron	<i>Egretta novaehollandiae</i>														
11 white-necked heron	<i>Ardea pacifica</i>		X	+											
12 black-shouldered kite	<i>Elaenius axillaris</i>	A													
13 letter-winged kite	<i>Elaenius scriptus</i>														
14 square-tailed kite	<i>Lophoictinia isura</i>	X													
15 black kite	<i>Milvus migrans</i>	A													
16 whistling kite	<i>Haliastur sphenurus</i>	A	X		A										
17 spotted harrier	<i>Circus assimilis</i>														
18 swamp harrier	<i>Circus approximans</i>														
19 brown goshawk	<i>Accipiter fasciatus</i>	X	X		A										
20 grey goshawk	<i>Accipiter novaehollandiae</i>	A													
21 collared sparrowhawk	<i>Accipiter cirrocephalus</i>	X	X		A										
22 wedge-tailed eagle	<i>Aquila audax</i>	X													
23 little eagle	<i>Hieraeetus morphnoides</i>	X	X		A	+									
24 brown falcon	<i>Falco berigora</i>	X	X												
25 Australian hobby	<i>Falco longipennis</i>	A	X		A										
26 grey falcon	<i>Falco hypoleucos</i>														
27 black falcon	<i>Falco subniger</i>														

FAUNAL HABITAT TYPES & EVCs: (GW = Grassy Woodland)		BOX-IRONBARK FOREST	MALLEE SHRUBLANDS	HEATHY WOODLANDS	INTERFACE WOODLANDS	HEATHY DRY FOREST	GRASSY DRY FORESTS	ELEVATED WOODLANDS	GRANITIC HILLS WOODLANDS	NORTHERN PLAINS GRASSY WOODLANDS
SPECIES										
Common Name	Scientific Name									
28	partridge falcon	Falco peregrinus			X			X	X	X
29	nankeen kestrel	Falco carchoides							X	X
30	Australian bustard	Ardeotis australis								X
31	little button-quail	Turnix velox	X							X
32	red-chested button-quail	Turnix pyrrhorostris	X							X
33	painted button-quail	Turnix varia	X	X	X	X			X	X
34	bush stone-curlew	Burhinus grallarius			X					X
35	masked lapwing	Vanellus miles			X					X
36	rock dove*	Columba livia								X
37	spotted turtle-dove*	Streptopelia chinensis								X
38	common bronzewing	Phaps chalcoptera	X	X	X	X		X	X	X
39	brush bronzewing	Phaps elegans	X	X	X	X		X	X	X
40	crested pigeon	Ocyphaps lophotes			X					X
41	diamond dove	Geopelia cuneata	X	X	X	X				X
42	peaceful dove	Geopelia striata	X	X	X	X				X
43	glossy black-cockatoo	Calyptorhynchus lathami								X
44	yellow-tailed black-cockatoo	Calyptorhynchus funereus								X
45	gang-gang cockatoo	Callocephalon fimbriatum			X					X
46	galah	Cacatua roseicapilla	X	X	X	X	X	X	X	X
47	long-billed corella	Cacatua tenuirostris	X		X	X	X	X	X	X
48	little corella	Cacatua sanguinea	X		X	X	X	X	X	X
49	sulphur-crested cockatoo	Cacatua galerita	X		X	X	X	X	X	X
50	cockatiel	Nymphicus hollandicus			X			X	X	X
51	rainbow lorikeet	Trichoglossus haematodus			X			X	X	X
52	musk lorikeet	Glossopsitta concinna	X	X	X	X		X	X	X
53	little lorikeet	Glossopsitta pusilla	X	X	X	X		X	X	X
54	purple-crowned lorikeet	Glossopsitta porphyrocephala	X	X	X	X		X	X	X
55	Australian king-parrot	Alisterus scapularis								X
56	superb parrot	Polytelis swainsonii								X
57	crimson rosella	Platyercus elegans	X	X	X	X	X	X	X	X
58	yellow rosella	Platyercus elegans flavescens	X	X	X	X	X	X	X	X
59	eastern rosella	Platyercus eximius	X	X	X	X	X	X	X	X
60	Australian ringneck	Barnardius zonarius	X	X	X	X	X	X	X	X
61	blue bonnet	Northiella haematogaster			X			X	X	X
62	swift parrot	Lathamus discolor	X	X	X	X	X	X	X	X
63	red-rumped parrot	Psepholus haematonotus	X	X	X	X	X	X	X	X
64	mulga parrot	Psepholus varius			X			X	X	X
65	budgerigar	Melopsittacus undulatus			X			X	X	X
66	blue-winged parrot	Neophema chrysoloma			X			X	X	X
67	turquoise parrot	Neophema pulchella	X	X	X	X	X	X	X	X
68	pallid cuckoo	Cuculus pallidus	X		X			X	X	X
69	brush cuckoo	Cacomantis variolosus			X			X	X	X
70	fan-tailed cuckoo	Cacomantis flabelliformis	X	X	X	X	X	X	X	X
71	black-eared cuckoo	Chrysococcyx osculans	X	X	X	X	X	X	X	X
72	Horsfield's bronze-cuckoo	Chrysococcyx basalis	X	X	X	X	X	X	X	X
73	shining bronze-cuckoo	Chrysococcyx lucidus	X	X	X	X	X	X	X	X
74	channel-billed cuckoo	Scythrops novaehollandiae			X			X	X	X
75	powerful owl	Ninox strenua	X	X	X	X	X	X	X	X
76	barking owl	Ninox connivens	X	X	X	X	X	X	X	X
77	southern boobook	Ninox boobook	X	X	X	X	X	X	X	X
78	masked owl	Tyto novaehollandiae			X			X	X	X
79	barn owl	Tyto alba			X			X	X	X
80	tawny frogmouth	Podargus strigoides	X	X	X	X	X	X	X	X
81	white-throated nightjar	Eurostopodus mystecalis			X			X	X	X
82	spotted nightjar	Eurostopodus argus	X	X	X	X	X	X	X	X
83	Australian owl-nightjar	Aegotheles cristatus	X	X	X	X	X	X	X	X
84	white-throated needletail	Hirundapus caudacutus	X	X	X	X	X	X	X	X
85	fork-tailed swift	Apus pacificus			X			X	X	X
86	azure kingfisher	Alcedo azurea			X			X	X	X
87	laughing kookaburra	Dacelo novaeguineae	X	X	X	X	X	X	X	X
88	red-backed kingfisher	Todiramphus pyrrophygia			X			X	X	X
89	sacred kingfisher	Todiramphus sanctus	X	X	X	X	X	X	X	X
90	rainbow bee-eater	Merops ornatus	X	X	X	X	X	X	X	X
91	dollarbird	Eurystomus orientalis			X			X	X	X
92	white-throated treecreeper	Clamator leucophaeus	X	X	X	X	X	X	X	X
93	red-browed treecreeper	Climacteris erythropus			X			X	X	X
94	brown treecreeper	Climacteris picumnus	X	X	X	X	X	X	X	X
95	superb fairy-wren	Malurus cyaneus	X	X	X	X	X	X	X	X
96	variegated fairy-wren	Malurus lamberti	X	X	X	X	X	X	X	X
97	spotted pardalote	Pardalotus punctatus	X	X	X	X	X	X	X	X
98	yellow-rumped pardalote	Pardalotus p. xanthopygus	X	X	X	X	X	X	X	X
99	striated pardalote	Pardalotus striatus	X	X	X	X	X	X	X	X
100	white-browed scrubwren	Sericornis frontalis	X	X	X	X	X	X	X	X
101	chestnut-rumped heathwren	Hylacola pyrrophygia			X			X	X	X
102	shy heathwren	Hylacola cauta	X	X	X	X	X	X	X	X
103	striated fieldwren	Calamanthus fuliginosus			X			X	X	X
104	speckled warbler	Chthonicola sagittata	X	X	X	X	X	X	X	X
105	weebill	Smicromis brevirostris	X	X	X	X	X	X	X	X
106	western gerygone	Gerygone fusca	X	X	X	X	X	X	X	X
107	white-throated gerygone	Gerygone olivacea	X	X	X	X	X	X	X	X
108	brown thornbill	Acanthiza pusilla	X	X	X	X	X	X	X	X
109	inland thornbill	Acanthiza apicalis	X	X	X	X	X	X	X	X
110	chestnut-rumped thornbill	Acanthiza uropygialis	X	X	X	X	X	X	X	X

SPECIES		FAUNAL HABITAT TYPES & EVCs: (GW = Grassy Woodland)												
Common Name	Scientific Name	BOX-IRONBARK FOREST	MALLEE SHRUBLANDS	HEATHY WOODLANDS	INTERFACE WOODLANDS	HEATHY DRY FOREST	GRASSY DRY FORESTS	ELEVATED WOODLANDS	GRANITIC HILLS WOODLANDS	NORTHERN PLAINS GRASSY WOODLANDS				
			Sandstone-rise Broombush Gravelly-sediment Mallee	Heathy Woodland Sedge-rich Woodland	Low Rises Grassy Woodland Alluvial Terraces Herb-rich Woodland Creekline Grassy Woodland	Grassy Dry Forest Valley Grassy Forest	Metamorphic Slopes Shrubby Woodland Hillcrest Herb-rich Woodland	Granitic Hills Herb-rich Woodland Granitic Hills Woodland Rocky Outcrop Mosaic	Terrick Cypress-pine Grassy Woodland West Riverine Grey Box GW/Shrubby Woodland Central Riverine Grey Box Grassy Woodland East Riverine Grassland / Eastern Low Rises GW					
110	burn-rumped thornbill	X	X	A	X	A	X	X	A	X	+	A	+	A
111	yellow-rumped thornbill	X	X	A	X	A	A	X	A	X	+	A	+	A
112	yellow thornbill	X	X	A	X	A	X	X	A	X	+	A	+	A
113	striated thornbill	X	X	A	X	A	X	X	A	X	+	A	+	A
114	southern whiteface	X	X	A	X	A	X	X	A	X	+	A	+	A
115	red wattlebird	X	X	+	X	+	X	+	X	X	+	A	+	A
116	little wattlebird	X	X	+	X	+	X	+	X	X	+	A	+	A
117	spiny-cheeked honeyeater	X	X	+	X	+	X	+	X	X	+	A	+	A
118	striped honeyeater	X	X	+	X	+	X	+	X	X	+	A	+	A
119	noisy friarbird	X	X	A	X	A	+	A	X	A				
120	little friarbird	X	X	A	X	A	+	A	X	A				
121	regent honeyeater	X	X	A	X	A	+	A	X	A				
122	blue-faced honeyeater	X	X	A	X	A	+	A	X	A				
123	bell miner	X	X	A	X	A	+	A	X	A				
124	noisy miner	X	X	A	X	A	+	A	X	A				
125	yellow-throated miner	X	X	A	X	A	+	A	X	A				
126	yellow-faced honeyeater	X	X	+	X	+	X	A	A	+	X	X	A	A
127	singing honeyeater	X	X	+	X	+	X	A	A	+	X	X	A	A
128	white-eared honeyeater	X	X	+	X	+	X	A	A	+	X	X	A	A
129	yellow-tufted honeyeater	X	X	+	X	+	X	A	A	+	X	X	A	A
130	purple-gaped honeyeater	X	X	+	X	+	X	A	A	+	X	X	A	A
131	yellow-plumed honeyeater	X	X	+	X	+	X	A	A	+	X	X	A	A
132	fuscous honeyeater	X	X	+	X	+	X	A	A	+	X	X	A	A
133	white-plumed honeyeater	X	X	+	X	+	X	A	A	+	X	X	A	A
134	black-chinned honeyeater	X	X	+	X	+	X	A	A	+	X	X	A	A
135	brown-headed honeyeater	X	X	+	X	+	X	A	A	+	X	X	A	A
136	white-naped honeyeater	X	X	+	X	+	X	A	A	+	X	X	A	A
137	painted honeyeater	X	X	+	X	+	X	A	A	+	X	X	A	A
138	crested honeyeater	X	X	+	X	+	X	A	A	+	X	X	A	A
139	new holland honeyeater	X	X	+	X	+	X	A	A	+	X	X	A	A
140	white-fronted honeyeater	X	X	+	X	+	X	A	A	+	X	X	A	A
141	tawny-crowned honeyeater	X	X	+	X	+	X	A	A	+	X	X	A	A
142	eastern spinebill	X	X	+	X	+	X	A	A	+	X	X	A	A
143	black honeyeater	X	X	+	X	+	X	A	A	+	X	X	A	A
144	white-fronted chat	X	X	+	X	+	X	A	A	+	X	X	A	A
145	jacky winter	X	X	+	X	+	X	A	A	+	X	X	A	A
146	scarlet robin	X	X	+	X	+	X	A	A	+	X	X	A	A
147	red-capped robin	X	X	+	X	+	X	A	A	+	X	X	A	A
148	flame robin	X	X	+	X	+	X	A	A	+	X	X	A	A
149	rose robin	X	X	+	X	+	X	A	A	+	X	X	A	A
150	pink robin	X	X	+	X	+	X	A	A	+	X	X	A	A
151	hooded robin	X	X	+	X	+	X	A	A	+	X	X	A	A
152	eastern yellow robin	X	X	+	X	+	X	A	A	+	X	X	A	A
153	southern scrub-robin	X	X	+	X	+	X	A	A	+	X	X	A	A
154	grey-crowned babbler	X	X	+	X	+	X	A	A	+	X	X	A	A
155	white-browed babbler	X	X	+	X	+	X	A	A	+	X	X	A	A
156	chestnut-crowned babbler	X	X	+	X	+	X	A	A	+	X	X	A	A
157	spotted quail-thrush	X	X	+	X	+	X	A	A	+	X	X	A	A
158	varied sittella	X	X	+	X	+	X	A	A	+	X	X	A	A
159	crested shrike-tit	X	X	+	X	+	X	A	A	+	X	X	A	A
160	crested bellbird	X	X	+	X	+	X	A	A	+	X	X	A	A
161	Gilbert's whistler	X	X	+	X	+	X	A	A	+	X	X	A	A
162	golden whistler	X	X	+	X	+	X	A	A	+	X	X	A	A
163	rufous whistler	X	X	+	X	+	X	A	A	+	X	X	A	A
164	grey shrike-thrush	X	X	+	X	+	X	A	A	+	X	X	A	A
165	leaden flycatcher	X	X	+	X	+	X	A	A	+	X	X	A	A
166	satin flycatcher	X	X	+	X	+	X	A	A	+	X	X	A	A
167	restless flycatcher	X	X	+	X	+	X	A	A	+	X	X	A	A
168	maggie-lark	X	X	+	X	+	X	A	A	+	X	X	A	A
169	rufous fantail	X	X	+	X	+	X	A	A	+	X	X	A	A
170	grey fantail	X	X	+	X	+	X	A	A	+	X	X	A	A
171	willie wagtail	X	X	+	X	+	X	A	A	+	X	X	A	A
172	black-faced cuckoo-shrike	X	X	+	X	+	X	A	A	+	X	X	A	A
173	white-bellied cuckoo-shrike	X	X	+	X	+	X	A	A	+	X	X	A	A
174	cidabird	X	X	+	X	+	X	A	A	+	X	X	A	A
175	ground cuckoo-shrike	X	X	+	X	+	X	A	A	+	X	X	A	A
176	white-winged triller	X	X	+	X	+	X	A	A	+	X	X	A	A
177	olive-backed oriole	X	X	+	X	+	X	A	A	+	X	X	A	A
178	white-breasted woodswallow	X	X	+	X	+	X	A	A	+	X	X	A	A
179	masked woodswallow	X	X	+	X	+	X	A	A	+	X	X	A	A
180	white-browed woodswallow	X	X	+	X	+	X	A	A	+	X	X	A	A
181	black-faced woodswallow	X	X	+	X	+	X	A	A	+	X	X	A	A
182	dusky woodswallow	X	X	+	X	+	X	A	A	+	X	X	A	A
183	grey butcherbird	X	X	+	X	+	X	A	A	+	X	X	A	A
184	piebald butcherbird	X	X	+	X	+	X	A	A	+	X	X	A	A
185	Australian magpie	X	X	+	X	+	X	A	A	+	X	X	A	A
186	piebald currawong	X	X	+	X	+	X	A	A	+	X	X	A	A
187	grey currawong	X	X	+	X	+	X	A	A	+	X	X	A	A
188	Australian raven	X	X	+	X	+	X	A	A	+	X	X	A	A
189	little raven	X	X	+	X	+	X	A	A	+	X	X	A	A
190	white-winged chough	X	X	+	X	+	X	A	A	+	X	X	A	A
191	apostlebird	X	X	+	X	+	X	A	A	+	X	X	A	A
192	satin bowerbird	X	X	+	X	+	X	A	A	+	X	X	A	A

SPECIES		FAUNAL HABITAT TYPES & EVCs: (GW = Grassy Woodland)												
Common Name	Scientific Name	BOX-IRONBARK FOREST	MALLEE SHRUBLANDS	HEATHY WOODLANDS	INTERFACE WOODLANDS	HEATHY DRY FOREST	GRASSY DRY FORESTS	ELEVATED WOODLANDS	GRANITIC HILLS WOODLANDS	NORTHERN PLAINS GRASSY WOODLANDS	TERRICK TERRICK GRASSY WOODLAND	WEST RIVERINE GREY BOX GW/SHRUBBY WOODLAND	CENTRAL RIVERINE GREY BOX GRASSY WOODLAND	EAST RIVERINE GRASSLAND / EASTERN LOW RISES GW
193 singing bushlark	<i>Mirafra javanica</i>													
194 Richard's pipit	<i>Anthus novaeseelandiae</i>										X	A	A	A
195 house sparrow*	<i>Passer domesticus</i>	A									X	+	A	+
196 zebra finch	<i>Taeniopygia guttata</i>	A	X	+							X		A	+
197 double-barred finch	<i>Taeniopygia bichenovii</i>				X									
198 red-browed finch	<i>Neochmia temporalis</i>	A			X	A	A				X	A	A	A
199 diamond firetail	<i>Stagonopleura guttata</i>	X	X	A	X	A	+	A			X	+	A	+
200 European greenfinch*	<i>Carduelis chloris</i>	A						X	+		X	A	A	A
201 European goldfinch*	<i>Carduelis carduelis</i>	A	X	A				X	+		X	A	A	A
202 mistletoebird	<i>Dicaeum hirundinaceum</i>	X	X	+	X	+	+	X	+	+	X	+	+	+
203 white-backed swallow	<i>Cheramoeca leucosternus</i>	A									X	A	A	A
204 welcome swallow	<i>Hirundo neoxena</i>	X	X	+	X	+	+	X	+	+	X	+	+	+
205 tree martin	<i>Hirundo nigricans</i>	X	X	A	X	+		X			X	+	+	+
206 fairy martin	<i>Hirundo anei</i>	X									X	+	+	+
207 rufous songlark	<i>Cinclooramphus mathewsi</i>	A		X	+	+		X	+		X	+	+	+
208 golden-headed cisticola	<i>Cisticola exilis</i>				X	+	+	X	+		X	+	+	+
209 silvereye	<i>Zosterops lateralis</i>	X	X	+	X			X	+		X	A	+	A
210 Bassian thrush	<i>Zosterops lunulata</i>	A									X		A	A
211 common blackbird*	<i>Turdus merula</i>	A			X			X			X		A	A
212 common starling*	<i>Stumus vulgaris</i>	A			X			X			X	+	A	+
213 common myna*	<i>Acridotheres tristis</i>	A						X			X		A	A
<b>Reptiles</b>														
1 common long-necked tortoise	<i>Chelodina longicollis</i>	A									X		A	A
2 tree dragon	<i>Amphibolurus muricatus</i>	X	X	+	X	+		X			X	A	+	+
3 eastern bearded dragon	<i>Pogona barbata</i>	A	X	+				A			X	+	A	+
4 southern spiny-tailed gecko	<i>Diplodactylus intermedius</i>				X						X	+	A	+
5 wood gecko	<i>Diplodactylus vittatus</i>	X	X	A				X	A		X	+	A	+
6 marbled gecko	<i>Christinus marmoratus</i>	X	X	A	X	+	+	X			X	+	A	+
7 thick-tailed gecko	<i>Underwoodisaurus milii</i>	X	X	+				X			X		A	+
8 pink-tailed worm-lizard	<i>Aprasia parapulchella</i>	X	X	+				X	+		X		A	+
9 olive legless lizard	<i>Delma inornata</i>	A	X	+				A			X	+	A	+
10 Burton's snake-lizard	<i>Lialis burtonis</i>	A									X	+	A	+
11 common scaly-foot	<i>Pygopus lepidopodus</i>	X	X	+							X	A		
12 hooded scaly-foot	<i>Pygopus nigriceps</i>										X	A		
13 southern rainbow skink	<i>Cartia tetradactyle</i>	X			X		X				X	+	A	+
14 Carnaby's wall skink	<i>Cryptoblepharus carnabyi</i>						X	A			X	+	A	+
15 large striped skink	<i>Ctenotus robustus</i>	A	X	+	A						X	+	A	+
16 copper-tailed skink	<i>Ctenotus teeniolatus</i>						X				X		A	+
17 uber striped skink	<i>Ctenotus uber orientalis</i>	A	X	+	X	+					X		A	+
18 Cunningham's skink	<i>Egernia cunninghami</i>										X	A		
19 black rock skink	<i>Egernia saxatilis intermedia</i>	A									X	X		+
20 tree skink	<i>Egernia striolata</i>										X	A		
21 white's skink	<i>Egernia whiti</i>	X									X		A	
22 three-toed skink	<i>Hamiergis decreasiensis</i>	X					X	X	A		X	+	A	
23 four-toed skink	<i>Hamiergis peronii</i>													
24 garden skink	<i>Lampropholis guichenoti</i>	X				X		X			X	+	A	+
25 Bougainville's skink	<i>Lerista bougainvillii</i>	X	X	+	X	+		X	X	A	X	+	A	+
26 grey's skink	<i>Monetia greyii</i>	X	X	+				X	+		X	+	A	+
27 Boulenger's skink	<i>Morethia boulengeri</i>	X	X	+	X	+		X	+	+	X	+	A	+
28 blotched blue-tongued lizard	<i>Tiliqua nigrolutea</i>	A									X	A	A	A
29 common blue-tongued lizard	<i>Tiliqua scincoides</i>	X	X	+				A			X	A	A	A
30 stumpy-tailed lizard	<i>Trachydosaurus rugosus</i>	X	X	+	X	+		X			X	A	A	A
31 sand goanna	<i>Varanus gouldii</i>										X	+	A	+
32 tree goanna	<i>Varanus varius</i>	X			X	+	+	A			X	+	A	+
33 carpet python	<i>Morelia spilota variegata</i>										X	A	+	A
34 Peter's blind snake	<i>Ramphotyphlops bituberculatus</i>	A	X	+							X	+	A	+
35 Gray's blind snake	<i>Ramphotyphlops nigrescens</i>										X	+	A	+
36 woodland blind snake	<i>Ramphotyphlops proximus</i>	X	X	+							X	+	A	+
37 eastern tiger snake	<i>Notechis scutatus</i>	A						A			X		A	+
38 red-bellied black snake	<i>Pseudochis porphyriacus</i>	A			X	+	A				X	A		+
39 eastern brown snake	<i>Pseudonaja textilis</i>	X	X	+	X	+		A			X	+	A	+
40 Dwyer's snake	<i>Suta dwyeri</i>	A	X	+	A			A			X	+	A	+
41 little whip snake	<i>Suta flagellum</i>	A			X	+		X			X		A	+
42 Mitchell's short-tailed snake	<i>Suta nigriceps</i>	X	X	+				X			X		A	+
43 bandy bandy	<i>Vermicella annulata</i>	A	X	+				A			X		A	+
<b>Amphibians</b>														
1 southern bullfrog	<i>Limnodynastes dumerilii</i>	X	X	+	X	+		X	+	+	X	+	A	+
2 spotted marsh frog	<i>Limnodynastes tasmaniensis</i>	X	X	+			X				X	+	A	+
3 barking marsh frog	<i>Limnodynastes fletcheri</i>										X		A	+
4 mallee spadefoot toad	<i>Neobatrachus pictus</i>	A	X	+							X	+	A	+
5 common spadefoot toad	<i>Neobatrachus sudelli</i>	X	X	+	X	+		X	+		X	+	A	+
6 Bibron's toadlet	<i>Pseudophryne bibronii</i>	X	X	+				A			X		A	+
7 southern toadlet	<i>Pseudophryne semimarmorata</i>	A									X		A	+
8 plains froglet	<i>Crinia parvisignifera</i>	X	X	+			X	A	+	X	X		A	+
9 common froglet	<i>Crinia signifera</i>	X	X	+	X	+		X	+	X	X	A	A	+
10 Sloane's froglet	<i>Crinia sloanei</i>	A									X		A	+
11 southern brown tree frog	<i>Litoria ewingi</i>	A	X	A			X	+	+		X		A	+
12 plains brown tree frog	<i>Litoria paraewingi</i>	A			X						X		A	+
13 Peron's tree frog	<i>Litoria peronii</i>	A	X	A			X	+	+		X		A	+
14 growing grass frog	<i>Litoria raniformis</i>	A			X			A			X		A	+

## Appendix VIII

### SIGNIFICANT AND NOTABLE VERTEBRATE FAUNA OF THE BOX-IRONBARK STUDY AREA

**Distribution:** assessed for Australia, Victoria and the Box-Ironbark study area using the following criteria:

- R restricted (occurs in less than 10 per cent of study area)
- M moderate (occurs in 10-50 per cent of study area)
- W widespread (occurs in greater than 50 per cent of study area)

**Mammals:** *Australia* — Strahan (1995)<sup>1</sup>; *Victoria and study area* — Menkhorst (1995).

**Birds:** *Australia* — Blakers *et al.* (1984); *Victoria and study area* — Emison *et al.* (1987).

**Reptiles and Amphibians:** *Australia* — Cogger (1994); *Victoria and study area* — Coventry & Robertson (1991), Hero *et al.* (1991) and Brown & Bennett (1995).

**Abundance:** assessed for Australia, Victoria and the Box-Ironbark study area using the following criteria:

- R rare
- U uncommon
- C common
- A abundant
- ? unknown

**Mammals:** *Australia* — Strahan (1995); *Victoria and study area* — Lindy Lumsden (LFL).

**Birds:** *Australia, Victoria and study area* — Charles Silveira (CES).

**Reptiles and Amphibians:** *Australia, Victoria and study area* — Geoff Brown.

#### Conservation Status:

- X Extinct
- E Endangered (taxa in danger of extinction if the causal factors continue operating).
- V Vulnerable (taxa believed likely to move into the endangered category in the near future if the causal factors continue operating).
- R Rare (taxa with relatively small populations that are not at present Endangered or Vulnerable, but are at risk).
- INS Insufficiently Known (taxa *suspected* to be Endangered, Vulnerable or Rare, but categorisation is not possible due to a lack of information).
- R/C Restricted Colonial Breeding or Roosting Sites (taxa that concentrate at specific sites for crucial events).
- S Secure at present
- Not extinct, endangered or vulnerable in Australia

**Mammals:** *Australia* — ANCA (1994, 1996); *Victoria* — CNR (1995); *study area* — LFL.

**Birds:** *Australia* — ANCA (1994, 1996), Collar *et al.* (1994) and Garnett (1992); *Victoria* — CNR (1995); *study area* — CES.

**Reptiles and Amphibians:** *Australia* — ANCA (1994, 1996), Cogger *et al.* (1993); *Victoria* — CNR (1995); *study area* — Brown & Bennett (1995).

#### Population Trend in Victoria

- D Decrease (number of records has decreased and/or distribution has contracted)
- S Stable (no apparent change in extent of distribution or number of records, allowing for varying coverage between eras)
- I Increase (number of records has increased and/or distribution has expanded, allowing for varying coverage between eras)
- D? Possible decrease
- S? Possibly stable
- I? Possible increase
- ? unknown
- N/A Not applicable

<sup>1</sup> For full citations see references for Chapter 9.

Common Name	Distribution			Abundance			Conservation Status			Vic. pop-trend	Comments
	Aust	Vic	B-I	Aust	Vic	B-I	Aust	Vic	B-I		
<b>Significant</b>											
spot-tailed quoll	M	M	R	U	R	R	-	V	E	D	A vulnerable species whose range has decreased markedly since European settlement. Few records from the study area.
brush-tailed phascogale	M	M	W	U	U	U	-	R	R	D	Marked declines in south-western Victoria and Gippsland emphasise the importance of the study area for this species.
common dunnart	M	M	M	C	U	R	-	R	R	D	Occurs throughout the study area but in very low densities.
squirrel glider	M	M	W	R	U	U	-	V	R	D	Most of the Victorian population occurs in the study area.
large-footed myotis	R	M	R	R	R	R	-	R	R	?	Associated with permanent, usually slow-flowing water-bodies.
malleefowl	M	M	R	R	R	R	V	V	E	D	An estimated five to 12 breeding pairs were left in the study area in the mid 1980s; current number unknown.
square-tailed kite	W	W	W	R	R	R	V	V	E	D	Fewer than 50 breeding pairs in Victoria.
grey goshawk	M	M	W	U	R	R	-	R	E	D	Breeding records from the Chiltern and Lake Eppalock areas.
black falcon	W	W	W	R	R	R	-	R	R	?	Its eggs are highly sought after by illegal collectors.
bush stone-curlew	W	M	W	U	R	R	-	V	V	D	Marked declines in southern Victoria emphasise the importance of the study area for this species.
superb parrot	R	R	R	R	R	R	V	V	V	D	Global population is fewer than 5000 pairs.
swift parrot	R	W	W	R	R	R	V	E	E	D	The entire population of fewer than 1000 pairs breeds in Tasmania, then spends the autumn and winter on the mainland.
turquoise parrot	R	R	M	U	U	U	-	R	R	I	Victorian population is still increasing in number and expanding its range since the species re-emerged there in the 1950s.
powerful owl	R	W	W	R	R	R	V	V	V	D	Fewer than 50 breeding pairs in the study area.
barking owl	M	M	W	R	R	R	-	R	R	D	Fewer than 50 breeding pairs in Victoria. Recent studies have confirmed that it is extremely rare in Victoria and may warrant classification as Endangered
masked owl	M	M	R	R	R	R	R	R	R	D	Records from the Yarrawonga area and Redesdale suggest that this cryptic species may breed in the study area. Recent studies have confirmed that it is extremely rare in Victoria and may warrant classification as Vulnerable
regent honeyeater	R	M	M	R	R	R	E	E	E	D	Global population is fewer than 1500 individuals.
painted honeyeater	M	M	W	R	R	R	V	R	V	D	Migrates to Victoria in spring, breeds, then departs by autumn.
grey-crowned babbler	W	M	W	C	R	R	-	E	E	D	Most of the Victorian population occurs in the study area.
apostlebird	M	R	R	U	R	R	-	R	R	D	Only a few groups left in the north-east of the study area.
pink-tailed worm-lizard	R	R	R	R	R	R	E	E	R	D	Victorian population is restricted to the Bendigo area.
hooded scaly-foot	W	R	R	C	R	R	-	E	E	D	Ground-dwelling species known only from a few localities in Victoria.
woodland blind snake	M	M	M	U	U	U	-	R	R	D	Most of the Victorian population occurs in the study area.
carpet python	M	R	R	U	R	R	-	V	V	D	Once fairly common, but now local populations in the study area are largely restricted to rocky outcrops.
bandy bandy	W	M	M	U	R	R	-	V	V	D	Nocturnal burrowing species that feeds exclusively on blind snakes.

Common Name	Distribution			Abundance			Conservation Status			Vic. pop. trend	Comments
	Aust	Vic	B-I	Aust	Vic	B-I	Aust	Vic	B-I		
<b>Notable</b>											
greater long-eared bat	M	R	R	R	R	R	-	INS	INS	?	Only four records for Victoria, one from black box along Bullock Ck. adjacent to Terrick Terrick State Park — given the close proximity to the park, it is likely that the bat species also utilises the habitats there. This species is poorly known ecologically.
emu	W	M	R	C	C	R	-	S	E	D	Probably widespread and possibly locally common at the time of European settlement but had disappeared from most districts soon after the turn of the century. Apparent vagrants or dispersing birds (probably from Barmah forest or mountain forests to the south-east) still occasionally reported. Successfully re-introduced at Puckapunyal.
letter-winged kite	W	W	W	R	R	R	-	R	R	N/A	Irruptive species in Victoria - sporadic, non-breeding occurrences in the study area.
grey falcon	W	M	M	R	R	R	R	V	V	N/A	Very infrequent vagrant, in low to very low numbers, to the study area — mostly in very open country.
red-chested button-quail	M	M	M	U	R	R	-	INS	INS	?	Little known in Victoria probably more common than the few records suggest. Prefers grassland, but does occur in grassy woodland, including recent record near Dunolly in creek-side grey box-yellow gum woodland with grassy understorey (G. Horrocks pers. comm.).
glossy black-cockatoo	M	R	R	U	R	R	V	V	V	D	Small groups recorded irregularly in the Wangaratta area may be vagrants or migrants (from East Gippsland or central NSW), or a resident — confirmation of status is required for assessing conservation needs. Nests in large tree hollows, feeds on <i>Casuarina</i> and <i>Allocasuarina</i> seeds.
blue bonnet	M	M	R	U	U	R	-	S	E	D	Formerly resident in much of the north and west of the study area — has disappeared from the study area during the 20th century with the removal of buloke woodlands.
ground cuckoo-shrike	W	M	M	U	R	R	-	R	R	D	Similar Victorian distribution to apostlebird, but irregular visitor (rather than resident) in the study area, and not as closely tied to box-ironbark vegetation as apostlebird.
tree goanna	M	W	W	U	U	U	-	S	S	?	Hollow-dependent species, rarely observed in open farmland or within the largest blocks of forest. Population densities are generally low and distribution in study area seems to be related to connected systems of habitat (usually involving roadsides and streamsides). Threatened by a loss of tree-hollows, and possible decline in rabbits — a major prey item — as a result of RCD.
Dwyer's snake	R	R	M	U	U	U	-	S	S	?	Few records exist for this cryptic burrowing species that is restricted, in Victoria, to a small number of scattered localities — Chiltern, Warby Ranges, Nagambie and Bendigo, for example. Prefers rock exfoliations and crevices; also shelters under leaf litter, in deep soil cracks and animal burrows and under fallen timber. Major threats to this species include habitat destruction and fragmentation.

## Appendix IX

Appendix IX(a): Public land categories, and LCC recommendations and investigations in the Box-Ironbark study area

Public land category and investigation area	LCC Recommendations	Area
<b>NATIONAL PARK</b>		
North-east Review	A10-A14 Chiltern Box-Ironbark*	4 230 ha
<b>STATE PARKS</b>		
Murray Valley Area	A1 Terrick Terrick* A3 Warby Range*	2 393 ha 7 430 ha
North Central Area	A1 Kara Kara A2 Kooyoora/Melville Caves* A3 Kamarooka* A4 Paddy's Ranges A5 Whipstick	3 868 ha 3 268 ha 6 844 ha 1 675 ha 2 303 ha
<b>REGIONAL PARKS</b>		
Melbourne 1 Review	A10 Hepburn	56 ha
North Central Area	A6 Mount Alexander, A7 One Tree Hill, A8 Eaglehawk, A9 Maryborough	3 660 ha
North-east Review	A9 Reef Hills, A15-A18 Beechworth (part)	2 729 ha
South-west 2	B5 Ararat Hills	1 000 ha
<b>MULTI-PURPOSE PARK</b>		
North-east Review	A25-A28 Mount Pilot	13 633 ha
<b>REFERENCE AREAS</b>		
Murray Valley Area	B1 Terrick Terrick, B4 Killawarra, B5 Warby Range	390 ha
North Central Area	B1 Mount Separation, B2 Kooyoora, B3 Korong Vale, B4 Kamarooka, B5 Sandhurst, B6 Rushworth Forest	2 160 ha
North-east Review	B5 Pilot Range, B15 White Box Ridge	1 220 ha
<b>NATURE CONSERVATION RESERVES</b>		
Melbourne 1 Review	Flora Reserves G3 Mangalore; G15 Fryers Ridge (See NC H12), G16 Upper Loddon	2 290 ha
Murray Valley Area	Wildlife Reserves C20 Gum Swamp, C22 Lehmann Swamp, C23 Shire Dam Swamp Flora Reserves G5 Doherty's Pine, G6 Gowangardie, G7 Upotipotpon Flora and Fauna Reserves G9 Mount Hope, G10 Mount Meg, G11 Boweya	106 ha 17 ha 631 ha
North Central Area	Wildlife Reserves C7 Bells Swamp, C16 Tabilk Lagoon Flora Reserves H2-H9, H10 Inglewood, H11 Hard Hills, H12 Fryers Ridge, H13 Dalyenong, H14 Tarnagulla, H15 Bendigo, H16 Metcalfe, H17 Walmer, H18 Mount Ida, H19 Mount Black, H20 Morri Morri Flora and Fauna Reserves H21 Mount Bolangum, H22 Wychitella, H23 Deep Lead, H24 Landsborough, H25 Pilchers Bridge	208 ha 8 260 ha 9 920 ha
North-east Review	Flora Reserve G2 Big Hill	62 ha
<b>WATER PRODUCTION</b>		
Ballarat Area	[Also water use, regulation and drainage]	Total area 25 900 ha
Ballarat Area	D6 Talbot Reservoir	

Public land category and investigation area	LCC Recommendations	Area
Murray Valley Area	D11-D13, D15-D24, D27-D43, D45, D47 various weirs, pumps, bores; D52 Ardmona Depression, D55 Waranga, D56 Lake Mokoan, D57 Lake Mulwala	
North Central Area	D1 Lake Eppalock, D2 Sugarloaf Res, D3 Lead (Avoca) Res, D4 Landsborough Res, D5 Redbank Res, D6 Bealiba Res, D8 Mosquito Flat Res, D9 Tullaroop Res, D10 Lake Cairn Curran, D11 Laanecoorie Res, D12 Loddon pump, D14 Caledonia Res, D15 Tooborac Res, D16 Campaspe pump, D17 Goulburn pump, D18 Loddon Weir, D19 Spring Gully Res, D20 Sandhurst Water Reserve, Crusoe No7 Res, Big Hill Res; D22-D38, D40-D43, D45, D45A, D46-D49 various channel-filled storages; D50 Waranga, D51 Goulburn Weir; also Teddington Res.	
North-east Review	D11 Diddah Diddah Ck., D12, D13 Barambogie Reservoir, D26 Lake Mokoan offtake	
North-eastern Area District 3	D1 Fifteen Mile Creek	
South-west 2	E5 Lake Lonsdale, E6 Glenorchy Weir, E8 Panrock Res; E57-E61 water reserves	
Wimmera Area	D154, D155 public tanks	
<b>STATE FOREST</b> [See Appendix XI]		
<b>HISTORIC AND CULTURAL FEATURES RESERVES</b>		
Historic Places Special Investigation, South-western Victoria	Highly significant places A2, A3, A4(see SW2 G1), A5, A25, A27, A29, A71(part), A81, A84-A87, A90-A97, A188 Significant places B1, B2(see NC J17), B3-B11, B18-B23, B32-B36, B65-B67, B74, B77, B78, B118, B123, B124, B126-B130, B155, B166 Notable places C18-C21, C41, C42, C78-C85, C87, C140-C144, C146, C163, C167-C188, C205-C208, C210-C213, C216-C219, C222-C226 Revocations M15 Stuart Mill, M16 Deep Lead	
Melbourne 1 Review	N2 Castlemaine-Chewton (See also NC J1)	80 ha
Murray Valley Area	Historic Reserves I1 Woolshed Swamp Sheepwash, I2 Boxwood, I3 Chiltern Valley Extended Mine	75 ha
North Central Area	Historic Areas J1 Castlemaine-Chewton, J2 Percydale, J4 Maldon, J5 Moliagul, J6 Diamond Hill, J7 Whroo Historic Reserves J8 Landsborough, J9 Glendhu, J10 Majorca, J11 Kong Meng, J12 Timor, J13 Tipperary Hill, J14 McIntyre, J15 Rheola Hill, J16 Nine Mile, J17 New Bendigo, J18 Wild Dog Diggings, J19 Bailieston, J20 Fosterville, J21 Wehla, J22 Lower Homebush, J23 Graytown, J24 Kinipalian Creek Weir, J25 Wanalta Weir, J26 Murchison Waterworks Trust, J27 Goldsborough, J29 Gooseberry Hill Tunnel	10 040 ha 655 ha
North-east Review	Historic Reserves N6 Cocks Eldorado Dredge, N7 Cocks Pioneer open cut	20 ha
South-west 2	Historic Reserve G1 Hand in Hand Co Mine	10 ha
<b>NATURAL FEATURES RESERVES</b>		
Ballarat Area	Bushland Reserves H1, H2, H5, H6 Public Land Water Frontage Reserve J1 Streamside Reserves J2, J4	53 ha About 1 km 25 ha

Public land category and investigation area	LCC Recommendations	Area
Melbourne 1 Review	<i>Bushland Reserves</i> I3, I4, I5, I26, I83, I84, I85, I87 <i>Public Land Water Frontage Reserve</i> K1 <i>Streamside Reserves</i> K6, K7, K8, K21, K23, K47 <i>Scenic Reserve</i> P1 Loddon River	47 ha About 35 km 44 ha 13 ha
Murray Valley Area	<i>Wildlife Reserves</i> C19 Black Swamp, C21 McBurney Swamp, C24 Jubilee Swamp, C25 Morphett Swamp, C26 Moodie Swamp, C27 Tungamah Swamp, C28 Rowan Swamp, C29 Dowdle Swamp, C31 Black Swamp <i>Bushland Reserves</i> H6, H8, H11-H13, H17-H19, H19A, H25-H41, H43-H45, H45A, H46, H47, H49-H100, H100A, H101-H105, H105A, H106-H126 <i>Public Land Water Frontage Reserve</i> K1 <i>Streamside Reserves</i> K9-K15, K18-K30 <i>Scenic Reserves</i> J1 Murchison North, J2 Mt Ochertyre <i>Highway Park</i> L10 Casey's Weir	1 427 ha  1 184 ha  About 419 km 759 ha 28 ha 42 ha
North Central Area	<i>Wildlife reserves</i> C2 Greens Creek Swamp, C8 Thunder Swamp, C9 Tang Tang Swamp, C14 Doctors Swamp, C15 Reedy Lake, C18 Murchison Lagoon <i>Geological Reserves</i> N2 Amherst Reef, N3 Parish of Mandurang, N4 Moorabbee shoreline, N6 Coliban Falls <i>Bushland Reserves</i> I3, I7, I10-I20, I30-I48, I50-I54, I56-I83, I85-I151, I153-I160, I162-I183 <i>Public Land Water Frontage Reserve</i> K1 <i>Streamside Reserves</i> K6, K8-K10, K13, K14, K16-K22, K24-K28, K31-K50 <i>Highway Parks</i> L1 Ravenswood, L12 Runnymede <i>Scenic Reserves</i> P1 Mount Korong, P2 The Granites, P4 McIvor Range	1 964 ha  65 ha 3 997 ha About 46 km 896 ha 34 ha 1 700 ha
North-east Review	<i>Bushland Reserves</i> I2, I4-I6, I8-I13, I15-I17, I40, I43, I48, I49, I51, I52, I63, I64, I67-I70, I71-I78, I83-I92 <i>Public Land Water Frontage Reserve</i> K1 <i>Streamside Reserves</i> K8 Indigo Creek, K12 Broken River, K14 Reedy Creek, K17 Reedy Creek, K18 Reedy Creek, K19 Black Dog Creek, K20 Fryngpan Creek <i>Scenic Reserve</i> J2 Barnawartha	532 ha About 103 km 145 ha 60 ha
South-west 2	<i>Bushland Reserves</i> I54, I56-I67, I69-I71, I79-I81, I83 <i>Public Land Water Frontage Reserve</i> K1 <i>Scenic Reserve</i> P2 Bunjil's Cave	228 ha About 12 km 418 ha
Wimmera Area	<i>Bushland Reserves</i> I157-I61, I163 <i>Public Land Water Frontage Reserve</i> K1 <i>Scenic Reserves</i> J1 Mt Gowar, J2 Howell's Hill, J3 Mt Buckrabanyule	238 ha About 32 km 180 ha
<b>COMMUNITY USE AREAS</b>	[Education Areas listed; numerous existing and recommended recreation reserves, not listed, are also Community Use Areas]	
Murray Valley Area	M2 Wallaby Hill (Killawarra)	310 ha
North Central Area	M1 Faraday, M2 Eppalock, M3 Deep Lead, M4 Waranga, M5 Mt Egbert	1 880 ha
North-east Review	L2 Barambogie	700 ha
<b>PLANTATIONS</b>		
North Central Area	F2 Mt Alexander, F3 Castlemaine	803 ha
North-east Review	F1 Barambogie	114 ha

Public land category and investigation area	LCC Recommendations	Area
<b>EARTH RESOURCES</b>		
Ballarat Area	R6-R10	53 ha
Melbourne 1 Review	R5 Clydesdale	95 ha
Murray Valley Area	R7-R20, R22-R27	241 ha
North Central Area	R5, R6, R9-R26, R28-R86, R87, R88(Various)	1 228 ha
North-east Review	R5(Various), R6, R7	123 ha
South-west 2	R9, R10, R13-R17, R19	97 ha
Wimmera Area	R15-R18	51 ha
<b>SERVICES AND UTILITIES</b>		
[Various services and utilities sites are located in the study area. Some lengths of railway line and cemeteries have remnant vegetation, and several tip sites were identified in recommendations, but these are not listed below.]		
Melbourne 1 Review	<i>Roadside Conservation</i> L2 Glenluce Road	About 500m
Murray Valley Area	S10 Dhurrigile Prison <i>Roadside Conservation</i> L3 Dingee-Rochester Rd, L4 O'Dea Rd, L5 Murray Valley Highway, L6 a. Thoona-Boughyard Rd, b. Bungeet Rd, c. Dookie-Devenish Rd, d. Road reserves west of Mount Major, L7 road reserve, Parish of Carlyle, L7A Dell'oro Road	197 ha
North Central Area	<i>Roadside Conservation</i> L2 Fogarty's Gap, L3 Derrinal, L4 Heathcote, L5 Lady's Pass, L6 Colbinabbin, L7 Wedderburn, L8 Wedderburn	
North-east Review	S3 Beechworth Prison <i>Roadside Conservation</i> Kelly Gap and Oak Valley Roads, Longwood	
<b>UNCATEGORISED PUBLIC LAND</b>		
[Applies to many blocks of public land recommended as 'other reserves & public land', 'township land', or land in former cities or towns without LCC recommendations. These are not separately identified by study area or location.]		
<b>LAND NOT REQUIRED FOR PUBLIC PURPOSES</b>		
[Various small parcels were identified for sale in past investigations. These are not separately identified - only large parcels remaining as public land are listed. Several agricultural research stations are shown in this category but these were not been recommended for sale.]		
Murray Valley Area	Q1, Q2, Q4 Research institutes at Kyabram, Tatura and Rutherglen	1 092 ha
North-east Review	Q9 Albury-Wodonga Development Corporation land near Wodonga	
<b>COMMONWEALTH LAND</b>		
Total area 42 660 ha		
Melbourne 1 Review	Part Puckapunyal, Mangalore	
North Central Area	Part Puckapunyal, Longlea, Stawell rifle range	

**Notes:**

\* Park areas exclude reference areas

'North-east Review' is the North-eastern Area (Benalla-Upper Murray) Review

'Melbourne 1 Review' equates with Melbourne Area, District 1, Review.

'South-west 2' is the South-western Area, District 2.

## Appendix IX(b): EVC representation in public land categories

PUBLIC LAND CATEGORIES  EVCs	PUBLIC LAND CATEGORIES																TOTAL
	National Park	State Park	Regional Park	Reference Area	Nature Conservation Reserve	Water Production	State Forest	Historic & Cultural Features Reserve	Natural Features Reserve	Community Use Area	Plantation	Earth Resources	Services and Utilities	Uncategorised public land	Land not required	Commonwealth Land	
Heathy Dry Forest	1,297	4,973	2,634	536	3,779	367	25,159	3,361	975	544	30	60	28	238	0	1,155	45,136
Grassy Dry Forest	90	1,886	5,297	812	350	16	4,908	43	55	167	1	0	29	0	0	151	13,805
Valley Grassy Forest	121	599	1,358	47	284	3	1,633	165	56	20	4	0	0	0	0	34	4,324
Heathy Woodland	0	16	0	0	477	0	1,623	4	112	16	0	62	20	47	0	0	2,377
Box-Ironbark Forest	2,492	4,414	2,207	541	5,557	1,203	133,081	1,994	1,472	1,593	0	502	139	2,042	0	10,934	168,171
Sandstone-rise Broombush	0	614	0	295	1,282	0	1,376	0	5	0	0	0	0	0	0	0	3,572
Gravelly-sediment Mallee	0	2,586	115	129	3,175	4	9,931	10	249	36	0	11	0	82	0	0	16,328
Sedge-rich Woodland	0	0	0	0	337	0	393	11	1	198	0	0	0	0	0	0	940
Low Rises Grassy Woodland	0	3,505	0	182	128	0	343	0	90	0	0	19	0	2	0	0	4,269
Alluvial Terraces Herb-rich Woodland	0	7	776	1	81	21	2,202	95	104	22	0	16	0	12	0	380	3,717
Creekline Grassy Woodland	10	8	0	2	14	2	472	19	146	17	0	0	1	4	0	70	765
Metamorphic Slopes Shrubby Woodland	0	365	0	6	309	0	1,500	0	41	0	0	2	0	10	0	0	2,233
Hillcrest Herb-rich Woodland	0	0	0	105	644	26	1,125	829	0	0	0	0	0	8	0	0	2,737
Granitic Hills Herb-rich Woodland	0	2,378	0	320	163	0	0	216	718	50	0	0	0	0	0	0	3,845
Granitic Hills Woodland	1	3,236	2,041	99	231	0	201	0	167	74	0	8	0	0	0	0	6,058
Rocky Outcrop Shrubland / Herbland Mosaic	0	217	2,780	23	2	0	132	0	54	21	0	0	54	0	0	0	3,283
Low Rises Grassy Woodland / Alluvial Terraces Herb-rich Woodland	0	115	0	0	840	0	1,032	0	47	0	0	2	0	0	0	0	2,036
Alluvial Terraces Herb-rich Woodland / Plains Grassy Woodland Mosaic	0	0	0	0	0	0	799	0	0	0	0	0	3	0	0	0	802
Central Riverine Grey Box Grassy Woodland	0	0	0	0	0	0	0	0	99	0	0	0	0	0	0	0	99
Terrick Terrick Cypress-pine Grassy Woodland	0	2,183	0	153	0	0	0	0	0	31	0	8	6	0	0	0	2,381
Eastern Low Rises Grassy Woodland	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	10
Eastern Riverine Grassland	0	78	40	0	0	0	0	0	26	0	0	0	0	0	0	0	144
Unclassified northern plains units	0	0	0	0	0	0	0	0	106	0	0	0	0	0	0	0	106

Note: Only inland hills areas with EVC mapping are included; northern plains areas reflect isolated occurrences.

## Appendix X

### MANAGEMENT OBJECTIVES FOR WYCHITELLA FLORA AND FAUNA RESERVE

1. To protect and conserve the natural environment and to permit natural processes to continue undisturbed. Special emphasis will be placed upon preservation of the mallee fowl and its habitat.
2. To restore the environment towards its natural state where it has been disturbed by human activity. Particular attention should be paid to recent gold mining sites.
3. To control exotic plants and animals.
4. To protect the Reserve and adjacent communities from damage by fire.
5. To minimise effects on the Reserve of surrounding land uses.
6. To control, and where appropriate terminate inappropriate land uses.
7. To provide recreation facilities where appropriate, and where these do not conflict with objective 1.
8. To provide and maintain suitable access for walkers and vehicles where appropriate.
9. To provide for scientific research, particularly research which seeks to assist in solving management problems.
10. To monitor the mallee fowl population and the ability of the mallee vegetation to maintain viable populations.

*Source:* CFL (1988) — see references for Chapter 11.

## Appendix XI

### FOREST BLOCKS

Block Name	LCC recs.	Area (ha)	Comments
<b>HORSHAM FMA</b>			
Ledcourt	SW2 — F14	680	Production forest; comprises most of the sawlog-productive river red gum forest in the area; important source of firewood for Stawell and Halls Gap.
Lake Lonsdale	SW2 — U1 (pt)	680	Community forest; significant future yellow gum sawlog resource; limited firewood production at present but with considerable potential as a major source for Stawell.
Illawarra	SW2 — F15	1 280	Production forest; large area of yellow gum with important sawlog potential; major source of green firewood for Stawell.
Jalluka	SW2 — F17	1 127	Community forest; only public land firewood source for Moyston.
Morrl Morrl	NC — E3	2 000	Community forest; extensive areas of regrowth and substantial sawlog resource; the only block accessible during winter; important wet-weather wood resource and only winter firewood source for Stawell.
Ironbarks	NC — E1	390	Community forest; dominated by red ironbark regrowth; pensioner firewood only.
Glynwyllyn	NC — E2	750	Production forest; extensive areas of grey box regrowth resulting from heavy cutting for charcoal production during World War II; one of the most timber-productive blocks; being thinned for future commercial production of sawlogs, currently producing green firewood (may produce up to 100 cu.m a month).
<p>Note for Horsham FMA:  Horsham FMA plan has not yet been started but each forest block is managed either as a 'production forest' or a 'community forest' depending on its inherent values and importance. The differentiation reflects the relative importance of each block for either commercial timber production or other values to the local community. Land is managed as a community forest when other values are rated more highly than commercial wood production. The local community retains access to firewood and minor produce but commercial firewood operations are excluded.</p>			
<b>BENDIGO FMA</b>			
Big Tottington	NC — E4	1 600	Future resources for sawlog and other sawn production (see Note 1).
Little Tottington	NC — E5	450	Future resources for sawlog and other sawn production (see Note 1).
St Arnaud Range (part)	NC — E7	10 120	Future resources for sawlog and other sawn production. Important source of domestic firewood. Army exercises in north part. Centre Road provides an attractive scenic drive, scenic views from West of England fire tower, and diverse historic sites (see Note 1).
Glenmona	NC — E8	940	(see Note 2)
Dalyenong	NC — E9	1 090	Future resources for sawlog and other sawn production (see Note 1).
Tunstalls	NC — E10	1 590	(see Note 3)
Paddys Ranges	NC — E11 ) BA — E8 )	8 970	Domestic and commercial firewood production mainly from thinnings; some from integrated sleeper and post operations. Important for Maryborough town supply. 1985 fire-damaged stand salvage completed (see Note 4).
Bealiba	NC — E12	15 000	Main current source for sawlogs, sleepers and posts, along with E20, E21; contains some of the best stands of ironbark regrowth following intensive historical use and silviculture (see Note 3).
West Brenanah	NC — E13	490	
Wedderburn	NC — E14	270	(see Note 3).
Dunach	NC — E15	800	(see Note 4).
Eglington	NC — E16	1 450	(see Note 4).
Majorca	NC — E17	190	(see Note 4).
Maryborough	NC — E18	1 370	(see Note 4).
Havelock-Timor	NC — E19	4 720	
Mt Hooghly	NC — E20	1 970	Main current source for sawlogs, sleepers and posts, along with E12, E21 (see Note 3).

## ENVIRONMENT CONSERVATION COUNCIL

Block Name	LCC recs.	Area (ha)	Comments
Dunolly	NC – E21	11 730	Main current source – State significance – for sawlogs, sleepers and posts, along with E12, E20; contains some of the best stands of ironbark regrowth following intensive historical use and silviculture. (see Note 3).
Longbush	NC – E22	1 220	(see Note 3).
Kingower	NC – E23	2 910	(see Note 3).
Glenalbyn	NC – E24	980	(see Note 3).
Sandon	NC – E25	2 540	Domestic firewood resource for Castlemaine, Maldon, Newstead; future fencing timber resource, local significance; (Table 33 lists production combined with E26, E30 and E31); high level of informal recreation, horse riding tours.
Muckleford	NC – E26	3 570	Domestic firewood resource for Castlemaine, Maldon, Newstead; future fencing timber resource, local significance; (Table 33 lists production combined with E25, E30 and E31); high level of informal recreation, horse riding tours.
Shelbourne	NC – E27	830	High level of informal recreation.
Lockwood South	NC – E28	975	Future fencing timber resource, local significance; high level of informal recreation.
Myers Flat	NC – E29	260	High level of informal recreation.
Castlemaine	NC – E30	590	(Table 33 lists production combined with E25, E26, E30 and E31).
Fryers Ridge	NC – E31	3 840	Regional significance for fencing timber and future sawlog resource; domestic firewood resource for Kyneton; (Table 33 lists production combined with E25, E26 and E30); important 4WD area.
Bendigo	NC – E32	2 250	High level of informal recreation; (Table 33 lists production combined with E33, E34 and E36).
Mandurang	NC – E33	970	High level of informal recreation; (Table 33 lists production combined with E32, E34 and E36).
Mandurang South	NC – E34	1 200	High level of informal recreation; (Table 33 lists production combined with E32, E33 and E36).
Axedale	NC – E35	930	High level of informal recreation.
Wellsford	NC – E36	10 130	Local significance for domestic firewood for Bendigo; regional significance for fencing timber and future sawlog resource; high level of informal recreation; (Table 33 lists production combined with E32, E33 and E34).
Kimbolton	NC – E37	1 920	Future fencing timber resource, local significance; high level of informal recreation.
Knowsley	NC – E38	1 140	High level of informal recreation; (Table 33 lists production combined with E39, E40, E41 and U1 Crosbie).
Heathcote	NC – E39	2 800	Domestic firewood resource for Heathcote, local significance; sawlog and fencing timber resource, regional significance; important for horse riding (Table 33 lists production combined with E38, E40, E41 and U1 Crosbie).
Crosbie	NC – E40	1 640	Future fencing timbers resource in northern part, local significance (Table 33 lists production combined with E38, E39, E41 and U1 Crosbie).
Whroo-Costerfield (Heathcote-Rushworth)	NC – E41	31 770	State significance for durable sawlogs, fencing timbers and commercial firewood; important for Army exercises and car rallies; northern section – domestic firewood resource for Rushworth, locally significant; southern section – domestic firewood resource for Heathcote, locally significant (Table 33 lists production combined with E38, E39, E40 and U1 Crosbie).
Cornella	NC – E42	190	
Bendigo (Whipstick)	NC – G1	2 770	Regionally significant eucalyptus oil resource; 3906 kg produced in 94/95.
Wedderburn	NC – G2	2 300	Centre of the eucalyptus oil industry, with G3; combined production 16 762 kg in 95/96.
Inglewood	NC – G3	5 800	Centre of the eucalyptus oil industry, with G2; combined production 16 762 kg in 95/96.
St Arnaud	NC – G4	565	Eucalyptus oil production 1360 kg in 95/96.
St Arnaud Range south	NC – U1 (pt)	5 270	
Lamplough	NC – U1 (pt)	700	
Granite Hill	NC – U1 (pt)	1 320	

## APPENDIX XI – FOREST BLOCKS

Block Name	LCC recs.	Area (ha)	Comments
Glenalbyn	NC — U1 (pt)	740	
Fryerstown	NC — U1 (pt)	950	(Table 33 lists production with E25, E26, E30 and E31).
Castlemaine	NC — U1 (pt)	250	
Maiden Gully	NC — U1 (pt)	900	
Eaglehawk	NC — U1 (pt)	1 100	High level of informal recreation.
Whipstick	NC — U2, U1 (pt)	840	
Sedgwick	NC — U1 (pt)	1 150	
Mosquito Creek	NC — U1 (pt)	3 220	Future fencing timber resource, local significance; high level of informal recreation.
Taradale	NC — U1 (pt)	200	
Redesdale	NC — U1 (pt)	375	
Crosbie	NC — U1 (pt)	380	(Table 33 lists production with E38, E39, E40 and E41).
Rushworth	NC — U1 (pt)	860	
Waranga	NC — U1 (pt)	700	
Tooborac	Melb1 — E1 (pt)	315	
Notes for Bendigo FMA:			
1. In E4, E5, E7 and E9, 113 ha were harvested in 1995/96, producing 2368 cu.m firewood and 5025 posts.			
2. In E6 and E8, 98 ha were harvested in 1995/96, producing 1185 cu.m firewood, and 3006 posts.			
3. In E10, E12, E14, E20, E21, E22, E23 and E24, 1357 ha were harvested in 1995/96, producing: 6101 cu.m firewood; 54 167 posts; and 778 sleepers.			
4. In E11, E15, E16, E17 and E18, 374 ha were harvested in 1995/96, producing: 6013 cu.m firewood; 16 580 posts; and 25 sleepers.			
MIDLANDS FMA			
Pyrenees Ranges	NC — E6 ) BA — E2 )	18 290	Foothills of Pyrenees of State significance for durable timber species; mixed species sawlogs from upper elevations. Waterfalls, Governors Rocks and viewing tower, Mt Cameron walking track are popular with visitors (see Note 2 above).
Dunneworthy	BA — E1	2 448	
Lexton	BA — U1 (pt)	240	
Ararat	BA — U1 (pt)	100	
Jim Crow Ranges	Melb1 — E1 (pt)	290	Small part in Box-Ironbark study area.
MID-MURRAY FMA			
Killawarra Forest	MV — F1 (pt)	2 777	
Barmah Forest	MV — F1 (pt)	-	
Cobram East	MV — F1 (pt)	-	
Arcadia	MV — F1 (pt)	-	
Toolamba	MV — F1 (pt)	-	
Mooroopna	MV — F1 (pt)	-	
St Germain's	MV — F1 (pt)	-	
Lower Ovens	MV — F1 (pt)	-	
Benalla	MV — F1 (pt)	-	
NORTH EAST FMA			
Barambogie Forest	NER — E1 (pt)	3 049	

**Notes:**

LCC recommendations column refers to the previous investigations as follows: MV — Murray Valley Area; NC — North Central Area; SW2 — South-western Area, District 2; BA — Ballarat Area; Melb1 — Melbourne Area, District 1 Review; NER — North-eastern Area (Benalla–Upper Murray) Review.

For the NC, SW2 and BA investigations, 'E' or 'F' recommendations refer to hardwood production; 'G' recommendations are for eucalyptus oil production; 'U' recommendations identify uncommitted land. For the MV, Melb1 and NER investigations, 'E' and 'F' refer to State forest.

## Appendix XII

### FOREST MANAGEMENT PLANNING

Planning in State forest occurs at three levels: forest management plans (FMPs), wood utilisations plans, and coupe plans.

#### Forest management plans

FMPs aim at integrating and balancing commercial uses of State forest with the conservation of natural and cultural values. An FMP has been approved for the Midlands FMA, and Bendigo and Mid-Murray FMA planning is in progress. These plans are to be reviewed every ten years, or sooner if necessary.

In FMPs State forest is allocated to three management zones which recognise particular resource values and uses, and specify management actions.

- **General Management Zone (GMZ)** — managed for a range of uses with timber production a major use, under standard controls imposed through prescriptions and other mechanisms;
- **Special Management Zone (SMZ)** — managed to conserve specific features, while catering for timber production to the extent it does not conflict with conservation of specified features.
- **Special Protection Zone (SPZ)** — managed for conservation; timber harvesting and other uses that conflict with conservation are excluded.

SMZ management may require application of specific timber harvesting or regeneration systems, retention of certain classes of trees, or a limit to the extent of harvesting.

Interspersed with productive timber stands are forest areas unsuitable for timber production. In the GMZ

harvesting of commercial products can only take place in parts of the forest that are both available (in terms of prescriptions) and suitable (that is, productive) for sawlogs.

#### Wood Utilisation Plans

Each year, the Forests Service prepares a draft wood utilisation plan (WUP) indicating areas proposed to be harvested the following year, and outlining proposals for harvesting coupes for the subsequent two years.

The draft WUP is circulated for comment within NRE, and advertised to encourage comment. The final WUP is authorised by relevant NRE Functional Managers and the Regional Manager.

All timber harvesting operations for a particular year are restricted to approved WUP areas, except where emergency situations necessitate tree felling for salvage or public safety.

#### Coupe Plans

Coupe plans derived from approved WUPs are required for each commercial timber harvesting operation. These:

- indicate operational areas and exclusion zones on detailed maps
- list product types
- outline estimated quantities of timbers available for utilisation
- indicate the harvesting method
- set out any special conditions not included in the standard prescriptions.

Coupe plans expire on 30 June each year.

## Appendix XIII

# PRESCRIPTIONS, GUIDELINES AND ZONING TO PROTECT ENVIRONMENTAL AND OTHER VALUES IN FOREST MANAGEMENT

### Timber harvesting prescriptions

In the Bendigo FMA prescriptions specify the following areas to be excluded from timber harvesting:

- specific sites known to contain rare, vulnerable or endangered species or communities of flora or fauna of State-wide significance requiring protection;
- other sites with significant conservation values requiring protection;
- land within 30 m of the banks of designated permanent streams and wetlands;
- land within 10 m of designated temporary streams
- sites of historical or archaeological significance requiring protection;
- areas within 40 m of developed recreation sites including fireplaces and picnic tables;
- land within 10 m of vertically or near-vertically sided gullies that have a depth of half a metre or more, and are actively eroding.
- areas within 20 m or more of any other asset so nominated on the coupe plan (see Coupe Plans, below).

### Veteran and hollow-bearing trees

Guidelines to protect existing veteran trees and provide for recruitment of new ones, in the Bendigo FMA, are as follows.

DBHOB Class	Bendigo FMA State forests general management prescriptions
20 to 40 cm	at least 2 trees per ha
40 to 60 cm	at least 2 trees per ha
60 cm or larger	at least 2 trees per ha

Notes:

1. These guidelines represent long-term goals and aim to develop an uneven-aged structure in the forests.

2. DBHOB = Diameter at Breast Height Over Bark. This is the diameter of the tree at 1.3 m from the ground.
3. Trees to be retained should be the larger ones within each of the size classes except where smaller trees currently display the characteristics of veteran trees, contain hollows or have the potential to develop hollows in the short term. Where the numbers of trees in a coupe permit, habitat trees may be grouped.
4. Where less than the prescribed number of trees is available for retention in any of the size classes, for each tree less than that prescribed, two trees should be retained in the next lower size class.
5. During thinning operations, the mix of tree species retained should be proportional to their numbers in the original stand.
6. Dead standing trees above certain minimum sizes are also retained.

Between 6 and 14 habitat trees per hectare are currently identified for retention, depending on their availability in the three size classes. This range is brought about by compensating for a lack of trees in one or more of the size classes. For instance, where there are less than two large suitable habitat trees per hectare, for each tree fewer than that prescribed, an additional two medium-size habitat trees must be retained. Similarly, a short-fall of the medium-size trees is compensated for by retaining an additional two small trees for each unavailable medium tree. Where both the large- and medium-size trees are absent, a total of 14 small trees must be retained.

As the forest develops, at least two trees must be retained within each size class, even if more than the minimum number of suitable trees exists within the other size classes. Overall, this selection process aims at both ongoing recruitment of hollow-bearing trees and some regulation of stocking.

## Habitat trees

Within each size class of retained trees, habitat trees are selected for retention, in accordance with the following list of decreasing priorities:

- a)
  - trees with branch or trunk hollows
  - holes at least 2 cm in diameter, at least 10 cm in depth, and at least 1.3 m above ground level (at least 4 trees per hectare are retained across all size classes if possible)
- b)
  - wide-crowned trees with high nectar producing potential
  - those with crown-widths at least two-thirds of the mature tree height (as least 2 trees per hectare are retained across all size classes if possible)
- c)
  - trees with the potential to form branch or trunk hollows
  - those with holes less than 2 cm wide and/or less than 10 cm deep, or dry branches or broken limbs at least 10 cm in diameter, which are at least 1.3 m above ground level
- d)
  - trees with the potential to form wide crowns
  - those with strong lateral branching over at least half mature tree height or trees located in openings at least 30 m wide
- e)
  - trees infested with mistletoe
- f)
  - largest available trees within each size class.

Prescriptions also specify that the following types of trees within coupes are excluded from timber harvesting:

- yellow box trees
- trees on the Departmental Register of Significant Trees
- trees at least 80 cm DBHOB
- trees regularly used by gliders (particularly the squirrel glider) for food

## Zoning for conservation of Ecological Vegetation Classes

Representative examples of EVCs are identified for protection in SPZs along with parks and reserves. For current forest management planning purposes in the Bendigo FMA, the proportion of each EVC to be protected from timber harvesting generally increases with the rarity of the EVC in the landscape. Each EVC on public land is ranked according to its total area and rarity across the FMA, and minimum targets of between 30 per cent and 90 per cent set

for protection. The target proportion of each EVC to be protected is calculated in terms of its extent on public land compared to the estimated natural extent — before European settlement — of forests and woodlands in the FMA.

Although aimed at planning for State forest, FMPs also take account of the uses and degree of representation and protection of values on other public land, including parks and reserves. Planning for forests aims to ensure that protected land categories — conservation reserves and SPZ in State forest — include:

- at least 30 per cent of the area of each EVC that occupies more than 1 per cent of the original extent of forests and woodlands in the FMA
- between 30 per cent and 90 per cent of the area of EVCs (depending on the extent of the particular community) that occupy between 0.1 per cent and 1 per cent of the original extent of forests and woodlands in the FMA
- at least 90 per cent of the area of EVCs that occupy less than 0.1 per cent of the original extent of forests and woodlands in the FMA.

Where feasible, examples of EVCs that are inadequately represented in the existing conservation reserve system are protected in State forest SPZ. No account is taken of the current extent of natural vegetation on freehold land, however, as NRE has no control over the maintenance of conservation values of these areas.

The representation targets (30 per cent and 90 per cent) are applied at the FMA level but have regard to the presence and degree of protection of the EVCs in adjacent FMAs. Where feasible, viable samples of the EVCs are also protected within geographic subdivisions of the FMA. This provides representation across the geographic range of the EVC, to address the principle of protection of genetic diversity within the EVC as well as to guard against the risk of a catastrophic event destroying isolated populations.

Where additional areas of State forest are required to meet the above targets, the EVCs are selected from areas, *inter alia*:

- known to contain, or to have once contained, threatened flora or fauna;
- identified as being good representative examples of the community;

- that support the requirements of other conservation strategies in the respective Plans;
- that help to establish an inter-linked protected area network across the FMA;
- that are unsuitable for timber production.

## Midlands FMA

In Midlands FMA, Box-Ironbark forest types have been identified for representation in reserves as summarised below:

Vegetation community	Occurrences in study area	% of original extent	Protection target (%)	Representation in Midlands FMA		
				Conservation reserves (ha)	State forest SPZ (ha)	Total protected (%)
Box/Ironbark Open Forest I/II (included in Box-Ironbark Forest EVC)	Pyrenees	0.07	30-90	285 <sup>3</sup>	25	46
Gum/Box Woodland I/Open Forest I (included in Box-Ironbark Forest EVC)	Landsborough Ridge, Dunneworthy	0.46	30-90	1640	670	51
Red Stringybark/Box Open Forest I/II (included in Heathy Dry Forest or Grassy Dry Forest EVCs according to aspect))	Pyrenees, Dunneworthy	2.4	30	5775	4505	43
Messmate/Peppermint/Gum Open Forest II/III	Southern Pyrenees, Jim Crow Ranges	-	-	Not Box-Ironbark vegetation		

### Notes:

1. Midlands public land in the Box-Ironbark study area covers 18 260 ha.
2. The largest area of Box/Ironbark Open Forest in the Midlands FMA occurs on the lower slopes of the Pyrenees State Forest. The FMA protection target recognises that the small area of this forest type is an artefact of the placement of the FMA boundary, rather than rarity of the forest type, which is relatively extensive in the Bendigo FMA.
3. Landsborough Flora and Fauna Reserve.

## MAJOR MINES – BOX-IRONBARK INVESTIGATION AREA

Company	Location	Titles	Area (ha)	Overlap with BIF (ha)	Operation	Total resource/reserve (contained gold)	Production 1995/96	Comment
Alliance Gold Mines NL	Maldon	MIN 4496,4831, 4852, 4977, 5065, 5066, 5146, ML 1461	707 (for main MIN5146)	136	Open cut & underground mine; 250 000 tpa CIP treatment plant	120 000 oz at Union Hill North and Alliance South (Eaglehawk & Linscotts Reefs)	2 214 oz (68.9 kg) - trial mining	Several prospects in the Maldon goldfield are under investigation. At Union Hill, an exploratory decline has been completed and Linscott and Eaglehawk Reefs have been drilled, and commercial underground mining is proceeding on two fronts. The plant at Porcupine Flat has been upgraded to treat ore from Union Hill and other sources. The company expects production to increase to 25 000 oz p.a (about 780 kg).
Perseverance Corporation Ltd	Fosterville	ML 1868, MIN 4877, 4456, 5177	1 897	479	Open cut mines; heap leach gold extraction; 1.1 M tpa plant	Total about 130 000 oz oxide; 637 000 oz sulphide	37 931 oz (1 180 kg)	Mining in past 2 years from Robbins Hill, Harringtons Flat and Sharkey's Pit. Production expected to increase to 90 000 oz p.a. when open-pit sulphide ore production comes on stream. Feasibility studies underway for a bacterial oxidation plant to treat sulphide ore. Exploration continues along strike from known orebodies.
Perseverance Corporation Ltd	Bailieston, near Nagambie	MIN 4784	225	69.9	Open cut mine; heap leach gold extraction	Total > 65 000 oz	n/a	Production commenced in February 1996
Perseverance Corporation Ltd	Nagambie	MIN 4244, ML 1983	784	Nil	Open cut mine and heap leach; now closed	Reserves exhausted, mid-1993	1 632 oz (51 kg)	Mine closed and under rehabilitation after several years production which reached a peak of about 40 000 oz p.a.
Stawell Gold Mines Pty Ltd (joint venture between MPI Gold Pty Ltd & Pittston Mineral Ventures of Aust.)	Stawell	ML 1219, MAL 65, MIN 5007, 4901	1 003	78	Two underground mines with declines; 750 000 tpa CIL plant	> 850 000 oz	97 321 oz (3027 kg)	An efficient underground operation with current resources for about 10 years, and the highest Victorian gold producer. Mining of Magdala lodes advancing at 50 vertical metres p.a. which rapidly increases haulage costs. Three specific ore types are stockpiled separately for batch milling.

## Major mines — box-ironbark investigation area (continued)

Company	Location	Titles	Area (ha)	Overlap with BIF (ha)	Operation	Total resource/reserve (contained gold)	Production 1995/96	Comment
New Holland Mining NL / International Mineral Resources	Heathcote	ML 952, 1552; MIN 4619, 4787	130	87	Open cut mine closed	Viable resource exhausted	2 558 oz (79.6 kg)	Mining ceased in October 1995 due to a decline in ore grade with depth in the Hird's Pit.
Australian Gold Development NL	Costerfield	MIN 4073, 4344, 4473	391	134	Open cut mine at Costerfield / Bombay; 160 000 tpa CIP plant	Total > 90 000 oz in Brunswick and Bombay Zones	7 018 oz (218 kg)	Production to date has been largely from tailings retreatment, drilling has established oxide and sulphide (including antimony) resources in the Brunswick zone and oxide resources in the Costerfield/Bombay zone. Further exploration aims to locate resources for a 10 year mine life at 18 000 oz gold and 2500 t antimony p.a. A new sulphide ore treatment plant is being built.
Reef Mining NL	Tarnagulla	MIN 4756, 5148, 5149	626	532	Underground mine with decline	about 175 000 oz	Nil	The South Poverty Reef inferred resources, established by diamond drilling, are currently being developed by means of the Crystal Hill decline which commenced in July 1995. Bulk and face sampling so far have confirmed drilling results. Mine access to high grade shoots is underway, with treatment at the Duketon CIP plant near Chewton.
Sedimentary Holdings NL	Ampitheatre, Mountain Hut	MIN 4814, 4556	881	Nil	Two open pits in alluvials; gravity separation plants	85 000 oz	3 642 oz (113.3 kg)	The Ampitheatre operation commenced in Feb. 1992 and is reworking old, disturbed areas. It feeds a central plant, whereas the Mountain Hut operation which commenced in mid-1996 uses more efficient in-pit processing.
International Mineral Resources NL	St. Arnaud	MIN 4372, 4802, 4543	257	170	Open cut (care & maintenance)		1 087 oz (33.8 kg)	After treating tailings from the Lord Nelson mine site, the company commenced mining at the nearby Comstock - Walkers deposit, but resources were soon depleted.

Key: n/a - not available; CIL - carbon in leach treatment; CIP - carbon in pulp treatment

Note: The column 'overlap with BIF' (box-ironbark forests) relates to existing tree cover, predominantly on public land.

## MAJOR PROSPECTS – BOX-IRONBARK INVESTIGATION AREA

Company	Location	Titles	Area (ha)	Overlap with BIF (ha)	Operation	Total resource/ reserve (contained gold)	Comment
Bendigo Mining NL	Bendigo	MIN 4584, 4878, 5151, 5165, 5167, 5172, ML 1345	4 494 (for main ML 1 45)	713	Various prospects	Total 300 000 oz	Open pits are proposed at Williams United, Birds and South Carshalton gold projects. Approval for underground mining being sought for Deborah project. Exploration continuing elsewhere on the Bendigo field, including Quartz Hill.
Duketon Goldfields NL	Castlemaine, Chewton, Fryerstown	MIN 4470, MAL 41, EL 3242	245.2 (for mining titles); 15 800 (for EL)	180 (for mining titles)	Exploration; mine infrastructure & operating CIP plant at Wattle Gully	n/a	Exploration is in early stages, with targets comprising massive quartz reefs, stockwork systems and alluvials. Diamond drilling has been undertaken at Argus Flat and Bonnett Flat.
Highlake Resources NL	Dunolly, Harvest Project	MIN 4965, 4838, 4837	624	574	Exploration	60 000+ oz	The most advanced of the many Highlake projects. Drilling around Harvest Home / Mother O'Gold & Appletons prospects totalling 7000 m was complete in Oct. 1996, with open-pit mine potential in wide zones of quartz veining.
Highlake Resources NL	Campbelltown Project	EL 3377	12 480	1 540	Exploration	n/a	Drilling in the Bosuns prospect area totalled 3221 m in Oct. 1996 with many favourable intersections & potential large tonnage targets. Some prospects within EL overlap with existing box-ironbark vegetation.
Metex Resources NL	Myers Creek	EL 3844, 4044, 4045	29 300	1 030	Exploration	n/a	Metex has several prospects in Victoria which are considered prospective for bulk mineable gold. Drilling in Myers Creek region has established hard rock targets beneath shallow cover, along strike from the Bendigo Goldfield. At the Mopoke Prospect, anomalous gold values have been obtained over a 700 m X 175 m zone.
Alliance Gold Mines NL / Eureka Gold Mines NL	Clunes	EL 3262, 3723	3 700	Nil	Exploration	n/a	Former partner Carpentaria Gold obtained encouraging drill results from northern end of Clunes lode system. Alliance is continuing investigations of this system.
Alliance Gold Mines NL / Metex Resources NL	Creswick	EL 3405, 3406, 3822, 3823	37 100	Nil	Exploration	n/a	Targets are reef systems, concealed beneath basalt, which may be primary sources for deep lead gold. Preliminary work has included assessment of airborne geophysical and old drilling data, and ground geophysical surveys have been performed.
Golden Heritage Mining NL/ Aberfoyle Resources Ltd	Allendale (by joint venture) Madam Berry (GHM)	EL 3646, 3647, 3807, 3780, 3953	92 00	Nil	Exploration	n/a	Targets are partly primary, i.e. gold-quartz veins in northerly extensions of Ballarat reef lines beneath basalt covered deep leads; and partly deep lead alluvial gold. Exploration is in the early stages.

**Key:** n/a - not available; CIL - carbon in leach treatment; CIP - carbon in pulp treatment

**Note:** The column 'overlap with BIF' (box-ironbark forests) relates to existing tree cover, predominantly on public land.

## Appendix XV

### LAND DEGRADATION HAZARD TYPES AND OCCURRENCES ON PRIVATE LAND

Water erosion is the detachment and movement of particles of soil in water, of several types:

- *sheet and rill erosion* is caused across soil surfaces by the impact of raindrops;
- *gullying* occurs in drainage lines where flowing water removes detached topsoil and subsoil. Gully heads proceed upstream; once established gullies commonly continue to widen, and tributary gullies form;
- *streambank erosion* can occur by gullying processes, scouring by water flows, or following removal of bank vegetation;
- *tunnel erosion* can occur in soils with dispersible horizons where subsurface water flows form cavities. These often collapse initiating gullies.

Recorded in OCE (1991), sheet and rill erosion observed over the previous six years was moderate to severe in the middle Avoca Valley from Bealiba to Charlton, in the area Maldon–Metcalf–Heathcote, along Mt Camel Range, around Puckapunyal, and moderate in hills around Dookie and adjoining the Warby and Pilot Ranges. Tunnelling was worst in the upper Wimmera and Avoca river catchments, and around Eppalock, Seymour and Dookie. Observed gullying was most severe between the Pyrenees and the western boundary of the study area, and the Indigo Creek valley.

Milton (1971) carried out a detailed survey of gully erosion, effectively covering the inland hills. The average density of gullies was 0.5 km/sq.km, with the highest density of 7.2 km/sq.km around Landsborough, and gully densities of 5.8 to 6.4 km/sq.km common, for example on Mt Camel Range and in the Eppalock Catchment.

Deposition of sediment onto land with lesser slope can follow erosion and transport of soil material. Sand- and silt-size soil particles are deposited in still water or may remain suspended in flowing water; the smaller clay particles may form colloidal suspensions, producing turbid water.

Structure decline is the result of various factors affecting pore spaces in soils. Inherent soil characteristics such as slaking (crumbling on wetting) and dispersion of clays, impact of raindrops or applied water, decline in soil fauna, inappropriate cultivation or other land-use practices, and traffic of hard-hoofed stock or vehicles in poor conditions, together or separately can contribute to structure damage, including:

- *surface sealing* or crusting, which reduces infiltration;
- *hard setting* when dry, which reduces penetrability for plant roots;
- *compaction*, which reduces pore space for air and water, restricting plant root growth; and
- *waterlogging*, which follows loss of aeration in poorly drained soils.

Soil structure decline was observed (OCE 1991) to be severe over the entire study area including the northern plains, except for the Maldon–Mt Alexander granitic areas, Mt Camel Range, Nagambie to Murchison, and around Benalla–Glenrowan.

**Leaching of nutrients** is the process by which dissolved nutrients are removed by water passing through a soil, resulting in the decline of soil nutrient levels. Leaching is an issue where low natural nutrient levels, or removal of nutrients in cut hay, silage, vegetables or other crops are combined with free draining soil types. Sandy loams in moderate to high rainfall conditions, well-drained gravelly soils dominated by quartz or ironstone, and highly weathered well-structured clay loams, can display nutrient leaching.

**Mass movement:** landslips can occur on deep soils or deeply weathered parent material on slopes, often following wetter than usual conditions. Mass movement is not a major form of land degradation in the study area. The south St Arnaud Range, Pyrenees and hills west of Wodonga are susceptible to mass movement, according to OCE (1991).

**Acidification** has been recognised as a significant problem during the past 20 years. Many Victorian soils are naturally acidic, but agricultural practices over recent decades have contributed to increasing acidity. Causes of this change include removal of (basic) plant and animal products, use of ammonium-based nitrogen fertilisers, and increased leaching of nitrates below the root zone following cultivation. Acidification can render the soil unsuitable for sensitive pastures and crops, and encourage acid-tolerant weeds and other plants that are not productive. Acidification favours aluminium and manganese concentrations that may be toxic, and leads to deficiencies in several beneficial nutrients.

Extremely acidic soils were observed (OCE 1991) around the margins of the Whipstick–Kamarooka public lands, from Taradale to Heathcote, and between Mangalore and Winton.

## Appendix XVI

### PROGRAMS AND PRIORITIES RELATING TO HAZARDS IN CATCHMENT MANAGEMENT AUTHORITY REGIONAL STRATEGIES

Program	Priorities
<b>GOULBURN BROKEN</b>	
General principles	<ul style="list-style-type: none"> <li>• local area planning to implement suitable land use and best management practices</li> <li>• strengthen support and resourcing for Landcare groups</li> <li>• encourage property management planning using land capability</li> <li>• advise Government on catchment management codes of practice</li> <li>• implement monitoring and assessment of programs</li> </ul>
Irrigation	<ul style="list-style-type: none"> <li>• accelerate implementation of Shepparton salinity management plan</li> <li>• accelerate implementation of irrigation part of Goulburn–Broken water quality strategy</li> <li>• develop and implement local area plans for pest plants and animals</li> </ul>
Dryland	<ul style="list-style-type: none"> <li>• accelerate implementation of the Goulburn–Broken salinity management plan</li> <li>• reduce sediment/nutrient loads by treating active gully and tunnel erosion</li> <li>• develop and implement programs to address acidity and structure decline</li> <li>• complete Dookie local area plan for priority pest plants</li> </ul>
River and water quality	<ul style="list-style-type: none"> <li>• commence implementation of the Goulburn–Broken water quality strategy</li> <li>• expand water quality strategy to address other parameters</li> <li>• accelerate implementation of waterway stability programs</li> <li>• reduce weeds on stream banks</li> <li>• complete river frontage licence review to achieve best practices</li> <li>• implement drainage component of the Shepparton salinity management plan</li> <li>• develop/implement a catchment dryland drainage strategy</li> </ul>
Public lands	<ul style="list-style-type: none"> <li>• improve efficiency of the Good Neighbour program</li> <li>• major pest species include foxes, cats, common mynas and St Johns wort</li> <li>• public land managers to perform in accordance with the C&amp;LP Act</li> <li>• support application of the Code of Forest Practices for biodiversity and water quality</li> <li>• ensure rare/threatened species/communities/habitats/other biological values are identified in fire plans with appropriate management</li> <li>• support review of fire policy and management to achieve ecological objectives and cost-effective wildfire threat management</li> </ul>
<b>NORTH CENTRAL</b>	
Irrigation	<ul style="list-style-type: none"> <li>• accelerate implementation of salinity management plans</li> <li>• expand SMPs to include emerging land and water priorities</li> </ul>
Dryland	<ul style="list-style-type: none"> <li>• accelerate implementation of dryland salinity management plans</li> <li>• expand DSMPs to include emerging land and water priorities</li> </ul>
Biodiversity	<ul style="list-style-type: none"> <li>• provide incentives to ensure retention of priority remnant vegetation</li> <li>• prepare a vegetation strategy for the region</li> <li>• ensure clearing applications maintain vegetative cover and are supported by municipal planning schemes</li> <li>• develop monitoring and assessment activities for remnant vegetation, biological monitoring and flora and fauna data</li> </ul>
Soil health	<ul style="list-style-type: none"> <li>• conduct a survey of soil structure decline and acidity to identify priority areas</li> <li>• prepare a coordinated strategy to target high priority areas</li> <li>• develop a monitoring program</li> <li>• address soil erosion through incentives, initiative funding, and extension programs</li> </ul>
Waterways and water resources	<ul style="list-style-type: none"> <li>• develop and implement water quality strategies for the Loddon, Avoca, Avon–Richardson, and Campaspe rivers</li> <li>• implement waterway management strategies</li> <li>• monitor threats to groundwater quality</li> <li>• prepare and implement groundwater quality control measures</li> </ul>
Pest plants and animals	<ul style="list-style-type: none"> <li>• 75 pest plant species are listed; rabbits and foxes are well established</li> <li>• support local groups to establish community pest plant control standards</li> <li>• follow up RCD outbreaks and support community groups</li> </ul>
Communication	<ul style="list-style-type: none"> <li>• support existing Landcare networks</li> </ul>
<b>NORTH EAST</b>	
Water quality and waterways	<ul style="list-style-type: none"> <li>• develop water quality strategy for the Ovens Basin</li> <li>• implement waterway stability and restoration action plans</li> <li>• implement surface and groundwater quality and quantity monitoring programs</li> <li>• promote adoption of best available frontage management practices to enhance riparian vegetation, including review of licence arrangements</li> </ul>

Land management	<ul style="list-style-type: none"> <li>• complete and implement North East salinity strategy</li> <li>• coordinate and support Landcare — technical support, property management planning and industry-based programs</li> <li>• develop and implement a strategy to manage acid soils</li> <li>• support management programs that reduce the effects of water erosion</li> <li>• promote best management practices</li> <li>• develop and implement statutory provisions to ensure appropriate land management</li> </ul>
Pest plants	<ul style="list-style-type: none"> <li>• eradicate State and regionally prohibited weeds</li> <li>• contain, reduce and where possible eradicate priority regionally controlled weeds — blackberry, Paterson's curse, St John's wort, broom (<i>Genista</i> spp.)</li> <li>• develop and implement a regional control strategy for priority pest plants</li> <li>• develop and maintain a database on the distribution and control of priority pest plants</li> <li>• develop and promote best management practices</li> <li>• determine and adopt appropriate levels of enforcement</li> </ul>
Pest animals	<ul style="list-style-type: none"> <li>• implement RCD action plan integrated with on-ground works</li> <li>• develop, coordinate and monitor fox reduction programs</li> <li>• determine the extent of cat, carp and pig infestations and develop appropriate action plans</li> </ul>
Biodiversity	<ul style="list-style-type: none"> <li>• develop a biodiversity strategy and incorporate principles into management strategies and programs</li> <li>• improve knowledge of species presence, distribution and biology</li> <li>• prepare and implement regional native vegetation retention guidelines and plans to enhance habitat</li> <li>• develop and implement strategies for particular ecosystems and species</li> </ul>
Fire management	<ul style="list-style-type: none"> <li>• ensure protection of natural environments is recognised in fire management strategies</li> </ul>
Land use and regional development	<ul style="list-style-type: none"> <li>• ensure planning schemes incorporate Authority objectives and priorities</li> <li>• establish a formal process between the Authority and stakeholders to ensure coordination of natural resources, management strategies and implementation</li> <li>• provide advice to local government over development proposals</li> <li>• cooperate with industry and regional development authorities</li> <li>• expand opportunities for the development of primary industries</li> </ul>
<b>WIMMERA</b>	
Sustainable land management and productivity	<ul style="list-style-type: none"> <li>• develop and implement a program to improve hill country management</li> <li>• encourage municipalities to undertake land capability assessments</li> <li>• develop a program to address soil structure decline</li> <li>• develop strategies for fertiliser application that minimises nutrient run-off</li> <li>• implement salinity management plan</li> <li>• develop a program to determine the extent and severity of soil acidity</li> <li>• support coordinated program of chemical drum disposal</li> </ul>
Water	<ul style="list-style-type: none"> <li>• develop an integrated water quality management program</li> <li>• ensure towns over 500 people with water supply have land-based waste disposal systems</li> <li>• improve septic tank management</li> <li>• develop an integrated groundwater management program</li> <li>• develop an environmental flow program</li> <li>• develop policies to protect water supplies for existing uses and the environment</li> <li>• encourage improved management of public and private stream and wetland frontages by reviewing licensing, limiting grazing, rehabilitation, advice and fencing incentives</li> <li>• develop a drainage management program</li> <li>• develop and implement an integrated waterway management program</li> </ul>
Environment	<ul style="list-style-type: none"> <li>• achieve a net gain in indigenous vegetation</li> <li>• promote rate (etc.) incentives to take land out of production</li> <li>• review native vegetation retention measures</li> <li>• undertake fauna protection activities on public and private land</li> <li>• develop and implement a detailed revegetation strategy, including water frontages, corridors, roadsides, and erosion and salinity control</li> <li>• deliver integrated pest control programs, including works, planning and education</li> <li>• support rabbit and fox control programs</li> <li>• increase efforts to minimise economic and environmental damage by problem wildlife, without compromising conservation</li> </ul>
General recommendations	<ul style="list-style-type: none"> <li>• deliver effective extension and support landholder groups</li> <li>• promote and increase property management planning</li> <li>• ensure planning schemes incorporate catchment strategy objectives and priorities</li> <li>• establish a formal process between the Authority and local government for coordination and strategy implementation</li> <li>• support the 'Good Neighbour' program</li> <li>• undertake road management to reduce impacts on the surrounding environment</li> <li>• review grazing licences to achieve sustainable management and protect conservation and recreation values</li> <li>• implement monitoring and assessment programs for salinity, surface and groundwater, and Waterwatch</li> <li>• provide advice on regional monitoring needs</li> </ul>

## Appendix XVII

### LCC RECOMMENDATIONS FOR GRAZING ON PUBLIC LAND

#### NORTH CENTRAL AREA

##### Edited extract from recommendations report

- For the areas available for grazing, an important management goal must be to maintain the vegetative cover and, where the cover is inadequate, to ensure its recovery.
- Areas of public land could be available to meet emergency situations, and such grazing could be controlled by the issue of agistment rights commensurate with the management goals of the particular areas of public land.
- There could be a greater degree of coordination and the formulation of a common policy in the selection and management of areas on which grazing will be permitted.
- A committee comprising representatives of the Department of Natural Resources and Environment and the graziers should advise on:
  - \* selection and delineation of grazing areas, their allocation, and terms of grazing rights (this may necessitate some re-allocation of grazing areas);
  - \* grazing charges;
  - \* exclusion of stock when and where necessary to provide for conservation of flora and fauna, prevention of soil erosion, protection of water catchment values, protection of forest regeneration works, or the reclamation of eroded areas;
  - \* additional research necessary to monitor the effects of grazing on catchment hydrology and nature conservation values;
  - \* the financial implications of terms that may be attached to the licence.
- Suggested terms and conditions are given below:
  - \* provision should be made to allow the land managing authority to exercise general supervision of grazing management, especially with respect to times of grazing and stocking rates;
  - \* grazing may be excluded from parts of the licence area, as determined by the managing authority;
  - \* no sub-leasing or assignment of grazing rights by a licensee should be permitted without the approval of the management authority;
  - \* cultivation and clearing should not be permitted, except

when this is necessary to control vermin and noxious weeds;

- \* grazing licences would not imply any form of exclusive use or control over the area by the licensee;
- \* licences should be subject to any other terms and conditions that the managing authority considers necessary;
- \* licences should be liable to cancellation for non-compliance with the conditions.
- The proposed committee should act as a review or monitoring body and should assess and report at regular intervals on the impact of grazing on public land.

#### MURRAY VALLEY AREA

##### Edited extract from recommendations report

- The intensity, location, and timing of grazing on public land should be consistent with the aim of maintaining an adequate vegetative cover, thereby minimising both soil erosion and the loss of sensitive species by grazing, either directly or indirectly, through a change in soil fertility.
- Some areas of public land should be managed primarily for the maintenance and enhancement of the ecosystems they support. In these areas, grazing by domestic stock is an inappropriate use and the land manager should take all practicable steps to exclude them.

##### Killawarra Forest

- Grazing should be substantially reduced in both intensity and frequency so that the native understorey vegetation can be re-established and maintained.
- Grazing should be confined to areas that have strategic importance for fire protection in the forest, and should be used in conjunction with other methods of reducing fuel accumulation. The severe erosion hazard in this forest should be taken into account when planning fire-protection measures and other management activities.
- The land manager monitor the effects of grazing on both native overstorey and understorey species in the forest.

##### Note:

In order to effectively monitor the effects of grazing, this use would have to be excluded from parts of the forest, and the area east of Chinamans Creek is suggested.