

MELBOURNE AREA

DISTRICT 2 REVIEW

DESCRIPTIVE REPORT



 LAND CONSERVATION COUNCIL

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AUGUST 1991



LAND CONSERVATION COUNCIL

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Cover Photograph:

*Old-growth ash forest in the Board of
Works' Wallaby Creek water supply catchment*

Photograph: Provided courtesy of the
Board of Works

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FOREWORD

The Land Conservation Council was established under the *Land Conservation Act* 1970. The function of the Council is to carry out investigations and make recommendations to the Minister with respect to the use of public land in order to provide for the balanced use of land in Victoria. (An extract of the Act is provided in Appendix I).

This report provides a factual basis for the preparation of submissions to the Council, by describing and assessing the natural, economic, and cultural resources and characteristics of public land in the study area. Its purpose is to ensure that all those persons and bodies who have an interest in the future use of this public land can obtain and study the basic information that the Council itself will study, and so make informed and constructive suggestions to the Council for its consideration.

Council is also aware that numerous community and industry groups and individuals possess specific information about the values and uses of such areas, and is therefore seeking their involvement in expanding its information base, prior to formulating any land-use recommendations.

Submissions are now invited and should be forwarded to the Secretary of the Land Conservation Council by the closing date for submissions, as notified in the Victorian *Government Gazette*, and advertised in State and regional newspapers. After considering all submissions Council will prepare its proposed recommendations and these will be published. Another public submission period will follow. The Council will then prepare its final recommendations and these are presented to the Minister for Conservation and Environment and tabled in Parliament.



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- * Australian Heritage Commission
- * Alpine Resorts Commission
- * Bird Observers Club of Australia
- * Board of Works
- * Department of Conservation and Environment
- * Department of Manufacturing and Industry Development
- * Environment Protection Authority
- * Department of Agriculture and Rural Affairs
- * Rural Water Commission
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ABBREVIATIONS

Organisations

ARC	Alpine Resorts Commission
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCE	Department Conservation and Environment
DCFL	Department Conservation, Forests and Lands
DMID	Department of Manufacturing and Industry Development
DPUG	Department Planning and Urban Growth
DVA	Dandenong Valley Authority
DWR	Department Water Resources
EPA	Environment Protection Authority
LCC	Land Conservation Council
LRWA	Latrobe Region Water Authority
LVWSB	Latrobe Valley Water and Sewerage Board
MMBW	Melbourne and Metropolitan Board of Works
MPE	Ministry for Planning and Environment
MPDWB	Mornington Peninsula and District Water Board
RAN	Royal Australian Navy
RWC	Rural Water Commission
SECV	State Electricity Commission of Victoria
SWL	State Water Laboratory
UYVDRA	Upper Yarra Valley and Dandenong Ranges Authority

Measurement Units

%	per cent
\$	dollar
£	pound
cm	centimetre
cu.m	cubic metre
cu.m per ha per annum	cubic metre per hectare per annum
°C	degrees Celsius
gm	gram
ha	hectare
kg	kilogram
kg per ha per annum	kilogram per hectare per annum
km	kilometre
kV	kilovolt
L	litre
m	metre
mg per litre	milligram per litre
ML	megalitre
ML per annum	megalitre per annum
ML per month	megalitre per month
ML per ha per annum	megalitre per hectare per annum
mm	millimetre
NTU	nephelometric turbidity unit
oz	ounce
sq. km	square kilometre
μS per cm	micro siemen per centimetre

PART I
INTRODUCTION

1. INTRODUCTION

This review follows the Land Conservation Council's first investigation of the Melbourne Area, which commenced in 1971. Council published a descriptive report in 1973 (LCC 1973), and released final recommendations for the use of public land in the area in 1977 (LCC 1977).

Since the first investigation, the Melbourne Area has been divided into two districts: District 1 west of the Hume Highway and District 2 east of the Hume Highway. The location of the study area is shown on Map 1. A review of District 1 has been completed; Council produced a descriptive report in 1985 (LCC 1985) and published its final recommendations in 1987 (LCC 1987a).

Advertisements stating that the Council intended to review the Melbourne Area, District 2 appeared in the *Government Gazette* and in local and Victorian newspapers on or about 18 July 1984.

Council made 540 recommendations for the Melbourne Area in 1977, of which some 36 were deferred or rejected and a further 33 varied by government. These recommendations were dominated by the land-use categories of hardwood timber production, parks, and uncommitted land. Baw Baw National Park and, Eildon, Kinglake, and Bunyip State Parks were among the 29 parks proposed by Council, as well as numerous other conservation reserves. In the original Melbourne investigation, the largest total area was recommended for hardwood production, amounting to some 39% of the public land. 'Uncommitted land' accounted for a further 21%. Since the time of the 1977 recommendations, Uncommitted land has been managed and used in the same way as hardwood production areas (and recent Council recommendations have amalgamated the two categories into one, called 'State forest').

Details of current land use are given in Chapter 11, Public Land Use.

Two special investigations conducted by Council have overlapped small portions of the Melbourne, District 2, study area:

LaTrobe Valley Special Investigation (LCC 1987b, 1987c); and Hill End Special Investigation (LCC 1982, 1983). Current LCC investigations at the State-wide level also overlap: the Wilderness and Rivers and Streams Special Investigations. Descriptive reports have been released for both studies (LCC 1989, 1990), and those land-use recommendations arising from them, where specified, supersede the previously approved recommendations for the study area.

Council's policy for undertaking reviews, as explained in the 'State-wide Assessment of Public Land Use' (LCC 1988), is also to re-evaluate unresolved issues from earlier studies, respond to altered demands or values regarding public resources, and incorporate some of Council's changed policies arising out of more recent studies. Some of these issues are discussed later in this chapter.

The Council is aware that many changes in demand for the use of public land cannot be foreseen, and that the value of resources will change as exploration, research, and technology progress. For these reasons, the Council believes that periodic reviews of public land use in the State are desirable, and it must be expected that resources will be reallocated or adapted to meet changed demands.

Aims and methods

The aims of this descriptive report are:

- * to describe the physical and biological attributes of the study area, including an assessment of various natural resources
- * to describe present public land uses
- * to examine alternative forms of land use
- * to assess hazards and conflicts associated with specific land uses
- * to identify the major issues relating to current and potential land uses

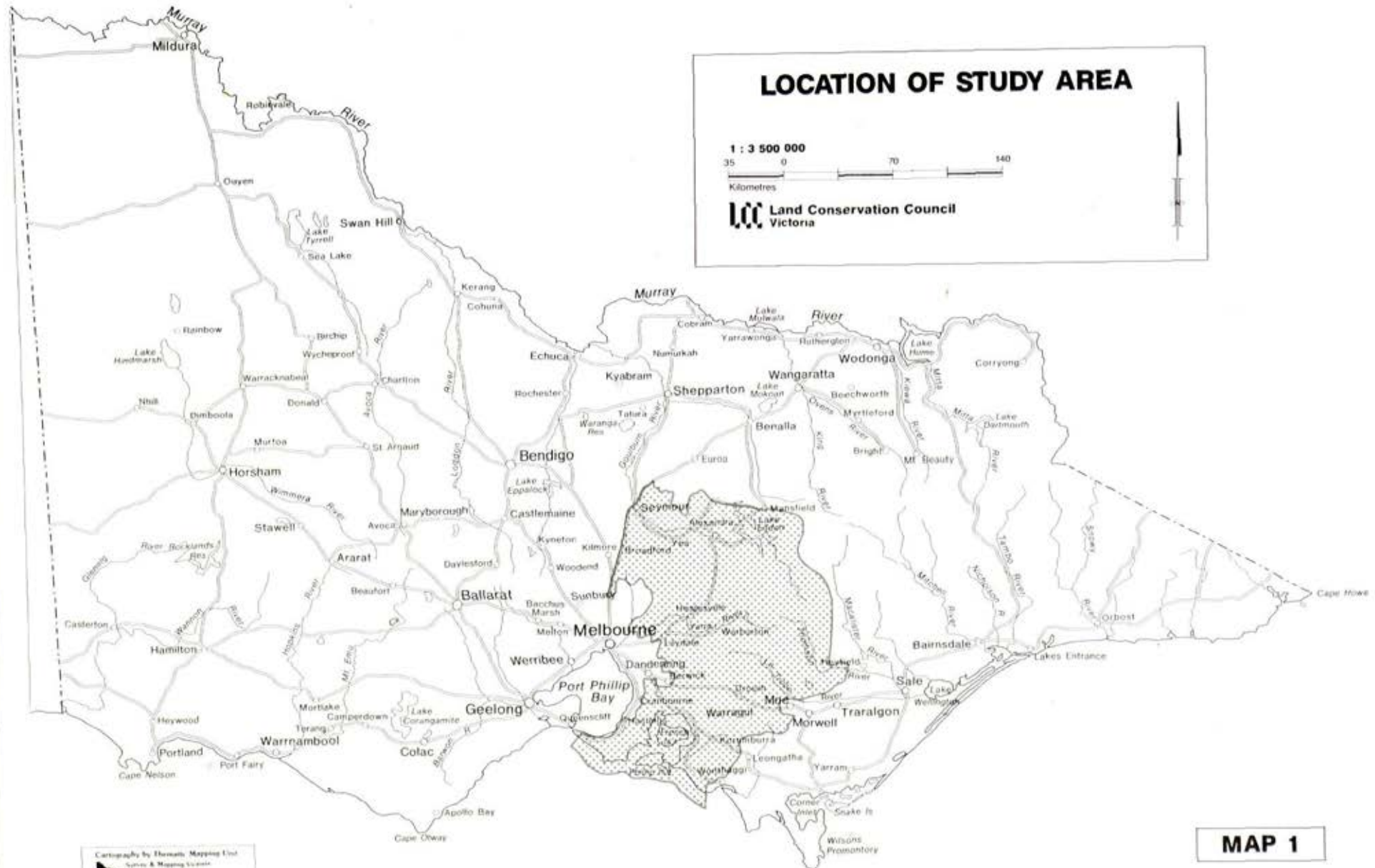
As with other Land Conservation Council reviews, this review draws upon materials in earlier investigations, in this case the 1973 'Report on the Melbourne Study Area' (LCC 1973).

LOCATION OF STUDY AREA

1 : 3 500 000



Land Conservation Council
Victoria



Cartography by Thematic Mapping Unit
Sydney & Mapping Victoria

MAP 1

A large variety of information contributed to the compilation of this report, including consultancy studies, data from government agencies, non-government organisations, and the public, as well as from published and unpublished materials. Where chapters draw strongly on commissioned consultancy studies this is acknowledged; these studies are available for inspection at the Council's offices. A major feature of the current review is the addition of information and data available since the earlier report. Readers seeking a more comprehensive description of some aspects of the study area should consult the original descriptive report and that investigation's Final Recommendations. Copies of these documents are held in local libraries and shire offices, and by regional and Melbourne offices of government departments such as the Department of Conservation and Environment. Copies are also available for inspection at the offices of the Land Conservation Council.

Review process

This review forms the first stage in the decision-making process for the future use of public land in the study area.

Figure 1 depicts the process, indicating the opportunities for public consultation and the respective roles of the independent Land Conservation Council and of government. Readers seeking an understanding of the powers and responsibilities of the Council are directed to an extract of the *Land Conservation Act 1970* in Appendix I. Copies of the complete Act are available from the Government Information Centre, public libraries, and similar organisations.

As Figure 1 indicates, the present report contains no recommendations, but provides a factual basis for the formulation of land-use recommendations.

Structure of the report

This report consists of predominantly the same chapter topics and structures as the other recent LCC area investigations and reviews, and is divided into three:

- * Part 1 - Introduction
- * Part 2 - Physical and Biological Resources
- * Part 3 - Current Resource Use

Comprehensive chapters on European history and Aboriginal occupation in Part 1 are based on studies conducted for Council, which represent a considerable addition to Council's information base. A specific chapter on the marine and coastal environment, principally describing Western Port, has been added to Part II. (The topic was not specifically covered in the earlier Melbourne Area investigation.) Water resources are also described in Part II, but water production and use are covered in a separate chapter in Part III. This change from earlier Council reports reflects the importance of water-harvesting in the study area.

Readers of Council's 'State-wide Assessment of Public Land Use' (LCC 1988) will discover that many of the suggested approaches for future studies have been incorporated here.

The study area

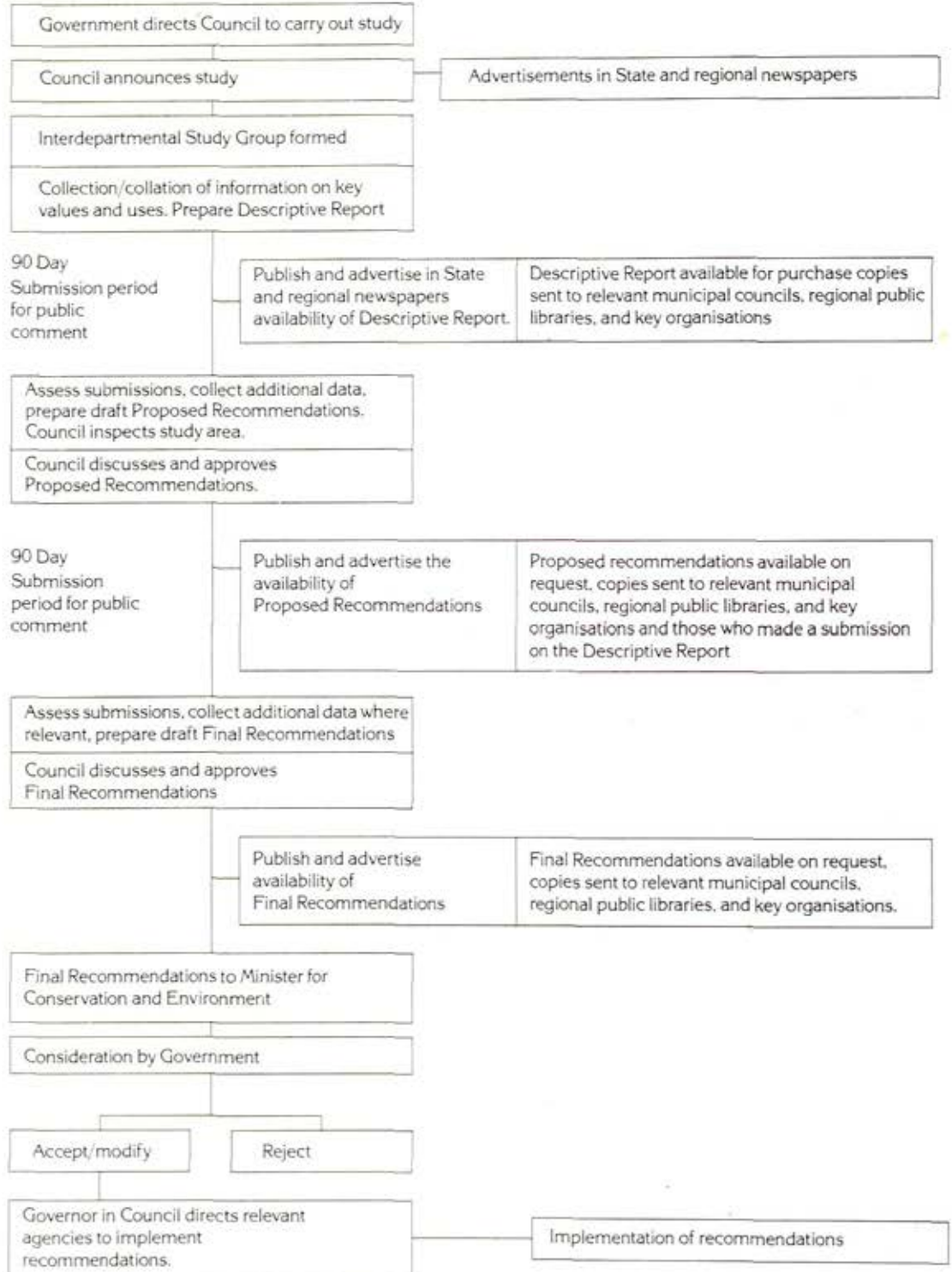
Melbourne Area, District 2 comprises the eastern portion of the original Melbourne region. It comprises some 20 entire local government areas plus sections of a further four - Broadford, Kilmore, Mansfield and Seymour; metropolitan Melbourne is excluded. Map 2 shows the study area boundaries and the local government units.

Along the western boundary, which follows metropolitan Melbourne from Hastings to Diamond Valley, the Hume Highway divides the Shires of Kilmore, Broadford, and Seymour. The northern boundary extends from Seymour across to Mansfield Shire; from the eastern boundary extends to Wonthaggi on the coast, while the coastline around to Mornington forms the southern edge.

Cities and rural cities are excluded from the Council's jurisdiction, under the *Land Conservation Act 1970*. Since this review began, the Shire of Whittlesea has become a city and, although information on the area is provided in parts of this report, no new land-use recommendations will be made for it in this review.

The Borough of Wonthaggi has now been added to the study area, although it was excluded from Council's earlier investigation. The City of Moe lies within the study area and is excluded from consideration. Further changes to the status of local government

FIGURE 1:
INVESTIGATION PROCESS



municipalities seem likely in the near future, as those highly urbanised shires on Melbourne's fringe become cities. Indeed, the Shire of Lillydale may become a rural city during the course of this review.

Western Port, including Phillip and French Islands falls within Melbourne District 2, although Port Phillip Bay lies within District 1. The sea and associated coastal waters out to the 5.5-km territorial limit are Victorian public lands and included in this investigation.

The total area of the Melbourne Area, District 2 is 1 711 800 ha, of which some 30% (508 500 ha) are public land. The areas of the local government municipalities are listed in Table 1.

Table 1

LOCAL GOVERNMENT AREAS

Municipality	Area (ha)
Alexandra	219 700
Bass	52 000
Broadford	48 700
Buln Buln	125 900
Cranbourne	75 500
Diamond Valley	7 438
Eltham	27 700
Flinders	32 400
French Island ²	17 000
Hastings	30 500
Healesville	46 600
Kilmore	11 000
Korumburra	61 400
Lillydale	39 800
Mansfield ¹	141 900
Mornington	9 100
Narracan	232 100
Pakenham	87 400
Phillip Island	10 100
Seymour ¹	62 400
Sherbrooke	19 200
Upper Yarra	173 200
Warragul	35 200
Wonthaggi	5 699
Yea	139 200
Total	1 711 837

Notes:

1. Portion only within study area
2. French Island is without local government, but is included in the study area

Source: Holzer, K.L. (Ed) (1988)

As described in the chapter on water resources, the study area covers six river basins: all of Bunyip, nearly all the Yarra, most of the upper Goulburn, upper Thomson (including Thomson Reservoir), and upper La Trobe, and a portion of South Gippsland.

Changes since the earlier investigation

Numerous changes to the policies, strategies, and administrative structures relating to the environment and natural resources have occurred since Council's first investigation of this area.

Legislative changes to several principal Acts in the environment and natural resource fields and the introduction of new Acts will need to be taken into account in the current review.

Administrative changes between and within the agencies responsible for environmental and natural resource issues have been numerous. Readers seeking details should refer to the Victorian Government Directory which lists the Acts administered by each agency, and to the annual reports of relevant departments for details on their roles and responsibilities.

A number of broad government strategies and plans have influenced public land and the management of public resources. Prominent among those relevant to this study are:

- * timber industry strategy (Victoria 1986)
- * conservation strategy (Victoria 1987a)
- * economic strategy (Victoria 1987b)
- * social justice strategy (Victoria 1987c)
- * *Flora and Fauna Guarantee Act* 1988
- * salinity strategy (Victoria 1988a)
- * wetlands conservation program (Victoria 1988b)
- * greenhouse effect - strategy (Victoria, DCE 1990)
- * *Forests (Timber Harvesting) Act* 1990

In addition, specific strategies and local programs apply within the study area, many of which are discussed in the report.

Changes in land use are described in Chapter 11 'Public Land Use', and other relevant developments are covered in each chapter.

Setting for the Review

Currently the community has great interest in and awareness of natural resources and conservation and this has been highlighted by international concerns about such issues as the greenhouse effect and climatic change, rainforest clearance, species extinction, and land degradation. Local and regional matters involving the environment can attract great attention, and the consideration of many of them now occurs in a broader context.

The Council has endeavoured, where possible, to embrace these wider concerns. In fulfilling the aim of achieving balanced land use in Victoria, Council recognises the relationship of regional land use planning to wider natural resource and environmental issues.

Greater legislative powers, regulations, and planning instruments, now in place, act to protect environmental values. Developments are now more carefully assessed for their environmental effects, and proposals may be modified to reduce losses of environmental values.

Considerable advances have been made in available information on the physical and biological resources in the State. Greater scientific knowledge has enabled land planners to recognise existing environmental values, and much decision-making has responded accordingly.

One outcome of these changes has been to make Council's task more complex. Demands on public resources have increased, greater volumes of information must now be examined and analysed, and the body of community and expert opinion to be consulted has grown.

Population growth and urban expansion

Since the first Land Conservation Council investigation (LCC 1973) significant changes have occurred in the population characteristics of the study area. As stated above, population size and distribution strongly influence the demands, uses, and management of public land and natural resources.

Aspects of public land resources and values subject to that influence include:

- * utilities - transport, communications, water supply and waste disposal, energy supply, community and emergency services
- * urban land use - public open space, floodways
- * recreation
- * nature conservation
- * resource use - such as timber, water, minerals, stone, and sand

Metropolitan Melbourne is the major influence on the levels and pattern of population growth in the study area.

Examination of these population characteristics, and of the plans for Melbourne's future urban expansion, indicates the distribution and influences that population changes impose on the region. Of particular interest are the urban growth corridors along the Plenty Valley and Berwick/Pakenham axis.

Local government areas provide a convenient geographical unit for examining population trends and are used by the Australian Bureau of Statistics for population data collection (ABS 1987, 1989). Three measures are size, rates of growth, and density within the region.

A pattern is evident when this information is analysed. Local government areas (LGAs) adjacent to metropolitan Melbourne and on the Mornington Peninsula differ from those elsewhere in the study area. All of the former had in excess of 20 000 residents in 1988, while the 'rural' shires had less than 20 000. Closer to Melbourne the LGAs tend to be smaller so the rural shires have relatively low population densities, measuring less than 50 persons per square kilometre, while population densities in LGAs fringing Melbourne exceed 50. Increases in population size can present difficulties in interpretation, but the largest increases in size, measured by the 1971, 1976, 1981, and 1986 censuses, have been concentrated around Melbourne. Table 2 gives details of population levels in each Local Government Area.

Within metropolitan Melbourne, population density averages approximately 1400 persons per sq.km using 1988 data (ABS 1989). No

MELBOURNE AREA, DISTRICT 2 - STUDY AREA
BOUNDARIES AND LOCAL GOVERNMENT AREAS



LEGEND

BOUNDARY OF STUDY AREA	---
MUNICIPAL BOUNDARIES	---
NAME OF MUNICIPALITY	HASTINGS

100 Kilometres

Land Conservation Council
Victoria

Cartography by Thematic Mapping Unit
Division of Survey and Mapping

MAP 2

Table 2

POPULATION SIZE BY LOCAL GOVERNMENT AREA - 1976-1988

Local government area	Estimated resident population as at 30 June			
	1976	1981	1986	1988 Est.
Alexandra	4 360	5 210	5 580	5 910
Bass	4 070	3 390	4 220	4 410
Broadford ¹				N/A
Buln Buln	8 610	9 450	10 640	10 980
Cranbourne	25 830	35 910	49 230	58 340
Diamond Valley	45 800	51 900	57 000	59 600
Eltham	29 000	36 000	41 500	43 100
Flinders	22 100	27 000	34 900	37 400
French Island	70	70	70	70
Hastings	13 600	18 000	23 700	25 700
Healesville	7 990	8 870	11 110	11 690
Kilmore ¹				N/A
Korumburra	6 740	6 870	7 250	7 450
Lillydale	52 200	64 000	74 000	77 700
Mansfield ¹	1 669	2 008	3 155	N/A
Mornington	20 900	24 600	28 500	29 900
Narracan	8 820	10 980	11 170	11 290
Pakenham	15 420	18 500	23 620	25 680
Phillip Island ²	2 340	3 070	4 350	4 780
Seymour ¹	9 892	7 767	8 588	N/A
Sherbrooke	25 900	31 100	36 100	37 400
Upper Yarra	8 090	10 400	14 150	14 850
Warragul	10 690	11 280	12 360	12 620
Wonthaggi		5 370	6 230	6 340
Yea	3 160	3 600	4 420	4 660

Notes:

1. N/A - Not available

2. Local government areas divided by the study area boundary are described using collector Districts substantially within the area for each census.

Source: ABS (1987) Cat No 3202-2, ABS (1989) Cat No 3203-2, ABS taken from Melbourne office

LGA's in the study area are not yet sufficiently urbanised to reach that density, although the Shire of Diamond Valley has in excess of 800 persons per sq.km. Shires such as Cranbourne, Eltham, Lillydale, Mornington, and Sherbrooke seem likely to achieve significantly increased population densities on the basis of current trends - a measure of increased urban development.

The density shows considerable variation across the study area, as expected from a mixture of rural and densely settled municipalities. Comparisons on this basis provide a useful quantification of urbanisa-

tion. Rural areas such as Alexandra, Buln Buln, and Yea have population densities around 10 person per sq.km. In more urbanised areas - Eltham, Lillydale, or Sherbrooke - the figure rises to about 100 to 200 persons. At the far end of the scale is Diamond Valley with 805 persons per sq.km; the densities for each LGA are given in Table 3.

Population growth can be assessed on the absolute increases in residents or on growth rate, which measures such increases in proportion to population size. The earlier Land Conservation Council study of Melbourne (LCC 1973) used the 1971 census

Table 3

**POPULATION DENSITY BY LOCAL
GOVERNMENT AREAS, 1988**

Local government area	Area (sq.km)	Density (persons per sq.km)
Alexandra	2 172	3
Bass	526	8
Broadford ¹	488	9
Buln Buln	1 259	N/A
Cranbourne	755	77
Diamond Valley	74	805
Eltham	277	156
Flinders	324	115
French Island	170	> 1
Hastings	305	84
Healesville	466	25
Kilmore ¹	110	70
Korumburra	614	12
Lillydale	398	195
Mansfield ¹	1 419	2
Mornington	91	329
Narracan	2 321	5
Pakenham	874	29
Phillip Island ²	101	47
Seymour ¹	624	14
Sherbrooke	192	195
Upper Yarra	1 732	9
Warragul	352	36
Wonthaggi	57	111
Yea	1 392	3

Notes:

1. Only 1986 population data are available for Seymour and Mansfield
2. N/A - Not available

Source : ABS (1989) Cat. No 3203-2

data. The further three censuses taken since (1976, 1981, and 1986) have revealed dramatic population changes.

In terms of increases in residents, no other Victorian areas would rival the performance of the shires to the east and south of Melbourne.

Since 1976 Cranbourne, Diamond Valley, Eltham, Flinders, Hastings, Lillydale, Mornington, Pakenham, and Sherbrooke Shires have experienced large and sustained increases in population, as shown in Table 2.

For example, Lillydale had about 36 000 residents in 1971, but exceeded 77 000 in 1988; Cranbourne increased from about 16 000 to more than 58 000 over the same period (ABS 1973, 1989).

By contrast, population level increases in the rural shires have been modest. Nearly all the rural shires gained fewer than 2500 residents over the 1971-88 period (ABS 1973, 1989).

Growth rates present a more complex picture. Shires with small populations can be expected to exhibit high growth rates in comparison with large shires with similar increases in population size.

A number of the rural shires have indeed done so, albeit from a low population base. At the time of the first Melbourne investigation (LCC 1973), many rural shires were declining in population. This trend has largely reversed since the 1981 census, with only Seymour fluctuating in growth rate; all remaining shires have clearly increasing populations.

Increasing population, especially its expression in urban expansion, influences public lands and resources and the decision-making associated with planning their use. A variety of resource demands increase with population: recreation opportunity, open space, water-harvesting, minerals, stone, and timber. Lands are required for residential, commercial, industrial, recreational, and other uses, and some of the demand is upon public land. Environmental threats also tend to increase - not only those posed by the greater waste outputs to land, air, and water from a greater number of persons, but those due to a wide variety of factors, such as pest plants and animals, and high-intensity recreation. In situations where demand is increasing for resources, conflict over allocation or distribution becomes more likely.

Melbourne's urban growth corridors

Recent population growth and the urban expansion of metropolitan Melbourne have been concentrated in three corridors, with the eastern and southern flanks influencing the study area. Urban planning has guided this expansion, with the current metropolitan policy directing growth south-east toward Pakenham and northwards in the Plenty Valley. The Plenty Valley, being within the

City of Whittlesea, lies outside the study area, although it exerts considerable influence. Readers with a particular interest in Melbourne's expansion are directed to 'Shaping Melbourne's Future: the Government's Metropolitan Policy' (Victoria 1987d).

South-east corridor

The south-eastern growth corridor is expected to house an additional 280 000 people within the next 20 years; currently its population is about 90 000 (Victoria 1990). Under the government's current plan, urban growth will be contained in well-served areas which are not environmentally sensitive. Growth in the established settlements will be approximately 30 000 at Officer, 60 000 at Pakenham, and 80 000 at Cranbourne. The balance will be housed around Hampton Park, Narre Warren, Berwick, and Beaconsfield.

North-west of Pakenham, north-east of Beaconsfield, and around Harkaway are excluded from urban growth to protect flora, fauna, and landscape values and also because of fire hazard and extractive industries. These non-urban areas will surround Officer, Pakenham, and Cranbourne.

Plenty Valley corridor

This relatively long and narrow area straddles the Plenty River. Accommodation for an additional 70 000 people is planned over the next 10 to 15 years, and almost 7000 ha of land will need to be rezoned. It is intended to have a metropolitan park along the Plenty River, with the immediate riparian zone serving conservation and recreation purposes. New residential allotments will cover 1600 ha, with retail, commercial, and employment zonings occupying a further 460 ha (Victoria 1989b). Nearly all the population increases occur within the City of Whittlesea, with the Shire of Diamond Valley's population expected to increase by about 3500 by the year 2000 (Henshall Hansen 1989).

It is in the context of these developments that Council is reviewing the use of public land.

Open Space 2000

This recent government initiative will develop a network of open space for

Melbourne, extending from the foothills of the Central Highlands to Port Phillip Bay. The areas involved include Port Phillip Bay, foreshores, parks and reserves, rivers and frontages, wetlands, utility corridors, and other lands. These will be linked by a co-ordinated management program and the creation of new parks and open space in areas currently deficient of such amenities.

The program will provide for environmental protection, recreation, and environmental education. Objectives of the program include the co-ordination of the activities of government agencies, municipalities and community groups. Enhancement of environmental quality and community involvement will be featured.

Because of a shared involvement in public land, Council's review and the Open Space 2000 program will require close co-ordination.

References

- Australian Bureau of Statistics (1987). 'Estimated Resident Population in Statistical Local Areas, Revised Intercensal Estimates, Victoria, 1981 to 1986.' Catalogue number: 3202.2.
- Australian Bureau of Statistics (1989). 'Estimated Resident Population in Statistical Local Areas, Victoria, 30 June, 1987 (Final) and 1988 (Preliminary).' Catalogue number: 3203.2.
- Henshall Hansen Associates (1989). 'Diamond Valley Local Structure Plan and Outline Development Plans for the Plenty and Yarrambat Areas.' Report prepared for the Ministry for Planning and Environment and the Shire of Diamond Valley.
- Holzer, K.L. (ed.) (1988). Victorian municipal directory. (Arnall and Jackson: Melbourne.)
- Land Conservation Council (1973). 'Report on the Melbourne Study Area.' (Victorian Government Printing Office: Melbourne.)
- Land Conservation Council (1977). 'Final Recommendations. Melbourne Study Area.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1982). 'Special Investigation Melbourne Area Hill End.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1983). 'Special Investigation Melbourne Area Hill End; Final Recommendations.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1985). 'Report on the Melbourne Area, District 1, Review.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1987a). 'Melbourne Area, District 1, Review: Final recommendations.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1987b). 'Report on the LaTrobe Valley Special Investigation.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1987c). 'LaTrobe Valley Special Investigation Final Recommendations.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1988). 'State-wide Assessment of Public Land Use.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1989). 'Rivers and Streams Special Investigation Report.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1990). 'Wilderness Special Investigation Descriptive Report.' (Victorian Government Printing Office: Melbourne.)

Victoria, Department of Conservation and Environment (1990). 'Greenhouse: Meeting

the Challenge. The Victorian Government's Statement of Action.' (Victorian Government Printing Office: Melbourne.)

Victoria, Government of (1986). 'Timber Industry Strategy; Government Statement 9.' (Victorian Government Printing Office: Melbourne.)

Victoria, Government of (1987a). 'Protecting the Environment; a Conservation Strategy for Victoria.' (Victorian Government Printing Office: Melbourne.)

Victoria, Government of (1987b). 'Victoria - the Next Decade.' (Victorian Government Printing Office: Melbourne.)

Victoria, Government of (1987c). 'People and Opportunities - Victoria's Social Justice Strategy.' (Victorian Government Printing Office: Melbourne.)

Victoria, Government of (1987d). 'Shaping Melbourne's Future: the Government's Metropolitan Policy.' (Victorian Government Printing Office: Melbourne.)

Victoria, Government of (1988a). 'Salt Action: Joint Action.' Victoria's Strategy for Managing Land and Water Salinity. (Victorian Government Printing Office: Melbourne.)

Victoria, Government of (1988b). 'Wetlands Conservation Program for Victoria.' (Victorian Government Printing Office: Melbourne.)

Victoria, Government of (1989b). 'Plenty Valley Strategy Plan.' (Ministry for Planning and Environment: Melbourne)

Victoria, Government of (1990). 'The South-eastern Growth Area Plan - Minister's Directions. (Department of Planning and Urban Growth: Melbourne.)

2. ABORIGINAL OCCUPATION

This chapter discusses the associations of the Aborigines with the land, recognising a continuity between the past and present of Aboriginal culture through the pre-contact and post-contact phases.

It provides details of Aboriginal life and culture prior to European settlement, and describes the effects of European settlement in the post-contact period. It provides data on known archaeological sites and survey information, and relates these to the pre-contact conditions where possible.

A report commissioned by the Land Conservation Council, 'Aboriginal Occupation of the Melbourne Area, District 2' (Goulding 1988) forms the basis of the chapter. This report, which is fully referenced, is available for inspection at the Council's offices. The report acknowledges the contributions of the Dandenong and District, Healesville and District, and Morwell and District Aboriginal Co-operatives.

A paucity of information limits the description of the pre-contact and early post-contact Aboriginal life. Most of the information used here derives from historical records dating from 1835. It is a record primarily of the impressions of explorers, settlers, and government officials.

One of the best sources of information comprises the diaries, letters, and government reports of William Thomas, Assistant Protector of the Port Phillip district and Western Port Aborigines from 1839 to 1849. In his capacity as guardian, Thomas had daily contact with the Aboriginal people. His insights are particularly valuable because of their detail, touching on all aspects of Aboriginal culture.

Aboriginal Culture - Pre-contact

The Dreaming

Every aspect of the lives of Aboriginal people, whether social, economic, or political, was tied, in some form or other, to the land they inhabited (Berndt and Berndt

1977). This link between the natural world and the daily lives of Aboriginal people is often referred to as the Dreaming or the Dreamtime. Aborigines believe that during the very distant past the world was formed by mythical beings and the characters enacting this creation took the form of features on the landscape. Aborigines recognized these characters as totems, believing '...that all forms of life (were) intimately linked: human beings and other creatures (plants and animals) shared the same general life essence and none of them (was) independent of the others' (Berndt and Berndt 1978). In this way, individuals or groups of individuals possessed an intimate relationship with a feature on the landscape or a particular plant or animal species.

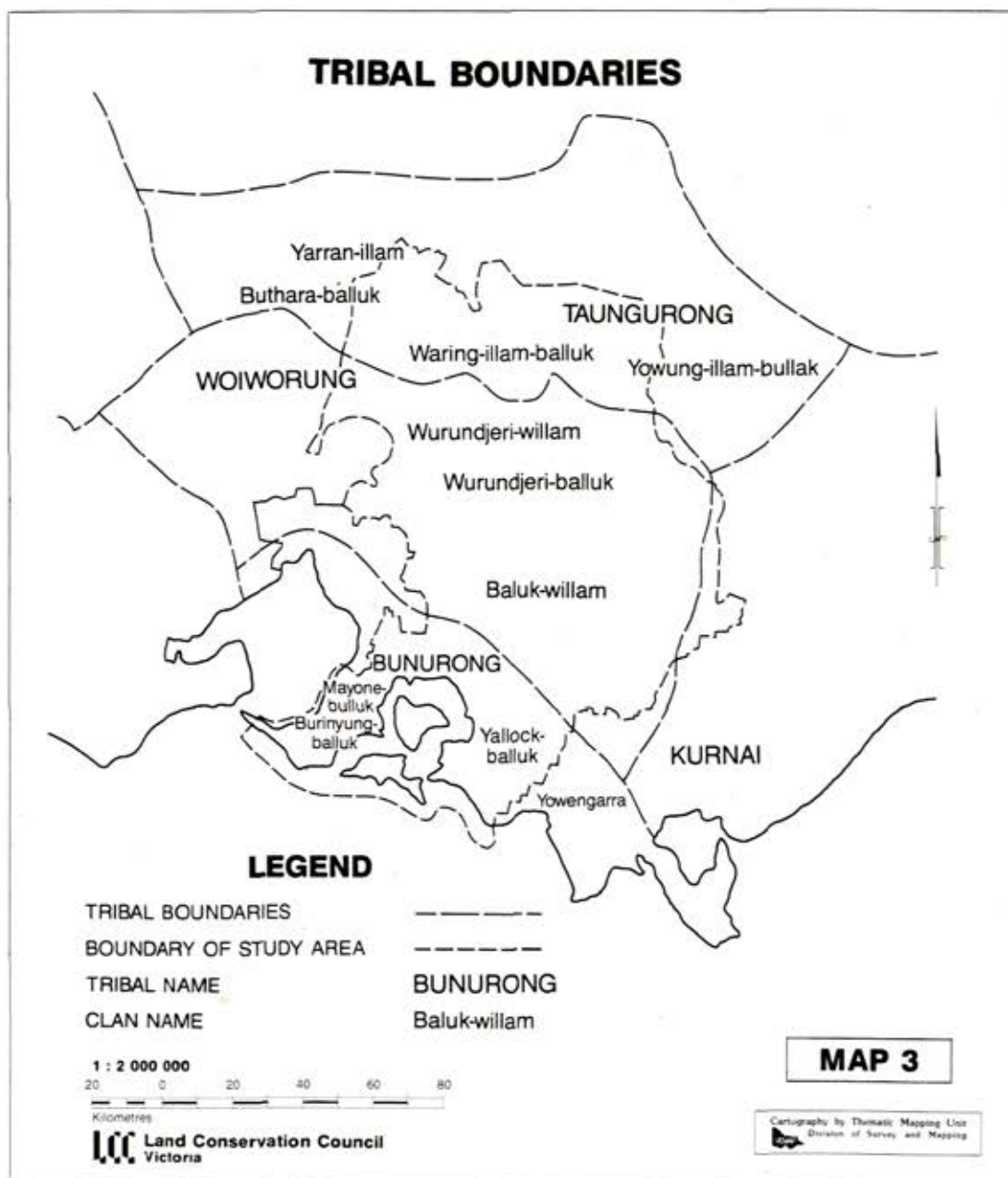
The Dreaming not only refers to a history of Aboriginal society but also represents a perspective of life and eternity, involving the past, the present, and the future in an ongoing belief system. This belief system provided Aboriginal people with guidelines for living as part of the environment they inhabited.

Aboriginal religion was maintained through myths recounting the Dreaming legends. These contained the knowledge, history, and social structures, which were maintained and passed on to each successive generation.

On one level, these beliefs were demonstrated in ceremonial practices, such as dances and songs in which stories of the Dreaming were recounted, and also in rituals such as the initiation of children once they reached puberty. On another level, tribute was paid to the forces of the Dreaming through everyday actions in the use of resources on the land. Individuals were born into clans that were responsible for designated areas of land, and each person within a clan acted as curator of the resources available.

Tribes

The study area was once occupied by several different tribes: the *Bunurong*, *Woiworung*, and *Taungurong* formed a dominant component of the 'Kulin nation' (Barwick 1984). These tribes and their



boundaries are illustrated in Map 3. A fourth *Kulin* tribe, the *Ngurai-illan-wurring*, lived to the east of the study area and is not discussed in this report.

Because the settlement of Port Phillip (later Melbourne) occurred within the Bunurong tribal boundary, the ethno-historical information on traditional life-styles of Aborigines belonging to that tribe is more extensive than that for the *Woiworung* and far outweighs that available on the *Taungurong* which was located further north.

A very small portion of the eastern part of the study area includes land that, it is argued,

belonged to the *Kurnai* Aborigines from Gippsland. The history of the *Kurnai* is described in the Land Conservation Council's East Gippsland Area Review (LCC 1985).

Social organisation

According to Howitt (1904) the *Kulin* peoples were distinguished from other tribes by their common language, referred to as the 'Eastern Kulin Language' - as well as by social and economic needs. This 'regional cultural block' was maintained by inter-marriage, a common language, and a variety of mutual interests. Complex relationships existed within and between the tribes belonging to

the *Kulin* nation. Within each tribe, individuals belonged to a clan, the membership of which derived from patrilineal descent. Within each clan, members '...had an historical, religious and genealogical identity' and each clan owned specific territories, to which they related through ceremonial and economic activities.

The interaction between the tribes in the *Kulin* nation came mostly through inter-marriage and this could only be achieved through the linking of partners from the same 'moiety' (Barwick 1984). There were two moieties dividing *Kulin* society - the *Waa* (Crow) and the *Bunjil* (eaglehawk) (see Table 4). Entire clans belonged to one or the other, and individuals from each clan were compelled to find marriage partners from a clan of the opposite moiety. While spouses could be found within the local region, for social and political reasons they were preferably found in regions some distance from the clan's territory.

Table 4

**TRIBES AND CLANS (IN BRACKETS)
BELONGING TO THE KULIN NATION**

BUNURONG

Burinyung-Balluk (Waa)
Mayone-Bulluk (Bunjil)
Yallock-Bulluk (Bunjil)
Ngaruk-Willam (Bunjil)

WOIWORUNG

Baluk-Willam (Waa)
Wurundjeri-Balluk (Waa)
Wurundjeri-Willam (Waa)

TAUNGURONG

Waring-Illam-Balluk (Bunjil)
Buthera-Balluk (Bunjil)
Yowung-Illam-Balluk (Waa)
Yarram-Illam (Bunjil)

Source: Barwick (1984)

Individuals of a clan had rights to a certain territory within their tribes' boundaries and subsequently the resources that came with this territory. While the territory belonged to

a particular clan, access could be acquired by other persons under certain circumstances.

There is little specific information on the social structure of tribes in the study area. References made to the hierarchy of tribal members mostly refer to men as holding positions of authority.

Thomas (n.d.) also gives a similar insight into the structure of clans:

'It does not appear that there are any persons among them which have kingly authority over the rest. Yet each leading man or men. And in all important matters which require the assemblage of the whole tribe, these influential men debate upon Public Matters, and decisions are come to by mutual consent. This kind of debating actually occurs in the evening when all are at their 'Miami Miams' and sometimes long and animated speeches are delivered'.

Men also had the authority to arrange the marriages of women within their tribe (Thomas 1854).

Although it seems clear that men rather than women initiated much of the authority within a tribe or clan, it would be unwise to assume that this was the only situation. Given that the documentation of the lives of Aboriginal people during contact in the region was made by European men, it is probable that their perceptions of Aboriginal society were clouded by their own views.

Contemporary Aboriginal women in the study area argue that women did hold positions of authority in traditional Aboriginal tribes and that any group of women contained dominant female leaders. Many of these women had spiritual powers, and in some of the tribal ceremonies they were the only tribal subdivision of a tribe has one or more members who were permitted to participate.

Social relations with other tribes

A great deal of social interaction occurred between the tribes within the region and its surrounds. Tribes held large meetings in order to negotiate marriages, settle disputes, and exchange goods. Traditionally, many of these gatherings among the *Bunurong*, *Woiworung*, and *Taungurong* took place along the banks of the Yarra River where

Melbourne now stands (Sullivan 1981). They also travelled much further north for meetings. In 1841, for example, Thomas reported that the *Bunurong* and *Woiworung* tribes held a joint ceremony at Port Phillip and that they then visited the *Taungurong* to assist in a ceremony being held in their territory (Gaughwin 1983).

Settling disputes appears to be a common theme for inter-tribal meetings; however, it may be that these incidents were recorded more often because of their sensational value. On 5 December, 1844, Thomas recorded the hostile meeting between the *Barrabool* (from Geelong) and *Buninyong* (*Bunurong*) tribes north of Melbourne. Called together by messengers who carried two message sticks, the *Buninyongs* charged the *Barrabools* with '...killing two of the *Buninyongs* and stealing lubras' (Thomas 1854). The disagreement was only resolved after the *Buninyongs* had finished attacking and injuring some of the *Barrabool* men.

Disagreements over women seem to have been a common problem among tribes within the region, although this may have more to do with tensions resulting from European presence rather than the traditional situation.

It is well documented that the *Kulin* tribes and the *Kurnai* to the east were traditional enemies, with the latter referred to by the *Kulin* as 'bad blacks'. Many fights between these tribes have been reported, often involving large losses of lives. In one such incident in 1835, 17 people were killed by Gippsland tribes just outside Melbourne (Gaughwin 1983).

Trade and exchange

Exchange of goods between tribes enabled social ties to be maintained. The *Woiworung* tribal territory included the valuable Mount William greenstone quarry situated near Lancefield, west of the study area. Aborigines used this volcanic greenstone to manufacture hatchet heads. Many of the axes were transported several hundred kilometres away from the quarry, with some hatchet heads recovered from the Upper Yarra ranges.

Although not clearly documented for the study area, the exchange of goods such as stone for axes, possum-skin cloaks, baskets,

bags, and spears probably occurred at large gatherings of tribes such as the end of season gatherings. During these times, social links were strengthened and arrangements for marriages made.

Material culture

Aboriginal people used a wide variety of material culture in their daily activities. Most of the available information concerns the *Bunurong* and *Woiworung* tribes, but it seems likely that the majority of the objects mentioned below were also owned by the *Taungurong* people.



Stone tools are among the most common evidence of Aboriginal occupation in the study area

In 1837, a European settler wrote that '...the original clothing of both men and women, seemed to be two mats, made of skins joined together, the one hanging before, the other behind' (Winter 1837). Alternatively, 'the young ladies wore around them a kind of bustle, composed of a rope yarn-like substance, which hung in pendant waves, half-way down to the knees' (Bunce 1859). In the colder season, possum-skin cloaks were manufactured and worn.

For personal decoration, people wore '...strings and a necklace called 'coornburt', composed of a number of short pieces of reed strung together, and hanging pendant from the neck'. Young men wore long pieces of bone or reed through the their noses and swan feathers in their hair.

Personal utensils were carried in individual bags. Women's bags were called *Baggerooks* and their baskets were called *Beenack*. The *Woiworung* made baskets from the leaves of reeds.

Eleven implements used by the *Bunurong* Aborigines in battle with other tribes included spears, clubs, and shields (Thomas 1840). The *Woiworung* used a boomerang called the *Barngeet*. Another important tool used by both men and women was the stone hatchet. A stone head, ground down to form a cutting edge, was usually hafted to a wooden handle using gum and twine made from animal sinews or plant fibres.

Women of the *Bunurong* tribe were rarely without their *Kannan*, a stick (usually as tall as themselves), which they used for digging roots and uncovering yams and also for fighting (Cannon 1983). The *Bunurong* also used bowls (called *Coolamons* or *Tamoks*) that they made out of the growth nodules of gum trees, used for carrying water and preparing beverages. Bark was also used to make canoes, shields, plates, and shelters.

Subsistence activities

There is little evidence in Australia that Aboriginal people cultivated plants as a food resource or participated in animal husbandry. The quest for food entailed, for the most part, a hunter-gatherer existence, involving the seasonal exploitation of foods. This required an intimate knowledge of the environment and '...although Aborigines were hunters and gatherers, the manner in which they satisfied their food needs was broadly adapted to the ecology of each region...' (Kirk 1981).

The smallest functioning component of a tribe was the band, usually comprising husband, wife/wives, and children. Normally, the band would break off from the larger tribal group, moving across the landscape to collect, catch, and process food and rest at night.

In 1840, Thomas observed the following about the movement of the *Bunurong* tribe along Western Port.

'They seldom travel more than six miles a day. For their migratory movements all are employed. Children are getting gum, killing bandicoots, getting grubs; the men hunting and scaling trees for opossums. They are mostly in camp an hour before sundown; the women first who get the fire and water; by this time their spouses arrive' (Thomas 1854).

During their foraging expeditions, Thomas noted, the *Bunurong* would rarely camp for more than three nights in one place, and often stayed only one night. In the warm weather when the tribe was moving about, Thomas wrote that the people seldom built *miams* (huts), preferring rather to build lean-to's, with bark sheets resting against a bough. When a more substantial 'village' was erected, he noted that it was arranged into small groups of about six mia-mias, 5 or 6 yards apart, with 20 yards between each group.

Food resources

Usually the hunting of large animals, such as kangaroos and emus, involved male members of the tribe. Although some women probably killed the occasional large animal, in general women (and children) were responsible for gathering and processing plant foods and killing small fauna. Plants formed the most reliable source of food and on many occasions, when large game could not be caught, vegetable foods were relied upon as the only source of food for camp members.

Gaughwin (1983) refers to an 1841 gathering of a group of 165 *Bunurong*, *Woiworung*, and *Taungurong* people, during which one group of people travelled to the mountains to obtain food, 'the second stayed in the camp while the third group comprising 70 people, speared eels in a nearby waterhole'.

In the summer season eels were in plentiful supply, enabling large groups of people to camp together - among the few occasions when tribes would become sedentary.

During a trip to the Dandenongs, a European botanist recorded Aboriginal men catching a range of fauna: kangaroo, porcupine, 'native

bear or 'sloth', wombats, opossum and fish (Bunce 1859). On one occasion, after three wombats were caught, a 'banquet' was held '...preceded, as a matter of course, by a grand corroboree' (Bunce 1859, p.72).

In 1837, there were large herds of kangaroos around the Port Phillip and Western Port regions, as well as emus (Jamieson 1853). Emus and their eggs were eaten by Port Phillip Aborigines; other birds were caught with nets (Coutts 1981).

References in the ethno-historical literature to Aboriginal exploitation of marine resources such as fish and shellfish are very rare. Men were recorded as having speared flounder and stingrays in Port Phillip Bay. They also caught fish at night, using fires on canoes to attract the fish. Fish were sometimes caught in a net with a draw-string opening.

Aborigines ate both fresh- and salt-water shellfish. Although there are few references to shellfish gathering and consumption on the coast, it is clear from the numerous Aboriginal shell middens along the coastline of both Port Phillip Bay and Western Port that this was a common activity. Europeans noted that men and women collected shellfish near Melbourne, and women procured fresh-water mussels from rivers and creeks.

Aborigines ate a large variety of vegetable foods. Tubers comprised an important component of their diet, the yam daisy (*Murnong*) is often referred to in the literature. Other types of edible root were available in summer and autumn and, according to Thomas (n.d.), formed the main dietary focus of women and children. There are several references to Aborigines eating tree-fern pulp and gum from wattle trees. Other plant foods included wild raspberries, cherries, currants, kangaroo apple, pigface, and mushrooms. They also ate many swamp-dwelling plants such as the roots of rushes.

On their food-gathering quests, the women also collected the large white moth larvae. Considered a delicacy, these grubs were slightly roasted before being eaten.

Nectar was often sucked out of certain flowers, and honey, when available, was also much relished.

Population - 1788

Estimating the size of the original populations of tribes inhabiting the study area is extremely difficult. No official censuses were taken of tribal numbers when Europeans first began to settle in the Port Phillip district in 1835. Information from the documents and letters of these first settlers are clearly inaccurate. Even by 1835, it is highly likely that the Aboriginal population was already affected by 50 years of European settlement. For 30 years prior to the settlement of Port Phillip, sealers and whalers had been making camps along Victoria's southern coast. During their stays, they often captured and kept Aboriginal women as sexual partners and domestic servants. Venereal disease and possibly smallpox were transmitted to these women, affecting population numbers. Historians also argued that disease also travelled overland from the settlement in New South Wales, claiming large numbers of Aborigines in Victoria.

Researchers have attempted to reconstruct the size of the Victorian Aboriginal population at contact and pre-contact. In 1930, Professor Radcliffe-Brown estimated that 11 500 persons had inhabited the whole of Victoria prior to European contact. Since this estimate, other authors have arrived at more radical figures. Smith (1980) argues that 15 000 would be a conservative estimate. Butlin (1983) argues that the figure of 15 000 probably reflects the period after 1835 and that a more realistic estimate of the 1788 population is between 50 000 and 100 000 people.

In 1840, William Thomas estimated that the total number of people in the *Bunurong* and *Woiworung* tribes in 1835 would have been between 300 and 500 people (Sullivan 1981). If 250 individuals (representing the *Taungurong* tribe) are added to this figure, then according to Thomas' estimates, the three tribes in the study area would have numbered between 600 and 750 people. This figure differs drastically from the later calculations. The study area covers about one-eighth of Victoria. If an even distribution of Aboriginal people living in Victoria prior to European contact were assumed, then available estimates for the *Taungurong*, *Woiworung*, and *Bunurong* vary from 1500 to between 6000 and 12 000.

With estimates between 600 and 12 000 individuals for the three tribes the difficulties of estimating the population sizes are clear. On present evidence it is difficult to challenge or substantiate any of the above figures.

The Frontier and Beyond

Events prior to Batman's Treaty

Between the years 1797 and 1802, both Western Port and Port Phillip Bays were surveyed by ship. From 1803 to 1804, the British government established a settlement at present-day Sorrento. During the next 20 years, European contact with Aborigines in the Port Phillip region was made by sealers, whalers, and escaped convicts.

In 1824, Hamilton Hume and William Hovell commenced exploration through inland Victoria. As a result of their favourable report to the New South Wales government, a military and convict post was established on the eastern shores of Western Port in 1826. It was abandoned in 1828 after being proclaimed as uninhabitable. Six years later, Edward Henty settled at Portland Bay without government approval. In the following year, Batman arrived to make his land purchase from the Aborigines.

Batman's Treaty - 1835

On 6th June, 1835, the Aborigines of Port Phillip signed a treaty with John Batman, a pastoralist from Van Dieman's Land. The treaty stipulated that for the exchange of £200 worth of goods, Batman could take possession of 600 000 acres of land around the Port Phillip district. This interaction with Batman signified the beginning of the 'Frontier', a period of European settlement that would have the most devastating effects on Aboriginal society.

This deal with the Aborigines was not considered legal by the British government in New South Wales. The implications of the deal for Aboriginal people must have been blatantly obvious to Batman, as he had been personally involved in the demise of Aboriginal society in Tasmania as a direct result of land conflicts with Europeans. It is unlikely that the Aboriginal people fully understood these implications or comprehended the European perception of

land ownership. Batman states that the Aboriginal people understood the treaty; however, he did not comprehend that they had no concept of buying and selling land. To them, land was an inherited possession, a part of an individual's psychological and physical existence. The simplicity of the transaction stands in contrast to the catastrophic impact of Batman and future settlers.

Loss of land 1835-1850

One of the most devastating effects the presence of Europeans had on Aborigines living in Victoria was the incredible speed with which the area was settled and opened up to pastoralism. Within months of the Batman treaty, numerous settlers had moved onto land around the Yarra, hereafter called the Port Phillip District.

In 1836, the Sydney government was compelled to issue grazing licences for the growing Port Phillip District. At that time, the number of European people in the settlement and surrounds totalled approximately 200. In 1837 there were more than a thousand settlers in Port Phillip, with large numbers of pastoralists arriving from Great Britain.

By 1840, the entire Western District had been settled. Those people settling in the north along the Murray were quickly making their way south and in 1840 met with settlers moving north from the Port Phillip District, along the Avoca and Loddon Rivers, north-east of the study area. In 1839/40, A. McMillan and P.E. de Strzelecki pioneered explorations into Gippsland, and by 1841 this region was also settled by pastoralists. At this time more than 20 000 Europeans were living in Victoria.

By 1851, when the Colony of Victoria was officially proclaimed, only the heavily forested mountains and the dry regions of the Mallee remained unoccupied. The total European population numbered 80 000 people. In the next 3 years, large numbers of people flocked into Victoria during the gold rushes at Ballarat, in Castlemaine, and in Bendigo. In 1854, 20 years after Port Phillip was first settled by a handful of people, Victoria's European population numbered almost 300 000.

Effects of Pastoralism - the First 5 Years of Settlement

The basic conflict underlying black--white relations was the incompatibility of pastoralism and the life-styles of the Aborigines. For the Aboriginal people, the most devastating effect of the influx of pastoralists was the loss of access to land.

Depletion of food resources

Constantly driven off the land by shepherds and pastoralists, the Aborigines were often denied access to the most basic resources such as water. This situation was exacerbated by pastoralists often settling on the best parcels of land around water-holes and rivers. These restrictions on the Aborigines severely disrupted their hunter--gatherer life-style.

Sheep and cattle had an enormous impact on the ecology of environments. In 1838, the first census undertaken for Port Phillip recorded the presence of nearly 311 000 sheep (Bride 1856). By 1851, the figure had grown to approximately 6 million (Cole 1981). Large tracts of bush were cleared for pastures, destroying the many diverse food resources (both flora and fauna) on which the Aborigines relied. In the first 4--5 years of settlement around Port Phillip (from 1835 to 1840), much of the study area land was claimed as pastoral runs and settled. Only the hilly and mountainous regions to the east remained relatively unoccupied.

The delicate balance between the foraging activities of Aborigines and the food yield of their environments was severely disrupted, often leading to critical shortages of food. These shortages often led Aborigines to kill sheep grazing on their former tribal lands. Constant conflicts between whites and blacks resulted and many Aborigines were shot attempting to kill sheep for food. This basic injustice led to attacks by Aboriginal people on the settlers and their workers. During the first 12 months of the settlement of Port Phillip, several shepherds were murdered (Bonwick 1956).

Christie (1979) argues that while the initial acts of aggression by Aborigines were 'unco-ordinated' and opportunistic, the increased tension arising from European presence on tribal lands led to 'organised resistance'.

Several accounts describe cases of outright massacre of Aborigines in the early settlement of the region, and no doubt many more went unreported. Massacres had been committed by the whalers at Portland Bay and other whaling stations. Some settlers also gave flour laced with poison to groups of Aborigines, although the frequency of such behaviour is impossible to gauge.

Another form of conflict arose from the maltreatment of Aboriginal women by male settlers, and in particular shepherds. Rape and forced detention had been inflicted on the Aboriginal women around Western Port by settlers and whalers for 30 years prior to settlement of Port Phillip. These attacks probably became more frequent during the frontier period. The rape and detention of Aboriginal women was commonplace in the more remote regions of the settlement.

Such abuse of Aboriginal women often led to attacks of revenge by Aboriginal men, with casualties occurring on both sides. The Assistant Protector wrote as late as 1845 that the maltreatment of Aboriginal women by Europeans was the cause of 'nearly every Aboriginal outrage which has occurred in my district'. In 1837, Governor Bourke proclaimed that it was illegal for squatters and their workers to forcibly detain Aboriginal women. However, there was no way of successfully policing these incidents.

Native police

In 1837, Captain Alexander Maconachie developed the concept of forming a native police corps that would act as a mediating body between the 'troublesome' Aboriginal people and the Europeans (Christie 1979). Initially the native police were recruited from *Woiworung* and *Bunurong* tribes. They refused to act against their own tribes; however, further afield, they were prepared to kill Aboriginal people causing disturbances. Their barracks were set up at Narre Warren (the site of the present-day police paddocks at Dandenong).

Although the corps was expected to act as a 'civilizing' body, Christie argues that it played a large part in crushing Aboriginal resistance around the Port Phillip District. Its members were expert trackers, and were under pressure from their European officers to kill rather than capture offending

Aborigines. But they were plagued by alcoholism and violence and in 1853 the corps disbanded after a highly controversial existence.

The Protectorate 1839--49

Despite the general lack of concern among settlers for Aborigines in Victoria by settlers, some members of the community wanted to see the situation change.

In 1837, a report from the Secretary of State recommended that the British Government set up a system enabling a group of protectors to look after the Aborigines throughout Victoria. An immediate task was the physical protection of the Aborigines, while the longer-term goal was to inculcate them with European values of religion, employment, and education. The protectors were to learn Aboriginal language and culture, protect them from cruelty and exploitation, and maintain a population census.

In 1839 the Protectorate commenced under the leadership of George Augustus Robinson. He was in charge of four assistant protectors, of whom William Thomas was responsible for the region encompassing most of the study area, with James Dredge's region encompassing the northern one-third.

There was a great deal of public opposition to the Protectorate system, made worse by the fact that it took the assistant protectors over 12 months to move into the field. Initially Thomas established a station at Arthur's Seat on the Mornington Peninsula. In 1840 he moved the station to Narre Warren (present-day police paddocks). The station provided an important refuge for Aboriginal people around the growing Port Phillip settlement. Food, medical supplies, clothing, and blankets were made available, where possible, to Aboriginal people frequenting the station.

By the time the assistant protectors reached their designated regions in 1839--40, the Aboriginal tribes had been severely affected by disease, starvation, and heavy population losses. Alcohol also posed a big problem, especially for those living on the outskirts of the Port Phillip settlement where it was most accessible. In order to pay for the alcohol and other supplies such as tobacco,

Aboriginal women were often prostituted to settlers by their husbands or other male relatives. Some money was earned from odd jobs or begging.

When Thomas first visited the camps along the Yarra and other parts of the District, many of the Aborigines were seriously ill, suffering from venereal diseases and from dysentery, influenza, measles, whooping cough, and smallpox.

Dredge reported a similar situation among the *Taungurong* when he moved to Mitchellstown in 1839. All of the Aboriginal people he met with were hungry and many were cold and ill (Cannon 1982b). The *Taungurong* were also affected by diseases.

While the medical assistance of Thomas, Dredge, and Dr Cussens (the Port Phillip doctor) relieved the suffering of some Aboriginal people, they could only control the often epidemic health problems to a limited extent. The Aboriginal population was steadily declining and continuing violent conflict with Europeans exacerbated the decline. Alcohol and shortages of women eligible for marriage also led to frequent fighting among the Aborigines themselves.

Depopulation

While the presence of disease and the outright massacre of Aborigines by settlers are obvious causes of the depopulation of the Aboriginal people, other factors such as sterility, starvation, alcoholism, dietary changes, infanticide, inter-tribal conflict, and psychological stress were also involved.

In 1839 by Thomas took the first official census of the Aborigines living around the Port Phillip District (presented in Table 5). No known census figures for 1839 are available for the *Taungurong* tribe to the north.

The 12 years between the 1839 census and the early '50s censuses show dramatic population losses, especially for the *Woiworung*. In 1839, 124 *Woiworung* were recorded. By 1853 only 36 remained, representing a population loss of 88 people, approximately two-thirds of the 1839 population. The *Bunurong* tribe had a less dramatic population loss of 20 individuals. In 1852, Thomas visited the *Taungurong* in

the Upper Goulburn, counting 53 males and 31 females, a total of 84 people.

The situation for the remnant Aboriginal populations in the early 1850s was extremely dim. Comprising only one-fifth - in conservative estimates - of the original population at the beginning of the 'Frontier', the Aboriginal people were well on the way to becoming extinct. The seriousness of this situation was compounded in 1850 by the abolition of the Protectorate, which, although largely ineffective, had at least given some relief to surviving Aborigines.

Table 5

POPULATION NUMBERS BY AGE GROUP AND SEX FOR THE WOIWORUNG AND BUNURONG TRIBES IN 1839

Woiworung tribe (Yarra)

Age	Male	Female	Total
<1	-	1	1
1-10	19	15	34
11-20	17	6	23
21-30	11	12	23
31-50	18	14	32
51-70	7	2	9
71-80	2	-	2
Total:	74	50	124

Bunurong tribe (Yarra)

Age	Male	Female	Total
<1	-	-	-
1-10	11	8	19
11-20	14	7	21
21-30	13	6	19
31-50	9	10	19
51-70	2	2	4
71-80	-	1	1
Total:	49	34	83

Beyond the Frontier

After the Protectorate was abandoned in 1850, Aboriginal people in the study area lived on the reserves in Warrandyte, along Mordialloc Creek, and the Merri Creek lands. Thomas continued to look after the

Aborigines as a guardian, although his territory was restricted to the Bourke, Evelyn, and Mornington counties. On 1st July, 1851, Victoria was declared a separate colony. During this time, government concern for the remnant population of Aborigines was dwindling, and most of the assistance given to Aborigines was by concerned missions.

Acheron Station

In February, 1859, two *Woiworung* and five *Taungurong* Aborigines put in a request to Thomas to obtain a tract of land at the junction of the Acheron and Little Rivers on which survivors of the *Kulin* nation could settle (Christie 1979). They chose the Acheron run as a compromise. The land was hilly and not ideally suited to pastoral activities, but carried plenty of kangaroo and possum. The plan was approved and the Aborigines moved onto the 4500-acre reserve late in 1859. Four settlers were appointed as trustees for the Station to ensure that it was being run properly and that '...the land was being used effectively'.

In June 1860, Peter Snodgrass, one of the trustees, proposed that the Station be moved 4 miles up the river to a run belonging to Stephen Jones. Jones wanted to sell the property back to the government because he claimed that the Aborigines' dogs were killing his sheep. After months of negotiations, Jones was paid £1000 compensation and the run was officially designated as the new Aboriginal Station. The Aborigines were upset at having to move off the land they had chosen for themselves and many refused to leave the Acheron site. The injustice of having to make the move was compounded by the fact that the trustees then allowed two local squatters to use the Acheron run. Only about 25-30 of the original 90 *Taungurong* and *Woiworung* who used the Acheron site settled on the new land.

Central Board for the Protection of Aborigines (1861-85)

In 1858, a select committee appointed by the Victorian government investigated the current state of Aboriginal people and their needs, leading to the formation of a central Board for the Protection of Aborigines (BPA). With the assistance of the Presbyterian,

Anglican, and Moravian missions, the BPA established Aboriginal reserves throughout Victoria.

Move to Coranderrk Station

In 1862 the BPA closed down Acheron Station. In March 1863, two leaders from the *Woiworung* tribe - Wonga and Barak - led more than 40 Aborigines across the Dividing Range and through the Black Spur to a new site they had chosen between Watts River and Badger Creek, just south of present-day Healesville (Wiencke 1984). The *Woiworung* were soon joined by the *Taungurong* people. In June 1863, the area was made into a temporary reserve of some 2300 acres, which the Aborigines named 'Coranderrk'.



The grave of Barak at Coranderrk Station cemetery

Although Coranderrk (like other stations in Victoria) probably saved Aboriginal people from extinction, its primary aim was to assimilate the Aboriginal people into European society, thereby destroying Aboriginal culture. This aim of 'civilising' the Aboriginal people involved main-

taining total control over their lives at the stations.

The daily lives of the Aborigines living on Coranderrk were regulated by a strict routine, which included domestic duties and schooling. Although the Aborigines were permitted to hunt animals on the station, they were only allowed to do so to obtain food and skins and not for sport (Massola 1975). All other aspects of the Aboriginal culture, particularly their spiritual beliefs, were banned. Where possible, children were separated from the influence of parents and tribal elders so that they were more likely to become indoctrinated with the 'civilised' European ways.

One of the aims of the station was to produce a self-sufficient community, where men were taught farming skills and women were educated in domestic duties. In 1874, the Aborigines began growing hops as a cash crop and eventually the venture grew into a commercial success. The residents also made traditional artefacts and sold these to tourists.

From 1863 to 1886 the population at Coranderrk steadily increased. Many of the diseases that formerly killed Aboriginal people had been eradicated and, on the whole, the living conditions were much healthier than had been the case during the Frontier period.

Despite the 'success' of the station in ensuring the healthy existence of some of the remaining Aboriginal people in Victoria, in the early 1870s the BPA attempted to move the station and its inhabitants to an isolated area along the Murray. The call for closure of the station was also backed up by the high number of deaths that occurred in 1875, when 38 of the 158 residents died from a measles epidemic and resulting respiratory problems.

The now-politically aware Aboriginal community sent several deputations to Melbourne to protest against the closure. Under increased public criticism for its treatment of the Aborigines, the BPA dropped the idea of closing the station. The Aborigines at Coranderrk had won the first battle against the European establishment. They had acquired a new-found power and with it came confidence and a sense of self-pride.

The *Aborigines Protection Act* 1886

The 'rebelliousness' of the Coranderrk residents represented a threat to the BPA and in 1886, on its recommendations, the *Aborigines Protection Act* was passed in both Houses of Parliament. Essentially the *Act* amended the previous definition of who was legally an Aboriginal person. It stipulated that:

'Aborigines were full bloods, half-castes over 34, female half-castes married to 'Aborigines', the infants of 'Aborigines' and any half-caste who was licensed by the BPA to reside on a station' (Christie 1979).

The aim of the *Act* was to assimilate half-castes, who did not fit into the above categories, into the European community. The policy had disastrous effects on the Aboriginal people as a whole. Half-castes were forced from the relative security of the stations into a generally racist white community, where they had to compete for jobs with non-Aboriginal workers. At the same time, the Coranderrk station lost most of its farm labour force. The *Act* also forced Aboriginal families to split, disrupting one of the only stable components in their lives since European settlement. Christie argues that the *Act* represented a form of 'legal genocide':

'...By restricting the full-blood and other half-castes to stations and by discouraging the marriage of younger half-caste girls with this group, the new policy virtually ensured that 'Aborigines', as defined by the *Act*, would eventually die out. There was ample evidence to show that the mortality rate of this group exceeded its birth-rate'.

Closure of Coranderrk

In the early 1900s, only small numbers of Aborigines were left living on stations in Victoria, and in 1917 the government recommended that, for economic reasons, all remaining Aborigines on stations should move to Lake Tyers in Gippsland. In 1922 some 42 Aborigines remained on Coranderrk station and, despite protests, the station was closed down during the years 1923 and 1924. Six would not shift to Lake Tyers and were permitted to remain there (Massola 1975).

Aboriginal History - 1924--1988

It is difficult to discuss in specific terms the history of the original tribes in the study area after the closure of Coranderrk in 1924. Many Aborigines moved to Lake Tyers in Gippsland and since this time, families have gradually moved out into the wider community, settling where possible in family clusters.

Several major changes in legislation concerning Aboriginal people have occurred during the last 65 years. In 1957 a government investigation was held into the state of the Aboriginal population in Victoria. The Board for the Protection of Aborigines was then replaced by the Aborigines Welfare Board and with this came a change in the definition of an Aborigine to include all people of Aboriginal descent. Despite the creation of this Board, Aborigines have continued to remain virtual outcasts in Australian society.

The turning point for the Aboriginal people came in 1968 with the introduction of the *Aboriginal Affairs Act*, which encouraged Aborigines to handle their own affairs. In 1975, the Commonwealth Department of Aboriginal Affairs was established to service the social, educational, health, employment, and housing needs of the Aboriginal community.

The recent history of Aboriginal people within the study area is highlighted by the strength gained and maintained through a group identity, which bonds people of Aboriginal descent together as a subculture. The basic units of identity within Aboriginal society today rest with the family and the region a family comes from. During the last 20 years this community spirit has been successfully channelled into community groups that provide the power and resources to allow Aboriginal people to take charge of their own lives and their culture.

Present-day Aboriginal communities

Two main Aboriginal groups now live within the study area - the Dandenong and District Aboriginal Co-operative and the Healesville and District Aboriginal Co-operative. The majority of members of these co-operatives are descendants of the tribes inhabiting the region at the time of contact. Both co-

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operatives provide services for the health, social, housing, and cultural needs of Aborigines within a 50-km (approximately) radius of their headquarters.

In recent years Aboriginal people have become more politically active. One focus of these activities has been claims regarding former tribal land by the Dandenong and Healesville Co-operatives. For the Aboriginal people, the current land claims represent a way of redressing some of the wrongs European society has inflicted upon their culture. At the same time, the land recovered represents a symbol of strength for Aboriginal people living in the present and provides hope for Aboriginal society in the future.

Archaeology Related to Aboriginal History and Prehistory

Background archaeology

The basic aim of archaeological investigation is to reconstruct the behaviour of people who once lived in the past. Archaeologists rely on diverse sources of information of which

the most common techniques are systematic survey, excavation, and reference to historical records.

Excavations

Five excavations have been undertaken in the study area, all of them on coastal sites relating to pre-contact human occupation. As a result of the sea-level changes, the age of most of the sites associated with coastline occupation does not exceed 6000 years.

Stinker Bay shell midden

The Stinker Bay deposit comprised a shell midden situated in a small rock shelter on Phillip Island.

Excavations here recovered quantities of shellfish, stone, bone, and charcoal (Gauthwin and Brennan 1986). The base of the midden has been dated to 280 plus or minus 55 years bp (before present). Results of the analysis indicate that shellfish from intertidal zones predominate in the deposit, although some shells requiring subtidal diving and the occurrence of animal remains



Coastal middens mark occupation sites and contain shellfish remnants, charcoal, and stone tools.

suggests some foraging inland from the coast. The site probably represents the remnants of a single occupation and it was concluded that 'the contents of the site reaffirm the lack of intense use of the site and surrounding area'.

Corinella 3

Corinella 3 shell midden lies at the base of cliffs north of Settlement Point headland in Western Port Bay. The midden, totalling some 30 m in length, with a deposit approximately 1 m deep, was excavated in 1986. The aim of the excavation was to establish whether it was formed by natural or human agencies and, while the results were inconclusive, two stone artefacts in the lower levels suggest that people had occupied the site during the past 2500 years (this date coming from radiocarbon samples) (Brennan 1987).

Point Grant 1

In 1983 the midden was excavated but the analysis of materials is as yet uncompleted. Situated on a cliff facing Seal Rocks, this midden has been dated: the pre-midden layer yielded a date of 1900 plus or minus 60 years bp and the midden layer a date of 1470 plus or minus 60 years bp (Gaughwin 1983).

Other excavations

Two other coastal middens were excavated by the Victoria Archaeological Survey in 1985/86 at Cape Schanck 7 and Boags Rocks. Reports on the studies are not completed.

Surveys

Detailed surveys undertaken by Hilary Sullivan (1981), Denise Gaughwin (1981), and Hilary Du Cros (1988) provide the greatest volume of background data on archaeological sites in the region.

The aims of these surveys were broadly: to locate archaeological sites; to generate information on the distribution of sites by environmental zone; and to assess sites and areas in terms of their significance.

Some 289 sites located during a 1981 survey of the Mornington Peninsula were occupied within the last 6000 years (Sullivan 1981). Coastal exploitation by small groups of Aborigines would have focused on the Bass Strait coast of the Peninsula and inland

movement would have been towards the faunal resources on the Western Port plains.

A survey of Phillip Island, French Island, and the area around the northern end of Western Port Bay located 260 sites (Gaughwin 1981).

The author argues that camp sites are mostly on the coastal dunes facing high-energy rock platforms and near fresh water, and observed that these sites rarely contain land-mammal or bird bone, suggesting that they were used exclusively to exploit coastal resources.

At inland areas north of the bay, subsistence activities were focused on swamps and other water sources where food resources abounded. Gaughwin argues that '...the coastal margins were relatively unimportant in the food quest' and that the subsistence strategies were keyed more to coastal plains '...particularly those areas which were adjacent to wetlands' (Gaughwin 1983).

A 1987/88 survey of the Upper Yarra Valley located 37 sites, with the author concluding '...there is no area which appears not to have been used by the Aborigines in the region' (Du Cros 1988).

Highland areas were occupied sporadically and probably on a seasonal basis, and camp sites '...are likely to be found on well drained settings overlooking resource-rich zones and in the forested regions, such sites might be found on ridge tops. In addition, Du Cros suggests that while sites were concentrated along the banks of the Yarra River they could also be expected on the floodplain and that larger sites were probably located close to swamps or lakes.

Analysis of some of the stone recovered revealed that many local sources of stone were probably exploited. Two hatchet-heads recovered were sourced to Mount William near Lancefield, indicating the long-distance movement of raw materials, possibly via exchanges.

Summary of archaeological work

Relative to most of Australia, the region has been extensively investigated. Despite this, we still know very little about the activities of Aborigines across the diverse landscapes of the study area. While the surveys have

demonstrated that Aborigines occupied the entire region at some time during the past, the focus of more detailed follow-up research has been limited to only one environmental area, the coast.

One of the reasons for this lack of research in inland areas is that these contain very few sites with the potential for excavation - that is, have undisturbed deposits.

Moreover, because no sites older than 6000 years have been excavated, little specific information is available about the length of human occupation in the area. It seems highly likely, however, given the dates from archaeological investigations just north of the New South Wales--Victoria border at Lake Mungo, that people had been inhabiting Victoria for at least the last 32 000 years. Future excavations inland should shed more light on the antiquity of the region.

Archaeological Sites on Public Land in the Study Area

Pre-contact sites on public land

Nine different site types of pre-contact origin occur on public land in the study area. Their frequency is listed in Table 6.

Shell middens comprise concentrations of shell and often flaked stone, animal bones, and charcoal remaining from human occupation. Middens may comprise the refuse of one occupation, although occasionally they are made up of successive occupation levels. Shell middens are common along the coastline and may occur up to a kilometre inland while fresh-water shell middens are usually associated with lakes and rivers.

Surface scatters of stone artefacts and worked stone often represent specific stone-working areas where tools were produced, but may also represent the surviving remnants of a camp site, where the organic components have disappeared.

Isolated artefacts, implements, and worked stone have no obvious relationship with a larger site.

Scarred trees are those scarred by the deliberate removal of bark. One type of scar is formed after the removal of a slab of bark

Table 6

FREQUENCY OF PRE-CONTACT SITE TYPES ON PUBLIC LAND IN THE STUDY AREA

Site type	Number
Shell midden	448
Surface scatter	175
Isolated artefact	60
Scarred tree	45
Quarry/stone source	2
Rock shelter/cave	1
Isolated hearth	1
Burial	1
	733

Source: Site Register, Victoria Archaeological Survey

from the tree trunk to make items such as shields, canoes, or carrying containers (Coutts and Witter 1977). Often these scars are symmetrical because they were deliberately cut into specific shapes. A second type of scar formed when Aborigines fashioned toe-holds in the trunk in order to climb the tree.



Scarred tree at Cranbourne

Quarry/stone sources are areas from which stone was obtained for the manufacture of stone tools and frequently include refuse from stone-working.

Rock shelters/caves provided protection from the weather. During the occupation of such shelters, debris such as stone tools, bones, shells, and charcoal from fires often accumulated.

Isolated hearths define the remnants of campfire, usually occurring as a cluster of ash and burnt bone, shell, and other materials, and possibly scorched earth or sand.

Burials include any pre-contact human remains.

Post-contact sites on public land

Two post-contact sites on public land in the study area had a direct relationship with Aboriginal culture and history - the Dandenong Police Paddocks and Coranderk Reserve. Each was assessed by the Dandenong and Healesville Aboriginal Co-operatives as having historic significance.

Assessing Significance

Australian archaeology employs a variety of methods for determining the significance of archaeological sites.

Three major criteria are used here to determine site significance:

- * scientific value
- * representative value
- * social value
 - educational
 - value to Aboriginal people

Scientific value

A highly significant site has the potential to provide a substantial amount of scientific information, plus evidence of its age and the activities associated with it. For the study area this is an important consideration, given that very little is known about the pre-contact history of people living in the region away from the coast. Significant sites generally have *in situ* well-preserved or undisturbed deposits.

Some site types found on the surface of the ground, such as lithic scatters, may yield a wealth of information. Large scatters in particular provide greater research opportunity to supply answers to a variety of questions.

Representative value

Rare sites are highly significant because they may represent unique manifestations of pre-contact human behaviour. A representative sample of site types needs to incorporate rare sites.

Social value

Sites may have the potential to provide information for the general public about post- and pre-contact Aboriginal history and also be significant for present-day Aboriginal groups. Those with public-education potential need to be clear and well-preserved examples of the site type being displayed.

Value to Aboriginal people

In assessing the significance of archaeological sites, Aboriginal people may differ from archaeologists. For the majority of them, the value of a site lies not in its scientific qualities but rather in its cultural ones.

In order to gauge the opinions of Aboriginal people on the value of different site types, representatives from the Dandenong, Healesville, and Morwell Co-operatives were consulted.

It was not possible to assess the significance of each individual site recorded; assessments were limited to those sites within the areas surveyed by Sullivan (1981), Gaughwin (1981), and Du Cros (1988).

Further assessment is not possible until more detailed surveys of the remaining areas are undertaken.

Pre-contact Sites of Significance

Most pre-contact sites of significance are coastal, particularly middens. This is not surprising given that two of the major surveys were undertaken along the coast. Ten of the significant sites occur in the Upper Yarra Valley survey area. Table 7 lists the site types recorded to date.

Table 7

NUMBER OF SIGNIFICANT PRE-CONTACT SITE TYPES

Site type	Number
Shell midden	32
Surface scatter	6
Isolated artefacts	-
Scarred trees	6
Quarry/stone source	2
Rock shelter/cave	1
Isolated hearth	1
Burial	1
	49

Middens

In the majority of cases, the middens were considered to be of value because they contain *in situ* deposits. The coastal region is particularly vulnerable to erosion and hundreds of middens have been disturbed by erosion during the past.

Seven of these middens are rare because each one has unique contents (in terms of both the

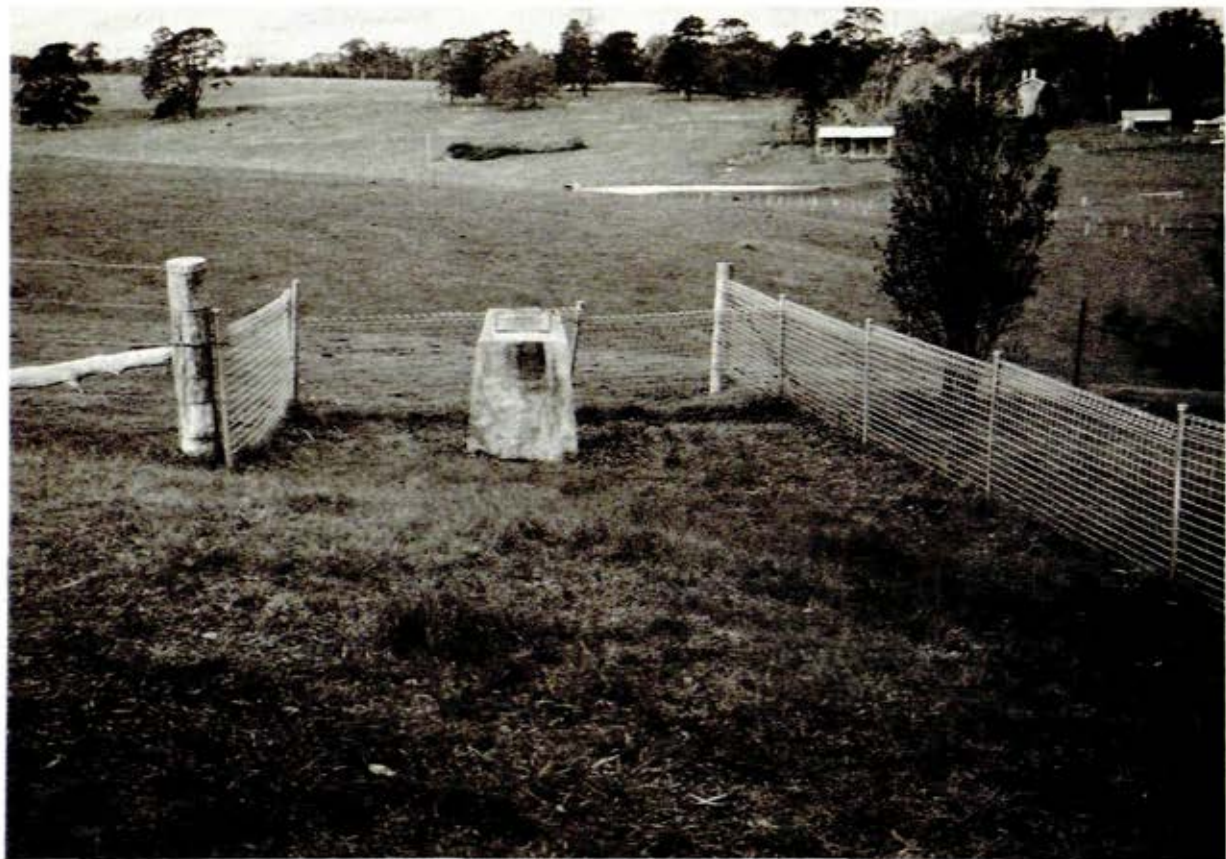
size of the deposits and the artefacts present). Two of these sites, Stinker Bay and Cape Schanck 7, have been excavated. Swan Lake 4, which is located on the edge of a lagoon, is the only midden situated away from the coast (Gaughwin 1981).

Surface scatters

The surface scatters given significance values have research potential due to their size and the uniqueness of their contents, whether the type of stone-working reflected in the artefacts or the raw material used.

Scarred trees

All six scarred trees occur in Du Cros' survey area. Five are significant because of their educational value. These trees are located in the Healesville Wildlife Sanctuary and accessible to large numbers of people. The Cement Creek scarred tree is the only one within the area surveyed by Du Cros in a mountainous environment. It should be noted here that it was only possible to consider 6 of 45 scarred trees occurring on public land in the study area.



The former Coranderrk Station site, as it appears today

Rare sites

Five site 'types' are particularly rare on public land within the region. These are: the two stone/quarry sources, La Trobe Valley Silcrete Quarry and Cape Woolamai 4 Quartz Quarry; Jessie's Cave 3; the Cape Woolamai 1 Isolated Hearth; and the San Remo Back Beach Burial.

Assessment of pre-contact sites by Aborigines

On the whole, the Aboriginal people interviewed about the significance of the archaeological site types found on public land in the study area saw little value in the archaeological definitions of site types. Some of them believe that all sites, both pre- and post-contact types, are equally significant.

Members of the three co-operatives (the Dandenong, Healesville, and Morwell Aboriginal Co-operatives) felt very strongly that the burial at San Remo has great significance and should not be tampered with. At the time the site was first located, several bones had eroded out from the sand-dune grave. This skeletal material was documented and reburied in accordance with *Wurundjeri (Woiworung)* burial practices in September 1988.

Post-contact Sites of Significance

Two areas of public land have historical significance for the Aboriginal people of the Dandenong and Healesville Co-operatives: the Dandenong Police Paddocks and Coranderrk Reserve at Healesville. Both are currently subject to land claims by the two co-operatives.

References

- Barwick, D.E. (1984). Mapping the past: an atlas of Aboriginal clans. *Aboriginal History* No 8(2): pp.100-131.
- Berndt, R.M. and Berndt, C.H. (1977). 'The World of the First Australians.' Revised edition. (Lansdowne Press: Sydney.)
- Berndt, C.H., and Berndt, R.M. (1978). 'Pioneers and Settlers: The Aboriginal Australians.' (Pitman Publishing: Victoria.)
- Bonwick, J. (1983). 'Port Phillip Settlement.' (Sampson, Low, Marston, Searle and Rivington: London.)
- Brennan, G. (1987). 'Investigating the Formation of Shell Deposits: An Analysis of a Site at Settlement Point, Corinella.' B.A. Honours Thesis, Department of Archaeology, La Trobe University, Bundoora, Victoria.
- Bride, T.F. (ed.) 1898 (1969). 'Letters from Victorian Pioneers.' New edition. (Heinemann: Melbourne.)
- Bunce, D., 1859 (1979). 'Travels with Dr Leichardt.' (Oxford University Press: Melbourne.)
- Butlin, N.G. (1983). 'Our Original Aggression: Aboriginal Populations of South-Eastern Australia 1788-1850.' (George Allen and Unwin: Sydney.)
- Cannon, M. (ed.), (1982). Aborigines and Protectors 1838-1839. *Historical Records of Victoria, Volume 2B*. Foundation Series, Government Printing Office, Victoria.
- Cole, K. (1981). 'The Aborigines of Victoria.' (Keith Cole Publications: Bendigo.)
- Coutts, P.J.F. (1981). 'Readings in Victorian Prehistory, Volume 2: The Victorian Aborigines 1800-1860.' (Victorian Archaeological Survey, Ministry for Conservation, Forests and Lands: Melbourne.)
- Coutts, P.J.F. and Witter, D.C. (eds.) (1977). 'A guide to recording archaeological sites in Victoria.' *Records of the Victoria Archaeological Survey (Special Issue)* No. 3.
- Du Cros, H. (1988). 'An Archaeological Survey of the Upper Yarra Valley and Dandenong Ranges.' A Report to the Victoria Archaeological Survey.
- Gaughwin, D. (1981). Sites of archaeological significance in the Western Port catchment. Ministry for Conservation, Victoria *Environmental Studies Series Publication* No. 367.
- Gaughwin, D. (1983). 'Coastal Economies and the Western Port Catchment.' Master of

Arts Thesis, Division of Pre-History, La Trobe University.

Gaughwin, D. and Brennan, G. (1986). Stinker Bay shell midden. *Archaeology in Oceania* No 21: pp.63--8.

Goulding, M. (1988). 'Aboriginal Occupation of the Melbourne Area, District 2.' A report to the Land Conservation Council.

Howitt, A.W. (1908). 'The Native Tribes of South-East Australia.' (Macmillan: London.)

Jamieson, R. (1853). In T.F. Bride (ed.) (1969): 'Letters from Victorian Pioneers', new edition, pp.89--92. (Heinemann: Melbourne.)

Kirk, R.L. (1981). 'Aboriginal Man Adapting'. (Oxford University Press: Oxford.)

Land Conservation Council (1985). 'Report of the East Gippsland Area Review.' (Victorian Government Printing Office: Melbourne.)

Massola, A. (1975). 'Coranderrk: A History of the Aboriginal Station.' (London Publishing Company: Kilmore.)

Radcliffe-Brown, A.R. (1930). Former numbers and distribution of the Australian

Aborigines. *Official Year Book of the Commonwealth of Australia* No. 23.

Smith, L.R. (1980). 'The Aboriginal Population of Australia. Aborigines in Australia Society 14.' (A.N.U. Press: Canberra.)

Sullivan, H. (1981). An archaeological survey of the Mornington Peninsula, Victoria. *Victoria Archaeological Survey, Occasional Reports Series* No 6.

Thomas, W. (n.d.). 'LT Notebook.' (Unpublished original MS.) In R.B. Smyth Papers Box 1176/6b, La Trobe Library, Melbourne.

Thomas, W. (1854). Brief account of the Aborigines of Australia Felix. In T.F. Bride (ed.) (1969): 'Letters from Victorian Pioneers,' new edition, pp.397--437. (Heinemann: Melbourne.)

Wiencke, S. (1984). 'When the Wattles Bloom Again: The Life and Times and William Barak, Last Chief of the Yarra Yarra Tribe.' (Globe Press: Melbourne.)

Winter, T. (1837). Letter from Hobart. In T.F. Bride (ed.) (1969): 'Letters from Victorian Pioneers,' new edition. (Heinemann: Melbourne.)

3. EUROPEAN HISTORY

This account of European history is organised into distinct themes of direct relevance to natural resource use and land use features of the study area. These themes are the pattern of public land, tracks, mining, forests, fire, farms, water, and recreation, and form part of a broader set of issues to be developed.

A comprehensive listing of the historical sites in the study area has been compiled by the Historic Places section of the Department of Conservation and Environment for this Review. A report written by the project leader (Griffiths 1990) forms most of this chapter. Copies of the report containing full referencing, the historic site listings, and site location maps are available for inspection at the Council's offices.

The Pattern of Public Land

Historical and cultural values reside not only in particular sites and places, but in the whole shape and balance of the landscape. Existing parcels and allotments of public land are themselves relics, historically defined and defended. Attention must be given not only to the history of what happened on the land and to the land, but also to what people wanted to happen there.

A distinctive characteristic of Australian history has been the prominent role of government in overseeing and planning district development. Crown land reserves were one tool by which a central and often distant government sought to shape local community attitudes and priorities. Space was formally allocated for essential and desirable purposes: a school, a cemetery, a quarry, a water reserve, a recreation ground, or a botanic garden. Although the survey and assessment of land often occurred in response to private initiative, the geography of official sanction remained a fair measure of the frontier of settlement. Often the two went hand in hand. In far-flung Matlock, the 1864 survey followed on the heels of the gold-rush settlement and accommodated the streets around the existing buildings.

Another role of Crown land reserves was the protection of resources, such as river-banks,

water resources, valued timber, and known minerals. Usually the definition of these reserves was a source of bitter contention. They limited and constrained settlement, and settlement was regarded as the highest public benefit of all, and the true measure of progress.

By the end of the 1840s, squatters occupied most of the plains and open valleys of the study area - much of the Mornington Peninsula, Western Port, French and Phillip Islands, the Yarra flats, and the Goulburn valley. Few towns had been proclaimed in the study area before the mid 1850s. The population was dispersed and the main centres lay along the Sydney road, and further east at Port Albert. But, within the study area, 'township' reserves were declared as early as 1847.

In that year, an Order-in-Council defined a number of significant areas, particularly water reserves, along the northern and eastern shores of Western Port. They were prospective sites, potential urban centres, placed strategically within a region of Victoria that, until the gold rushes, was one of the areas of higher population. The discovery of gold revolutionised the pattern of settlement, and few of these early reserves were activated.

The most revealing legislative history of resources concerns the forests. Most public land is forest, and most forests are on public land. This is because the first signature to private ownership was a clearing.

One of the obvious reasons why forests have been allowed to remain is because they occupied lands regarded as marginal for settlement or agriculture: too wet, too dry, too steep, or too inaccessible. 'Reserves for native peoples' were a product of the enlightenment and of evangelical Christianity, which held that dispossessed races deserved compassion and could be 'civilised'. Two principal places were nominated for this purpose: the site of the present Dandenong Police Paddocks, selected for Aborigines from 1837, and sites in the Acheron and Healesville districts (Coranderrk Station) from 1859.

During World War II, Australia interned enemy aliens and 'naturalised British subjects of enemy origin', some of them in forest camps within the study area. Prisoners of war including from overseas were also housed in large internment camps, including two forestry camps in the Mount Disappointment forest and one in the Dandenong forest.

A different sort of prison was that established on French Island in 1915, where inmates experienced farming as well as isolation.

Parcels of public land have been set aside for the management of Nature from the earliest times, but the reasons for their proclamation have changed markedly. Modifications of a wholly utilitarian land management perspective appeared in Victoria from the 1860s with the protection of timber reserves and water frontages.

It took longer before Crown land was reserved for non-economic purposes. The early history of Victoria's national parks illustrates the growing importance of outdoor recreation as much as the emergence of any conservation ethic. Often these roles were in tension, as is suggested by the term 'park'.

The modern mosaic of Nature reserves has its own historical context. It reflects a new respect for scientific opinion such that the 'romantic' vision, so important in the formation of the first parks, now has much less influence. Many of the parks and reserves have 'disturbed environments'. For example, the Langwarrin Flora and Fauna Reserve has a long military history; Mount Worth State Park includes original forest as well as abandoned farms, and much of Fraser National Park was settled by graziers, and parts of it had been subject to mining.

Tracks

The first recorded European in the study area was probably George Bass, who named and explored Western Port in January 1798. Many of the early coastline incursions were for defence purposes, and the enemy was not the Aborigine; but the French.

In 1800, H.M. brig *Lady Nelson* was dispatched to make survey of Bass Strait, and it returned in 1800-02 for a more detailed exploration of possible settlement sites and to

consolidate the British claim. On 9 March 1802 at Point King, the Union Jack was raised and all the southern shores of New South Wales formally annexed.

Others followed: Matthew Flinders climbed Arthur's Seat in 1802 and, in 1803, land parties from the Cumberland walked around Port Phillip Bay, crossed the peninsula to Western Port, and ventured up the Yarra River as far as Studley Park. The British government, to further forestall the French, had decided to form a settlement at Port Phillip. But a hostile Aboriginal presence, poor soil, scarce water, and sickness meant that the settlement at The Sisters lasted less than a year.

Another official settlement - this time of 20 soldiers, some with their wives, and 20 convicts - was established at Western Port in 1826, near the present town of Corinella. It too was later abandoned.

Throughout this period of the beginnings of official exploration of the coastline of Port Phillip, many informal, seasonal camps (especially in Western Port) must have been established by sealers and whalers who were harvesting the rich resources of Bass Strait.

In December 1824, Hamilton Hume and William Hovell reached Corio Bay from the north. In doing so, they crossed the Yea district, climbed Mount Disappointment, and named it for its lack of view. One of their lasting tracks was the pass they found over the Divide, which was followed by later overlanders and perpetuated by the railway line and (roughly) the western boundary of the study area.

Another route into the study area from the north was pioneered by Count Paul de Strzelecki, who led a party across the Australian Alps into Gippsland and across to Western Port in 1841. Attempts to establish a trading route linking Melbourne with south Gippsland were frustrated by 'the Great Swamp' north of Western Port and heavy forest between Bunyip and Moe. By 1847, C.J. Tyers had surveyed a route from Traralgon to Melbourne, although people generally preferred the route by sea to Port Albert until a rail link to Sale was made in 1877.

Nevertheless the pastoralists, and soon the miners, were the chief pathfinders. An



Railway construction near Korumburra

overlander, John Gardiner, came across rich pastures in the Croydon–Mooroolbark area when seeking lost cattle in 1837. By the early 1840s, squatters had claimed most of the flat land along the Goulburn Valley, and by 1850 their runs encircled the Dandenongs and extended down the Mornington Peninsula and along the Yarra Valley. The Surveyor-General, Robert Hoddle, made the first exploration of the Upper Yarra in 1844, but the miners opened up the rugged country beyond.

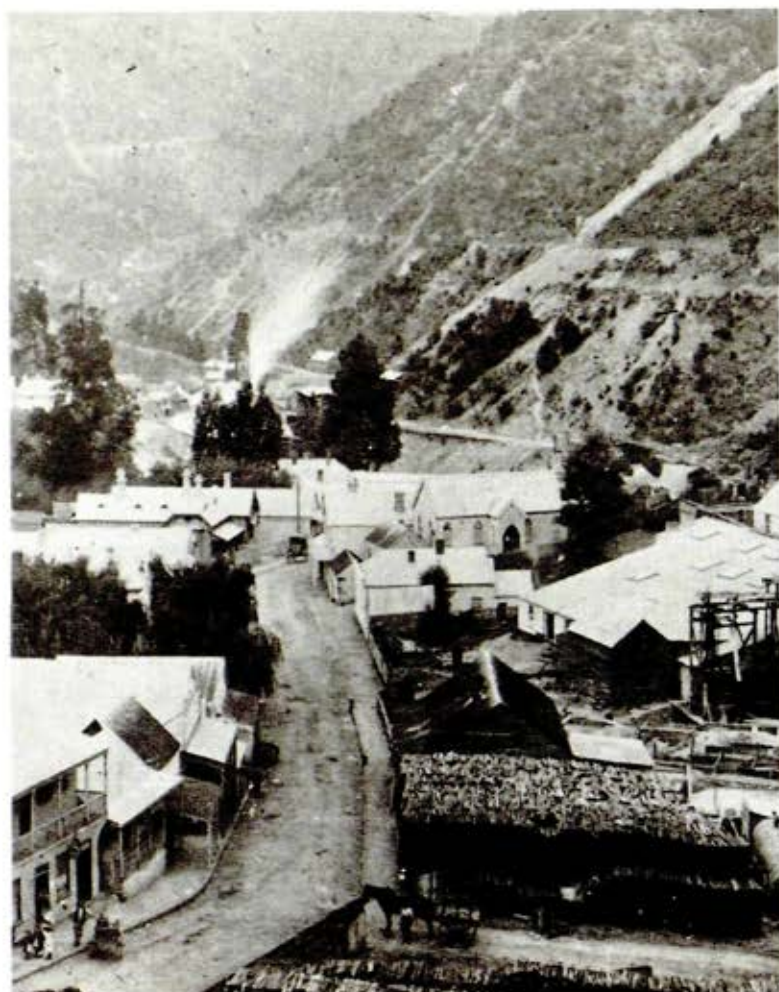
The discovery of gold probably delayed development in the east. For most of the 1850s, the central and western goldfield drew money and population. From the late 1850s, however, gold was found in the eastern valleys and mountains. Mining generated new settlements and strings of stores, hotels, and townships along the tracks made to the diggings. Miners' tracks were often barely a foot in width, and they expended much time and money in cutting them. From 1863, the development of the Yarra Track up the Blacks' Spur from Healesville to Marysville,

and on to Woods Point, had enormous impact on settlement along the Yarra Valley.

The early European history of the study area was played out along these tracks, commemorated by the name of their creator or by a feature they passed: Mia Mia, Campbell's, Porter's, McEvoy's, Yarra, Hogarth's, McDonald's. Their monuments are the avenues of ferns, the stone culverts, the string of hotel sites, and the modern overlay of bitumen. The routes of the most successful tracks have been preserved by modern roads, but at the expense of their physical monument.

Sea transport and coastal development played a major role in the State's development. Ships brought immigrants, stores, and stock, carried resources for export, and plied a trade between the colonies' coastal settlements.

Until around the turn of the century their journeys were especially hazardous undertakings, with frequent shipwrecks and much loss of life. More than 600 shipwrecks



Walhalla, in its heyday in 1910

occurred along the Victorian coast, with over a dozen involving vessels exceeding 100 tons wrecked from Port Phillip Heads to Cape Paterson. Of the 62 possible shipwrecks in the study area, the Victorian Archaeological Society knows the location of 14. As expected, most of the known sites cluster around the navigation hazards - Point Nepean, Cape Schanck, and Western Entrance - and most are close to shore.

Mining

The major goldfield in the study area (often known as the Jordan) stretched along a 3-mile-wide belt of auriferous land from Jamieson in the north to Walhalla in the south. It had significance for several reasons. Opened up in the 1860s, it was the site of Victoria's major gold-rush in that period and was the only goldfield in the colony where the miners were also the explorers, the first white settlers. It boasted Walhalla, which for 50 years was one of Victoria's outstanding mining districts.

One of the first Victorian discoveries of gold occurred in 1851, east of Melbourne at Anderson's Creek (War-randyte). However, finds in the Ballarat, Bendigo, and Beechworth districts drew miners north and west for most of the 1850s. Emerald field was opened up in 1858 and short-lived rushes developed along the Little Yarra and Upper Yarra Rivers. Despite a small rush near the Jamieson Flat in 1854, it was not until 1857 that miners returned to explore the Big River and discover gold at Enochs Point - the first gateway to the Upper Goulburn field.

Jamieson developed from 1860 as a stopping place and market town for the new and rapidly extending goldfield. There, the packhorses took over from drays and began their tortuous journey south. The cost of isolation was one reason why wooden water wheels proliferated as a means of power in the early years of this district. They could

be constructed from local timber, and only the iron hub and buckets needed to be imported.

Woods Point field was opened up from the north in May 1861. During the next 3 years, spectacular quartz reefs (particularly the Morning Star) were quietly developed in this area while the bulk of the miners were seeking fast alluvial wealth in the broader Jordan River valley further south. This new field revived Victoria's gold fever of the early 1850s. Nuggets were plentiful and sluicing was richly rewarded. In February 1862, 3 months after the first parties had reached the Jordan, the Mining Registrar for the division reported some 4000 diggers on the field.

Initially this new extension of the Jamieson field was tethered to civilisation by a 12-mile (19-km) precipitous track over the Divide and then by a further 40-miles (64-km) of packhorse trail to Jamieson. New tracks were quickly established to the west and

south. The Yarra Track, the most direct route from Melbourne to Woods Point via Healesville and Marysville, was first used in 1862. Porter's, Campbell's, and, pre-eminently, McEvoy's Tracks were forged. Packers discovered Donnelly's Creek field in late 1862 and, by February 1863, Edward Stringer spread word of his find at Walhalla. Thus the major fields and transport routes in the rugged Upper Goulburn and Jordan valleys were established within 3 years of their discovery.

The working population came to depend on the few continuously operating mines - the Al, Morning Star, All Nations, Loch Fyne, Golden Lily, and the Toombon, as well as the Long Tunnel at Walhalla.

At the end of 1867, as the richer portions of the original reefs were exhausted, the boom quickly collapsed. The goldfield drifted into decline in the 1870s.

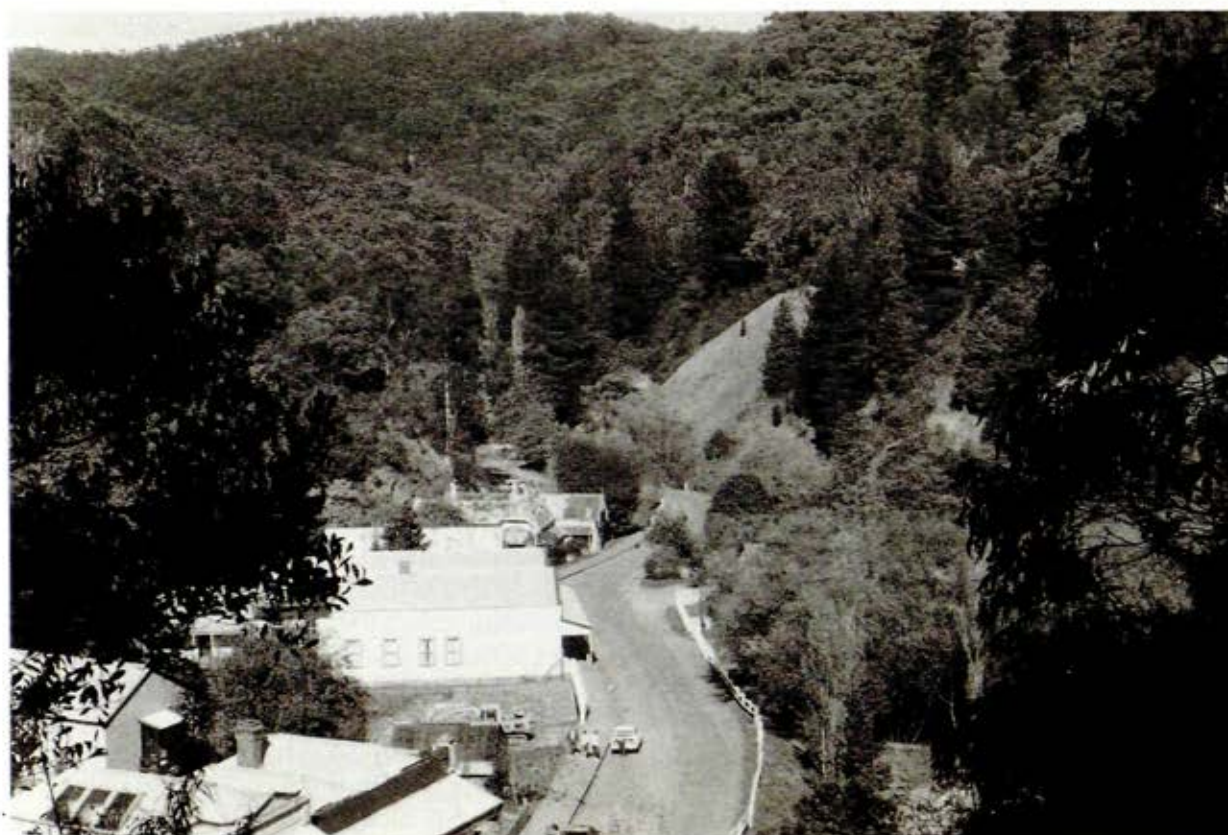
By the 1880s about 2000 people lived in Walhalla, the centre of a field that was second only to Bendigo in gold production. But the town itself remained a frontier

settlement and even by 1896 had no domestic water supply, court house, or railway.

The 1890s and early 1900s witnessed a widespread mining revival which continued until World War I. The first decade of the twentieth century was one of Walhalla's most successful mining periods, but also the eve of its sudden decline. Built after decades of lobbying, the Walhalla railway was completed in 1910, just in time to take people, their belongings, and some of their houses away.

Mining continued quietly along the Jordan goldfield in the 1920s and, in the 1930s depression, received some impetus from the rising price of gold and high national levels of unemployment. The 1939 bushfires drew a black, final line across the lives of the already dwindling mining communities. Only two mines continued to operate after the 1930s: the Al at Gaffneys Creek and the Morning Star at Woods Point. Both figured among the top ten gold producers in Victoria until well after World War II.

Mining activity revived in the 1980s and, combined with a new interest in history,



Walhalla, as it is today

further diminished the evidence of past mining. The 1970s and '80s have therefore been a period of rapid loss of mining heritage.

Waterwheels were particularly dominant in the district's history. One has survived intact (Donnelly's Creek), and the remains of others indicate major battery sites. Incline tramways, used to ferry ore from the mine to river-side batteries, and extensive tramway networks to supply wood for the boilers were peculiar to mountain mining. At the Royal Standard and Sir John Franklin mines, incline tramways survive as notable features in the forest and retain associated relics and stonework. Walhalla developed an intricate network of tramways to supply timber for the mines.

Quartz reefs were the main object of mining in this goldfield, but some evidence of alluvial diggings remains, particularly on the Jordan and Jamieson flats. These features include sluicing banks and channels, river-diversion tunnels, and congregations of shafts. One human dimension of alluvial, as opposed to quartz, mining was Chinese settlement. There were relatively few Chinese on the whole Jordan goldfield, and evidence of their activities is scarce. A ceremonial oven and some isolated, unmarked graves are perhaps the only conspicuously non-European relics in the district.

The signs of 1860s settlement and industry are obviously important. The 1890s and early 1900s were the other years of major development, and relics dating from this later time are also important elements in the district's heritage. The area's isolation has, in some cases, ensured the survival of relics that have become scarce in the more accessible mining districts of Victoria.

Coal became the dominant extractive industry in Gippsland this century. Mining was undertaken at Cape Patterson from 1859 and at Kilcunda in the early 1870s. A syndicate at Coal Creek brought its mine into production in 1890, and by 1892 others had opened at Jumbunna and Outtrim and soon had their critical rail links with Melbourne. Seams at Wonthaggi were discovered in 1908, and production in this area peaked in the late 1920s. The last of the Wonthaggi shafts closed in December 1968.

Although most brown-coal deposits were located outside the study area, the development of the La Trobe Valley had great impact on patterns of settlement in Gippsland. From the early 1950s there was progressive large-scale development of the La Trobe Valley industrial region, and from the late 1960s of natural gas and oil supplies in Bass Strait.

Other forms of mining plumbed and scraped the surface of the study area. Lime-burning for mortar was a very early and significant industry on the Mornington Peninsula, and a large limestone deposit was quarried for building purposes at Lilydale from 1878. Tin, Victoria's second most valuable mineral, was found at the head of the Bunyip River in 1876; wolfram was mined in the Yarra Valley; and saltworks were established on the shores of Western Port Bay. Copper ore was mined at Cooper's Creek on the Thomson River from 1863 until 1881.

Forests

The first Europeans to venture into the vast mountain forests east of Melbourne regarded them with awe. They captured the popular imagination and have persisted as symbols of the region. Some colonists regarded the lushness and magic of the mountain forests as almost un-Australian: they applied place-names like Jordan and Jericho a response to their sense that the forests were truly 'Eastern'. This wonder at the forests did not stop Victorians from destroying them.

So vast were the forests, and so much did they dwarf the human figure, that restraint in their use seemed unnecessary. However, in just a few decades, miners, splitters, and millers wrought immense destruction.

The search for Victoria's (and the world's) giant trees - which took place from the mid nineteenth century - illustrated some of these conflicting feelings about the forest. Inter-colonial and international exhibitions were occasions to boast about Victoria's tall trees. At the time of the Centennial International Exhibition held in Melbourne in 1888, a reward of £20 (\$40) was offered to anyone who could locate a tree 400 feet (122 m) in height. No such tree was found, but several over 300 feet were identified.



*Forest clearing near Mt Horsfall -
last century*

Tall trees and huge stumps and logs continue to be made into artefacts of wonder. In 1933 Harold Furmston discovered a magnificent mountain ash on Mount Monda with a circumference of almost 64 feet (19.5 m). The Healesville Shire President led an excursion to the tree and it became a popular pilgrimage for hikers. In 1976 a monument was unveiled to the 'World's Tallest Tree' near Thorpdale in the Strzeleckis, which, in 1884, was said to be 375 feet (114 m) high.

The Cumberland Reserve near Marysville was proclaimed to preserve a stand of tall mountain ash.

Trees were initially regarded as an enemy rather than as a resource. Ringbarking, which created landscapes of gaunt, dead trees, was the supreme expression of this attitude. Settlers were often overwhelmed and frustrated by the quantity of bush timber. Clearing it was seen not only as a private necessity but as a public good.

In a pioneer country, settlement was the priority. Squatting, selection, and mining, the three major phases of land use in nineteenth century Victoria, all placed pressure on the forests. As the Secretary of the Forests Commission put it in 1924, 'in most parts of the State today burnt and ring-barked skeletons bear mute witness where fine timber has been destroyed, but settlement has not been able to make good'. The slowness with which forest husbandry was adopted in Australia was probably partly due to the dominance of the British, who came from a country where few original forests remained, and where a cherished right and freedom (particularly for the landless poor) was to chop down trees.

The first Victorian legislation to create reserves for 'the growth and preservation of timber' was embodied in the 1862 *Land Act*, although trees on such reserves could still be cut. This provision was strengthened in the 1865 Act, and within years more than a million acres of Victoria had been set aside as State forests or timber reserves.

A series of reports from the 1870s detailed huge waste in the timber industry and irresponsible and ineffective management of the forest resource. Forestry Bills were presented to Parliament in 1879, 1881, 1887, and 1892, but none was enacted.

These circumstances eventually culminated in a Royal Commission on Forests, which sat from 1897 to 1901, produced 14 reports, and led to the 1907 *Forests Act*, which established a Department of Forests. This professional emergence of scientific forestry consolidated with the establishment of the 1910 School of Forestry at Creswick. The development of forest management coincided with the early years of intensive commercial sawmilling in the eastern forests. Much of the momentum for this legislative change came from the devastation and exhaustion of forests in other parts of Victoria, particularly in the goldfield districts.

This timber tramway era is most represented in the physical relics left in the forest today. It began with the extension of the railways into the east and ended with the construction of roads and use of motor vehicles during salvage operations following the 1939 fires.

Sawmills were established from as early as the 1850s. Some mills developed directly from mining, such as the earliest in the Gembrook district, which converted its waterwheel from driving a battery to operating a saw. Other well-known mills existed at Bass River in the 1870s, at Crystal Creek near Alexandra in 1875, and at Monkey Creek near Yea in 1878.

A new, large-scale era of sawmilling was initiated in the eastern forests by the extension of the Victorian Railways system to towns such as Wandong and Nar Nar Goon (in the 1870s), Yea (1883), Healesville (1889), Fern Tree Gully (1890), Gembrook (1898), Warburton (1901), Alexandra (1909), Erica and Walhalla (1910). During the period from 1885 to 1950, sawmilling developed a common and relatively stable pattern.

Tramways developed as a cheap, efficient, and year-round means of conveying timber to the rail lines, where it was destined for the Melbourne market. They were first constructed of wooden rails with closely packed wooden sleepers, which provided a firm base for horses as they hauled the bogies. Steel rails, sometimes used on corners, eventually totally replaced many wooden lines, and steam locomotives and winches took over the work of the horse and bullocks.

Sawmilling activity in the study area peaked in the 1920s and immediately after World

War II with fire-salvage work. The number of forest sawmills reached a peak of 241 in 1921, and then dropped steadily, especially after 1924, to 169 in 1930. Yarra Junction, where the lines from the Warburton and Powelltown forests met, boasted that more timber passed through it than any other place in the world except for Seattle in the United States.

In the 1920s the sawmilling industry was taking off further east. As gold-mining declined in the Walhalla district, timber took over as the major source of employment. Mills sprang up in the forests from Moondarra and Erica across the ranges to the Upper Tanjil Valley and Mount Baw Baw. Erica took over as the district's major centre. By the early 1930s millers were entering the 'virgin bush' country around Matlock and on the Tanjil.

The 1939 fires claimed the lives of many timber workers, destroyed 41 mills, and destroyed much of the forest vegetation. Salvage work following the fires meant that the tramway network was used and extended in some areas until the 1950s.

But mills eventually established themselves more safely in the towns - a move facilitated by the use of roads and trucks. Tractors were used for snigging logs, roads took over from tramlines, the chainsaw replaced the axe and cross-cut saw, diesel and electricity replaced steam power, and milling equipment became more sophisticated. This technological revolution and the retreat to the towns left their residue: sawdust heaps, mill sites and huts, tramway formations, cross-log bridges ('make-ups'), and trestle bridges.

The 1939 fires created an urgent and widespread need to understand the circumstances under which mountain ash successfully regenerated. Artificial regeneration by 'tubing' was experimented with at this time, and became widely used. Seedling regeneration in burnt ash areas varied and areas of higher elevation were generally slower to recover. In badly damaged stands of ash, coppice regeneration predominated. Messmate and silvertop, by contrast, regenerated quickly and well. The balance between salvage work for immediate gain and restraint for long-term benefit was confronted directly in many districts. Feet, machinery, and rolling logs were destroying young

seedlings. By the end of the 1940s, timber-salvage operations were being curtailed in many fire-killed areas, due to the increasing damage that logging operations caused to advanced regrowth.

Both before and after the war, the Forests Commission aimed at diversifying the range of forest products. The development of the kiln seasoning and reconditioning process in the early 1920s replaced the slow air-drying of timber for joinery, and enhanced the competitiveness of Australian timber with imported oregon and Baltic woods.

By 1931, the Commission, in its annual report, was noticing an increased use of local kiln-seasoned hardwoods. Also, from the early years of the Commission, encouragement was given to the production of paper pulp from mountain ash. In 1936, the government, the Commission, and Australian Paper Manufacturers Limited reached an agreement that led to the establishment of a pulp plant at Maryvale in Gippsland. This commenced production in October 1939 and for several years drew its wood supply from the fire-killed ash forests.

Softwood (and some hardwood) plantations were also developed in the study area. Examples of the early plantations were those at Frankston from the early 1900s, on French Island from 1910, and at Korumburra and on abandoned farmland in the Strzeleckis; a tree nursery was established at Broadford in 1910.

At the same time, the Commission recognised the need to establish wildflower sanctuaries within some of its forests. 'Multiple use' of the forests, although long said to be a policy, had to be more effectively implemented in the face of growing community concern about environmental issues.

Fire

The years 1851, 1898, 1902, 1926, 1932, 1939, 1962, 1983: this litany of dates is instantly recognisable to bush-dwellers. They represent some of the major fires that have swept across the study area. The most critical of these was 1939. In January of that year, perhaps 1.4 million hectares burned, whole settlements were incinerated, and 71 lives were lost. Most of the forests in the study area were severely damaged or killed.



Effects of fire at Tanjil Bren, 1939

The eucalypt is adapted to fire and dependent on it. In the study area, human settlement, the eucalypt, and fire clustered intimately and dangerously. Fossil ash deposits confirm the presence of lightning-started fires long before any human habitation. Recent research into modern fires indicates that lightning continues to be the cause of half, perhaps more, of Victoria's forest fires. But the human factor - in ignition and control - remains the dominant influence.

Aboriginal land-use practices included the use of fire. On the open plains, and the margins of the wet sclerophyll forests, they kept their hunting grounds open and freshly grassed by burning them regularly and lightly.

Europeans initiated a thickening of the forest. Although graziers used fire much as the Aborigines had, to ensure a sweeter pasture, the attachment of Europeans to material belongings and property made fire more often their enemy. They feared it and fought it, and the scrub grew back.

Aboriginal 'fire-stick' farming had created one landscape; European suppression of fire,

and its consequent explosive outbreaks, fashioned another. However, pollen analysis has supported the contention that white settlement, in some parts of Victoria, produced more fires. So it is clearly a question not just of the number of fires, but also of their type, placement, regularity, and seasonality.

Europeans introduced a host of new sources of ignition. Miners fired the bush to ease prospecting, graziers burnt their paddocks, selectors cleared the land with a sequence of axe and fire, bush-dwellers protected themselves from fire with fire.

The fire that has had most effect on the landscape of the study area was the 1939 one. It killed or damaged most of the forests in the study area, timber mills eventually moved out of the forests, and the industry shifted away to centres in eastern and north-eastern Victoria. The 1939 fire paradoxically gave new, if brief, life to many of the established timber-producing districts due to salvage logging. But it proved the knockout blow for many of the mining settlements that had lingered through the depression years.

The *Forests Act*, 1939, gave the Forests Commission responsibility for forest-fire protection in all unoccupied Crown lands, plus a strip of land 1 mile (1.6 km) beyond State Forests and national parks. This increased the Commission's territorial fire responsibility threefold, from 5 500 000 acres to upwards of 16 000 000 acres (that is, from 2.2 to 6.5 million ha).

The Annual Report of the Forests Commission Fire Protection Officer for 1939/40 identified 'an entirely new and potent hazard' due to the 1939 fires: the vulnerability of the ash seedlings posed a threat to the hope of regeneration. A second burn of the seedlings would result in 'the permanent deforestation of a portion of the best water catchments - and their reversion to scrub areas'. Lake Mountain offered another example of how a rapid succession of burns affected an Ash forest. There, the original cover of alpine ash, which needs fire but at the right frequency for regeneration, was entirely killed off by the fires of 1926 and 1939, and has been replaced by wattles.

Farms

Two themes emerge strongly in the history of farming: firstly, that farming was a form of land use charged with social and moral ideas: secondly, that it changed the landscape dramatically, perhaps even more than mining. Often the two themes were closely related, especially in the promotion of closer settlement. The attempt to settle 'yeoman farmers' dominated the alienation of land in Victoria for a century.

The squatters, although few in number, made significant ecological impact. Their lonely names printed across vast spaces of the early pastoral maps give a misleading representation of the density of their invasion. Each was accompanied by thousands of cattle and sheep whose hooves compacted the delicate vegetation and light soil, muddied and eroded precious watercourses, and introduced and spread new grasses and seeds. Their displacement of the Aborigine and dingo originally created the conditions for an increase in the population levels of some marsupial species.

Because they occupied vast spaces with thousands of animals but few people, the squatters were seen as the enemies of closer



Cleared land in the Strzelecki Ranges, 1895

settlement. Surviving examples of homesteads, such as Gulf Station in the Yarra Valley, illustrate the self-contained nature of the squatter's community.

The *Land Acts* of the 1860s were designed to break their dominance, and to 'unlock the lands'. The 1869 *Land Act*, the first to allow selection before survey, was the most successful in settling farmers. Under the Act, men and single or widowed women could select up to 320 acres (130 ha) under licence for 3 years, and then could become eligible to lease it and gain it freehold. Commitment to the land was measured by requirements to live on it, pay two shillings per acre rent, and make 'improvements' to the extent of £1 per acre. 'Improving' included building huts, constructing fences, and clearing lands.

One selector in eastern Victoria estimated that in the first 5–10 years of settlement, nine-tenths of the labour was devoted primarily to axe-work. This fight with the forest assumed gargantuan proportions in South Gippsland where, each summer, neighbours gathered to watch the giant burns that, they hoped, would turn last year's fallen and ringbarked forest into this year's clearing.

Many selectors were misled into believing that tall forests guaranteed rich and fertile soil. Through clearing, they also unleashed the savage forces of erosion. Animals attacked newly sown paddocks: insects, wild

pigs and horses, cockatoos, kangaroos and wallabies, possums, and even wombats harried the selector. Rabbits arrived later in the study area than in many other parts of Victoria.

The moral dimensions of farm settlement emerged clearly with the *Settlement of Lands Act* of 1893. A response to the poverty and unemployment of the depression years, the *Act* was inspired by the belief that the countryside would restore the failed city-dweller to innocence.

People with little or no experience of the bush were sent into some of the most difficult areas for farming. Three village communities were established in the Dandenongs - at Monbulk, Ferny Creek, and Woori Yallock Creek - and, although the one at Monbulk had some success, the other two failed utterly.

At Koo-Wee-Rup, the government set up labour camps for unemployed men to cut timber and dig drainage channels. After the World War I, the Koo-Wee-Rup swamp and surrounding lowlands also provided blocks to accommodate nearly 300 returned soldiers. On their small, flood-prone blocks, they faced continual hardship and frustration.

Agriculture developed successfully in many parts of the study area. The new markets created by the gold rushes stimulated wheat-growing and flour-milling. Wheat and oats were grown on the flats of Olinda and Brushy Creeks in the 1850s, and the Cashin brothers operated a mill there, driven by a waterwheel, one of the first in Victoria.

Dairying commenced in the Yarra valley as early as the 1860s, but it was not until the 1880s that the industry took off there and in the Warragul district. After 1888, farm dairies were replaced by district butter factories, and these became notable community features, especially in Gippsland. Hop-growing and drying became especially profitable at the Coranderrk Aboriginal Reserve and, for a while, gave the Aboriginal community some economic independence. Orchards were developed along Melbourne's eastern fringe, in the Dandenongs (berry fruits especially) and on the Mornington Peninsula. For about 50 years, the Toomuc valley apple orchard near Pakenham was the largest in Victoria producing a single fruit. The cleared and drained land at Drouin,

Koo-Wee-Rup, and Carrum produced cereal crops and potatoes were a successful

At Gembrook, Carl Exel Nobelius bought land in 1886 and, by the early twentieth century, had established the largest nursery in the Southern Hemisphere. Vineyards were established very early in the Yarra valley, but suffered severely from phylloxera in 1880s. Wine-making and associated tourism have revived there in recent decades.

Water

Irrigation has played only a small and indirect part in the history of the region, whereas hydro-power, swamp drainage, and water-harvesting have been major themes.

The harnessing of water for power was widespread for mining purposes from the 1850s and '60s, and the dominance of waterwheels in the Jordan goldfield has been discussed. Water races remain as some of the most prominent and intriguing relics of this period. These primitive but exact features of engineering extended for miles through rugged country, carefully maintaining a steady gradient.

A hydro-electric scheme was mooted for Snobs Creek as early as 1910, but only in the 1920s was one eventually established in the Rubicon district. Five generating stations were built on tributaries of the upper Goulburn and fed into a substation at Sugarloaf near the Eildon dam, which was part of the irrigation system designed for the lower Goulburn valley. The Eildon reservoir, built in 1927, went through a further transformation - for irrigation and power - when it was greatly enlarged in 1955.

Massive swamps at Carrum, Koo-Wee-Rup, and Moe were major landscape features at the time of European settlement. Reputedly haunted by the bunyip, thickly covered in tea-tree, and frequently under water, they discouraged settlement and isolated Gippsland from Melbourne. Some land was selected on the border of Koo-Wee-Rup swamp from 1865, and a further 8873 acres (3591 ha) were made available for settlement in 1875.

These farmers faced a battle for survival, with their cattle wading belly-deep, and feuds with neighbours constantly erupting over drains, walls, and outlets. Agitation for

governmental action to drain the swamp grew in the 1880s.

The 1884 *Land Act* included swampland provisions, and a Swamp Board was set up in the following year. Between 1889 and 1897, £184 996 was spent on drainage works, more than double the Swamp Board's original estimate. The work provided some unemployment relief during the 1890s depression and formed the nucleus of a doomed village settlement scheme. The disastrous bushfires of 1898 destroyed crops, fences, and houses in the area and ignited the underlying peat, which burnt for months. Major floods occurred in 1901 and 1911, and excavation for a new drainage network began near the end of World War I.

During its first two decades, Melbourne's population relied on tanks, wells, and water from the Yarra. Water from the first reservoir, Yan Yean, reached the city on 27 December 1857. Yan Yean also drew attention in the 1850s as one of the world's largest artificial water storages. It remains part of the Melbourne water supply system, although the early concern about the quality of its catchment area persisted and its water was increasingly drawn from more distant sources.

Construction of the Wallaby Creek weir and aqueduct in 1883 and the Silvery Creek aqueduct in 1886 made this the only part of the Melbourne system to draw water from north of the Divide.

In the same decade, the building of the Clear Water Channel and the Toorourrong Reservoir, and the exclusion of water from the western branch of the Plenty River and Scrubby Creek, enhanced the quality of the Yan Yean supply. These dams, weirs, and bluestone aqueducts are remarkable early feats of surveying and engineering and many of them, now notable historic features, continue in use.

Melbourne's population grew quickly in the boom decade of the 1880s and settled increasingly in the undulating eastern suburbs. The Melbourne and Metropolitan Board of Works (MMBW) was constituted in 1890 and embarked on its principal task for sewerage 'Marvellous Smellbourne'. For the next two decades, construction work for Melbourne's water supply took place -

further diversions into the Watts River, the building of service reservoirs, and extension of the mains to outer suburbs.

A weir was built on the O'Shannassy River from 1911 to 1914 and, a decade later, a dam. In the 1920s, the Maroondah dam was also built, as was the Silvan reservoir in the Dandenongs.

This period of construction work was a response to Melbourne's rising population, who had a steadily increasing average daily water consumption. This rose from 53.50 gallons per head in 1891 to 76.89 gallons in 1940 (that is, from 243 to 350 L).

The Upper Yarra dam, built upstream of Warburton, was completed in 1957 and tripled the amount of water impounded for Melbourne's use. The severe drought 10 years later provided further impetus to the MMBW's building program, and new reservoirs at Cardinia Creek (filling 1973-77) and the Thomson River (dam wall completed 1983) each created new capacity records.

The Board of Works controls some 120 000 ha of catchments, most of which is forested. Since the Board was formed in 1890, and indeed before then, one of the recurrent debates has concerned the 'closed catchment' policy, and especially whether or not timber-harvesting is compatible with water conservation. This debate has continued throughout the twentieth century, focused in the dialogue of the MMBW and the Forests Commission.

Recreation

The study area includes Melbourne's chief holiday resorts, and has catered for the city tourist since last century. Tourism took off in the 1880s as Melbourne's population boomed and railways extended further into the hinterland. The wedge of forested land between the Sydney and Gippsland rail lines attracted visitors, with its image of ferns and waterfalls and mountains glens.

Victoria's first tourist information office had been established at Flinders Street station in 1888, as a service to visitors to the Centennial Exhibition.

Formation of clubs such as the Field Naturalists' Club of Victoria in 1880, the

Melbourne Amateur Walking and Touring Club in 1894, and the Walhalla Mountaineering Association in 1907 signalled a new interest in active, outdoor recreation.

The declaration of national parks, which was particularly intensive in the first and third decades of the twentieth century, was a measure of this new enthusiasm for Nature. Victoria's second national park was Ferntree Gully, reserved for recreational use in 1882, and was already a popular destination for Melbourne's day-trippers.

One of the most popular walking trails in the first decades of the twentieth century followed part of the Yarra Track. In 1906, the Public Works Department laid out a tourist track from north of Warburton to Walhalla which opened access to the spectacular Yarra Falls and the Baw Baw plateau. The track enjoyed a further burst of popularity during the 'hiking craze' of the 1930s depression, but the 1939 fires destroyed the huts.

Not until the turn-of-the-century was skiing actively encouraged in the Victorian mountains, and resorts only developed after World War II. A local Rover Scout crew cut ski runs on the Baw Baw plateau in the mid 1930s, and in 1944 the Mount Erica division of the Ski Club of Victoria was formed.

In 1963 the Country Roads Board completed a new road to the Baw Baw alpine village site, where lodges were built and downhill runs and tows developed. With the surge of interest in cross-country skiing since the 1970s, Lake Mountain has become the most popular snow resort in the study area.

In the mountain valleys and along the coast, guesthouses proliferated, particularly between the wars. Healesville, Warburton, Marysville, and the Dandenongs boasted stylish accommodation for thousands.

Although Healesville was a popular outing for many of the new car clubs established between the wars, cars eventually opened up wider and more distant tourist horizons for

the city traveller. From the 1930s, the holiday fashion became more lively and informal.

People increasingly turned to the beach for this informality. Sorrento had been an attractive and dignified holiday town since the 19th century, boasting new pier baths in the 1880s, and steam and horse trams running across to the surf beach in the 1890s.

But the growing private ownership of cars eventually spelt the end of many of the seaside boarding houses and the steamers that ferried people down the Bay to their doorsteps. The era of the tent and caravan had begun. Rosebud, and similar resorts along the Mornington Peninsula, became the sought-after holiday spots.

Boating grew in popularity, and by 1973 some 40 000 people were annually towing their registered power boats to the Bay, Eildon, or elsewhere.

The history of recreation revives and brings together many of the other themes: the renewal of old tracks for tourists, the modern search for gold, enthusiasm for the natural environment and ecological integrity, new pressures on forest management, and the economic dependence of this region on a mobile urban populace.

Popular pursuit of history and its relics, an emergent hobby since the 1960s, has robbed the area of many of its historical treasures. Many significant landscape features and artefacts have recently been lost to 'collectors', and those remaining need protection.

Historic sites

A listing of historic sites, with an evaluation of their significance, is given in Appendix II.

Reference

Griffiths, T.L., 'Environmental History of the Melbourne 2 Study Area.' Report to the Land Conservation Council.

PART II
PHYSICAL AND BIOLOGICAL RESOURCES

4. LANDSCAPE EVOLUTION AND SOILS

Coastal and riverine plains, foothills, and mountains comprise the topography of the study area, which is geomorphologically diverse and geologically complex. The descriptive report of the first investigation of the Melbourne area (LCC 1973) described geology, physiography, and soils in separate chapters. These physical features are brought together in this chapter, with an emphasis on the integration of these elements and on the contribution of each to the development of the contemporary landscape.

Dominating the study area are the Central Highlands, oriented east-west, their elevations increasing from around 300 m in the west to more than 1500 m in the east. South of the Highlands lie extensive plains and foothills (under 300 m), with only the Dandenong Ranges and southern Victorian uplands rising above this height. In the north of the area, the riverine plain of the Goulburn River and its larger tributaries separates the Central Highlands from the Strathbogie Ranges in the north. The major physiographic units are shown in Map 4.

The following descriptions employ a number of technical terms defined in the Glossary (see Appendix IX) and refer to geological time, as outlined in Table 8.

Geomorphic evolution

Many processes have combined to form the existing landscape, and some continue to shape existing landforms in a dynamic process - vulcanicity, surface and sub-surface forces, sea-level change, weathering, and deposition.

Eastern Australia was an extensive erosional plain close to sea level by the Jurassic period, and extending eastward. Late in this period, uplift and warping initiated the development of the Central Highlands, with depressions to the north and south. While uplift and downwarping continued intermittently during the Tertiary period, the study area's basic topography was formed.

Watercourses draining the uplands were short tributaries, forming broad plains to the north and south and mature valleys in softer rocks.

Resistant rocks (granites, Devonian lavas, and Palaeozoic sandstones) remained as larger features, with remnants of the Mesozoic plain forming monadnocks and plateaux. In the river valleys extensive gravel deposits were laid down. Remnant erosion surfaces on the Kinglake Plateau, the hills east of Melbourne, and the Dandenong Ranges provide evidence of the advanced stages that erosion reached in the Tertiary period.

During the Eocene and Oligocene, much earth movement and volcanic activity occurred with eruptions and tectonic movements. Lava flows filled river valleys, and a lava plain formed in South Gippsland.

Table 8

GEOLOGICAL TIME SCALE

Era	Period	Epoch	Age (million years)
Cainozoic			
	Quaternary	Holocene	0.01
		Pleistocene	1.8
	Tertiary	Pliocene	5
		Miocene	24
		Oligocene	37
		Eocene	54
		Palaeocene	65
Mesozoic			
	Cretaceous		143
		Jurassic	212
		Triassic	247
Palaeozoic			
	Permian		289
		Carboniferous	367
		Devonian	416
		Silurian	446
		Ordovician	509
		Cambrian	575
Precambrian	Not outcropping in Victoria		

Lower areas were submerged by the sea's advances during the Oligocene and Miocene epochs, notably the Port Phillip District. Sedimentary deposits have provided evidence of this ingression. A further lifting of the Central Highlands, with warping in some places, accompanied a retreat of the sea towards its present level. These changes led to further erosion. Valleys deepened and the Central Highlands were dissected by watercourses. Valley tracts with mature profiles developed and lateral planation produced broad plains, depositing sheets of sands, clays, and gravel on the lowlands.

In the late Pliocene and early Pleistocene, the South Gippsland Uplands were elevated by tectonic activity and the Central Highlands further uplifted by renewed earth movements. A number of faults, that have influenced the topography of several areas, including the Rowsley Fault and Beaumaris Monocline, occurred at this time. Areas of uplift were subject to erosion; uplifted gravels were dissected, creating hill cappings in the South Gippsland Uplands and on the margins of the Eastern Highlands.

Volcanic activity was a feature of central and western Victoria during the Upper Tertiary and Quaternary. Portions of the resulting extensive basalt plains extend into the south-west of the study area.

Melting of glacial ice at the end of the Pleistocene caused sea-level rises, which combined with final downwarps to drown Port Phillip Bay, Western Port, and Bass Strait. A concomitant upwarp brought the Central Highlands to their present level. No glaciation took place anywhere in Victoria during the Pleistocene ice age, although watercourses might have carried greater discharges during the heavier rainfall of this time. Many minor watercourses now occupying large river valleys may be features of this period. Former sea-floor sediments, now comprising calcareous sand dunes along coastal stretches, are the result of exposure due to the eustatic sea-level fall.

Geomorphology

Geomorphology is the description and interpretation of landforms, and includes the study of processes affecting the Earth. This section concentrates on the major landforms

within the study area: northern uplands (Central Highlands), southern uplands (South Gippsland Hills, southern Mornington Peninsula), and southern lowlands (Western Port and Mornington Peninsula lowlands).

Northern uplands

These mountains and foothills comprise several geomorphic entities, notably a series of stepped plateaux - Baw Baw, Kinglake, and Nillumbik.

The Baw Baw surface, composed of volcanics and granites, is the oldest and highest in the study area. Several high plateaux constitute the unit - Baw Baw, Cerberean, and Acheron, with remnants outlying at Mounts Matlock, Selma, Terrible, and Useful. Steep escarpments mark the perimeter of the units in several places along the Acheron and Baw Baw Plateaux and Cerberean Ranges, often with associated waterfalls.

The Kinglake unit comprises an extensive area of the northern uplands, and includes a number of linked and separate surfaces: Gregory Plateau, Kinglake Plateau, and Strathbogie Plateau. Dissection is generally moderate on these surfaces of Palaeozoic sedimentary and igneous materials, whose elevations are some 300 m lower than those of the Baw Baw unit. Steep escarpments have developed on the southern Kinglake and Strathbogie Plateaux and western Gregory Plateau. Along the upper reaches of the western watercourses - Big, Goulburn, La Trobe, and Thomson Rivers, and parts of the Yarra River - the edges of the Kinglake unit are indistinct from the adjoining foothills, which are highly to moderately dissected. Erosion has left few remnants of the Kinglake unit in the upper Goulburn and Big Rivers, in producing a steep mountain terrain. The Blue Ranges and Cathedral Ranges are outlying remnants of the Kinglake unit, in which erosive processes have produced a similarly rugged topography. A general slope across the Kinglake unit rises from west to east, with Mt Disappointment being about 800 m, the Black Ranges 900 m, and the Gregory Plateau 1100-1200 m.

The Nillumbik surface almost extends across the south of the study area. Although of similar origin to the remaining uplands, Nillumbik has lower elevation and subdued relief. At its western extension, the unit has



The western aspect of the Strzelecki Ranges, where the central lowlands meet the southern upland landform, near Trafalgar.

elevations of less than 100 m, rising to around 300 m near the Dandenong Ranges and to 500–600 m in the east, on the Erica Plateau. As elevation increases to the east, the topography becomes dissected and the slopes steeper.

Southern uplands

This unit comprises the South Gippsland Hills and parts of the Strzelecki Ranges and the Mornington Peninsula Horst, both of which result from block faulting.

Central lowlands

The lowlands unit contains the (former) Koo-Wee-Rup Swamp, (former) Carrum Swamp, Brighton coastal plain, the northern and south-western Mornington Peninsula and French and Phillip Islands. There are few distinct borders between the lowlands and northern and southern uplands. Comprising sedimentary and small areas of older volcanic plains, this unit has low elevation and subdued relief.

Numerous faults in the lowland belt have influenced local topography and mark geomorphic features. Prominent faults include Selwyn Fault, Tyabb Fault, Clyde Monocline, Beaumaris Monocline, Heath Hill Fault, and Yarragon Monocline. Selwyn

Fault marks the western edge of the Mornington Peninsula, and is still active with occasional movements, such as the earthquake at Mornington in 1932.

Extensive Quaternary dune sands around Frankston–Cranbourne–Langwarrin form one of the major sand supplies for eastern Melbourne.

Ancient dune sands on the Pt Nepean coast have become lithified as dune limestone.

Areas with little dissection are generally located on the sunklands, namely the Brighton coastal plain, French and Phillip Islands and Lang Lang district.

Newer volcanic plains

A small area of the eastern extension of the Werribee volcanic plains lies north of Melbourne. Except for a few small volcanic cones, it has a gently undulating surface. A few major streams have dissected channels into the plain along Darebin and Merri Creeks.

River plains

The four main areas of river flats in the study area adjoin the present locations of the Goulburn, Acheron, Moe, and Yarra Rivers.

Composed of alluvial materials, the river plains are typically less than a few kilometres wide.

Foothills and river valleys

Within the northern uplands, major watercourses and other sources of erosion have created extensive areas of foothills and river valleys, notably the Goulburn River and its tributaries, the upper Aberfeldy, Thomson, and Yarra Rivers.

Geology

This brief account of the complex geology of the study area concentrates on major features. Readers seeking greater details are directed to the geological maps of the area, together with explanatory guides by the Victorian Geological Survey, as well as Douglas and Ferguson (1988) and the numerous other references.

For most of the Palaeozoic the study area lay under the sea, and the resulting marine sediments were uplifted in the late Devonian and folded along east-west axes, with intrusions of granite and areas of acidic volcanic flows. The bedrock of the study area consists of these Palaeozoic rocks.

Cambrian to Carboniferous

Within the Tasman Geosyncline, extruded submarine volcanics were covered by marine sedimentation from the Cambrian to early Devonian. Consequently, a thickness of sediment occurred - 5800 m for the Silurian sediments west of Melbourne, 4300 m for the Lower Devonian sediments north-west of Melbourne. These sediments consist of inter-bedded sandstone, siltstone, and block shale. In the Middle Devonian period, they were subject to considerable folding.

Areas of folded sediments underwent intrusions of acid igneous rocks during the late Devonian. The study area contains several granitic landforms, including the Baw Baw-Gembrook granodiorites and granites, Mt Cobaw, Mt Disappointment, and the Strathbogie Ranges, as well as those smaller features on the Mornington Peninsula - Arthurs Seat, Mt Eliza, and Mt Martha. Downfaulted basins containing deep layers of

volcanic materials, known as cauldron subsidences, are found in the Acheron, Cerberean, and Dandenong Ranges.

Permian-Triassic

Sediment deposition, of fluvial and marine origin, occurred during the Permian period. These sandstones and siltstones were originally widespread, but subsequent erosion during the Triassic and Jurassic periods removed most deposits.

Cretaceous

In southern Victoria, prior to the Cretaceous, a lengthy trough running east-west formed, filling with arkose, conglomerates, and mudstones. Coal seams found at Wonthaggi and Korumburra were created from the accumulation of plant debris in swamps. During the Cretaceous, earth movements resulted in the lifting of the Central Highlands area, flanked by depressions to the north and south.

In the lower Cretaceous beds, fossil plant assemblages indicative of the Mesozoic era are prominent, which include liverworts, mosses, horsetails, cycads, ferns, and conifers. Dinosaur remains also from the lower Cretaceous have been found at Cape Paterson.

Tertiary

Sea-level changes caused the deposition, generally confined to the La Trobe Valley, Port Phillip sunkland, and Western Port Basin, to have two terrestrial phases interspersed by a marine phase.

Volcanic activity occurred intermittently during each of these phases. Thick sequences of older volcanic material (basalts) resulted from extrusions in downfaulted basins, such as the Mornington Peninsula. The Erica, Gembrook, and Noojee districts contain elongated valley flows of older volcanics.

Marine sediments were covered by a widespread, thin sequence of terrestrial sand, gravel, and silt from the rivers draining the highlands. The Werribee Plains, represented only in the extreme west of the study area, were formed by basaltic lava flows in the late Pleistocene.

Quaternary

In the early Pleistocene, the modern drainage system developed and the Pleistocene sediments and volcanics were dissected to produce wide river valleys and sediment deposits. Older fault lines were the sites for movement that produced several features within the area.

Both marine (sandy limestone, shelly limestone and shell-beds) and non-marine (alluvium, colluvium, calcareous sand, and dune limestone) were deposited in coastal and riverine locations. These Quaternary sediments comprise the surface geology of the KooWeeRup Swamp and Lang Lang areas, south-western Mornington Peninsula, and the river valleys of the Goulburn and its larger tributaries, Yarra River, Powlett, Bass, and the Moe, lower La Trobe, and lower Tanjil Rivers.

Soils

Soil types vary considerably across the study area. The Land Conservation Council descriptive report for the first investigation (LCC 1973) described each of the major soil types, but only a brief description of the major ones and their distribution are provided below. Soil type is one of the elements of the land systems description (see Chapter 10). The purpose of this chapter is to provide sufficient information to allow readers to comprehend the soil component of the land systems mapping.

A few technical terms and concepts are provided here for readers unfamiliar with the subject. Particle size determines the feel or texture of soils, and the form of any aggregation of particles is its structure. Soil colour refers to the lower horizons, which are more highly colour-differentiated than the upper horizon. Duplex soils have a distinct upper horizon of sand or loam, with clayey subsoils. Gradational soils increase uniformly in clay content with depth. Soils with a high proportion of exchangeable sodium (called sodic) cause clays to disperse when wet, inhibiting both drainage and aeration (Rowan 1982).

The following broad description of soil type distribution is based on the land systems information, using geomorphic units as the basis for description.

On the elevated plateaux and tablelands, the high rainfall and low temperatures of the sub-alpine climate have resulted in the formation of organic loamy soils. These organic loams include brown friable earths and peats.

Over the dissected uplands of the Central Highlands, the complex geological features, incised valleys, and intricate stream networks are strongly influenced by structure and local lithology. Several soil types have been recorded: red and brown friable earths, hard acidic duplex soils with red clay subsoils, shallow stony soils, and yellow duplex soils.

The uplands of the Mornington Peninsula have hard acidic duplex soils with yellow clay subsoils and red friable porous earths. Soils recorded include yellow duplex, red friable, grey clay, yellow earth, and pale sands. Soils are similar in the South Gippsland uplands, but with the addition of brown friable earths. Recorded soils are yellow duplex, red and brown friable earths, and shallow stony loam.

To the north-west, the South Gippsland Uplands give way to the alluvial East Gippsland plains in the Moe swamp area. A range of soil types includes yellow duplex, brown earths, dark clays, pale sands, and gravels.

Fans and terraces of the western Gippsland and Western Port coastal plains feature sands and duplex soils with yellow clay subsoils. The Koo-Wee-Rup and Lang Lang area carry pale sands, calcareous sands, dark clays, yellow duplexes, and yellow earths. French and Phillip Islands have pale and calcareous sands, yellow and dark clay and yellow duplex soils.

Sands and clays predominate on the Point Nepean coast and peninsula and in the Brighton district. At Cranbourne and the lower Mornington Peninsula, areas of leached sands are important for horticultural production.

Hills, ranging from gentle to steep and the plains surrounding the Yarra River and its tributaries, comprise the Yarra Valley, a productive agricultural area. Soils of the hills are red friable earths, yellow duplexes, and shallow stony earths. On the river plains are loams, dark clays, and yellow duplex soils.

The flat and undulating volcanic plains north and north-east of Melbourne have hard

alkaline or neutral soils with yellow clay subsoils, variable friable earths, and loamy soils. Prominent soil types recorded are yellow duplex, yellow stony, and shallow stony soils with areas of dark clay.

Geological and Geomorphological Features of Interest

Geological and geomorphological features in the landscape can be of value for education, research, or reference, or have scenic landscape, or other outstanding values. Their conservation requires a basis of inventory and research.

Several studies of sites and/or features of significance have been conducted in the study area and a State-wide study has been completed, as shown in Table 9, but these do not give a complete coverage of the area in detail.

Assessing the significance of a feature usually involves an appraisal of how repre-

sentative or outstanding it is. The degree to which it is representative can be more objectively determined, being based, in summary, on the area the feature represents - local, regional, State, national or international. The studies often use different criteria to assess each one and lack any consensus on the significance of particular features.

Table 10 summarises the results of these studies. Although the results of different studies are not comparable, this information is useful for land planning and for the identification of geological and geomorphological features.

Some features are protected by appropriate land management - most notably the Organ Pipes National Park in the Melbourne Area, District 1. Protection can also occur through provisions of public land management plans. National Estate listings also include some features. However, there is no comprehensive system of conservation of these features.

Table 9
STUDIES OF SITES OR FEATURES OF SIGNIFICANCE

Area covered	Author(s)	Sites or features	
		Significance	Number
Gippsland Lakes catchment	Rosengren (1984a)	local	3
		regional	18
		State	7
		national	1
Floodplain of upper Yarra River	Rosengren <i>et al.</i> (1983)	local	36
		regional	21
		State	2
		not ranked	29
Victorian coast Western Port	Bird (1977) Rosengren (1984b)	local	24
		regional	124
		State	64
		national	8
Victoria	Joyce and King (1980)	international	2
		nominated	697
		local	36
		State	5
Port Phillip Bay	Rosengren (1988)	international (unassessed)	1 26
		regional	10
		State	12
		national	1

Notes:
1. These sites occur wholly or partly in the study area
2. These sites occur on public and private lands
3. Classifications of significance are not comparable necessarily between different studies



*Dava Beach, Mt Martha - part of the Fossil Beach area
site of geological and geomorphological significance*

Table 10

GEOLOGICAL FEATURES OF VICTORIAN, AUSTRALIAN, AND WORLD SIGNIFICANCE

Feature number ¹	Name	Description	Significance level
ML 82	Limestone Road, Yea	Baragwanathia fossil site, representing the oldest known vascular flora in the world	World
QN 03	Cape Schanck to Burrabong Creek, Boneo	Freshwater limestone overlies igneous clay and basalt of the Older Volcanics sequence	Victorian
QN 08	Fossil Beach/Fishermans Point, Mt Martha	Type section of the Balcombian Stage. Fluvialite, marine sediments and Older Volcanics also present	Victorian
QN 18	Pyramid Rock to The Nobbies, Cowes	The coastline shows two distinctive physiographic types: the high cliffs and Lower Tertiary basalt; and dunes of Quaternary calcareous sands	Victorian
WR 11	Cathedral Range, Buxton	Dip slopes developed on Middle Devonian sediments; alluvial fans formed at the base of escarpments	Victorian
WR 43	Loyola Limestone Quarries	The only known Emmsian fauna in the Melbourne Trough	Victorian

Note:

1. The feature number is prefixed by the relevant 1:250 000 geological map name - ML-Melbourne; QN-Queenscliff; WL-Warragul; WR-Warburton.
2. Geological features of local significance and those as yet unassessed are not included in this table.

Source: Joyce and King (1980)

References

- Bird, E.C.F. (1977). 'Sites of Special Scientific Interest in the Victorian Coastal Region - a Report on Geological and Geomorphological Aspects.' (Town and Country Planning Board: Victoria.)
- Douglas, J.G., and Ferguson, J.A. (eds) (1988). 'Geology of Victoria.' (Geological Society of Australia: Melbourne.)
- Joyce, E.B., and King, R.L. (eds) (1980). 'Geological Features of the National Estate in Victoria. (Victorian Division of Geological Society of Australia: Melbourne.)
- Land Conservation Council (1973). 'Report on the Melbourne Area.' (Victorian Government Printing Office: Melbourne.)
- Northcote, K.H. (1979). 'A Factual Key for the Recognition of Australian Soils.' Fourth ed.. (Rellim Technical Publications and CSIRO: Adelaide.)
- Rosengren, N.J. (1984a). Sites of geological and geomorphological significance in the Gippsland lakes catchment. *Department of Conservation, Forests and Lands Environmental Studies Program No. 404.*
- Rosengren, N.J. (1984b). Sites of geological and geomorphological significance in the Westernport Bay catchment. *Department of Conservation, Forests and Lands Environmental Studies Program No. 401.*
- Rosengren, N.J. (1988). 'Sites of Geological and Geomorphological Significance on the Coast of Port Phillip Bay, Victoria.' (Technical Report series. Making the Most of the bay.) (Ministry for Planning and Environment: Melbourne.)
- Rosengren, N.J., Frood, D., and Lowe, K. (1983). 'Sites of Environmental Significance in the Floodplain of the Upper Yarra River.' Report to the Upper Yarra Valley and Dandenong Ranges Australia.
- Rowan, J. (1982). Land Types. In Duncan, J.S. (ed)., 'Atlas of Victoria', pp.39-47.
- Rowan, J. (1990). 'Land Systems of Victoria.' (Victorian Government Printing Office: Melbourne.)

5. CLIMATE

Climatic conditions across the study area can be generally described as 'Mediterranean', meaning a dry and warm to hot summer and a wet winter. A feature of temperate latitudes is regular changes in weather, a characteristic here. For most of Victoria, including the study area, the weather systems move from west to east, producing a cycle of weather from cool, through warming up, to rapidly becoming cool again; although variable, the cycle usually lasts 5–7 days (ACBCS 1973).

In general, the climate is temperate, with altitude, landform, geography, and distance from the coast influencing the patterns of temperature and rainfall.

The Great Dividing Range, prominent in the east, is a major climatic influence. South-westerly winds carry cool and moist air from the southern oceans, often bringing cloud and rainfall to coastal and rising country of the Great Dividing Range. North of the Divide cloud cover is less frequent in winter, giving greater temperature ranges and colder nights; in summer, the northern areas are hotter than the south.

Precipitation

Mean annual rainfall varies from less than 700 mm on the plains in the north-west and south-west, and in rain-shadow areas such as the Goulburn and Big River valleys, to in excess of 1400 mm on the high-altitude and southern slopes of the Great Dividing Range. Rainfall comprises the bulk of precipitation, except for snowfalls across the alpine areas.

Landform combines with the westerly frontal weather systems to account for the predominant pattern of precipitation. Slopes along the southern and western aspects of the highlands and mountains receive substantially higher rainfalls than the rain-shadow areas. The major rain shadows occur in the river valleys to the north, predominantly the upper Goulburn River and its tributaries, and on the plains north of Melbourne, which are affected by the mountains and highlands to the west.

Examination of the monthly and annual rainfall statistics (as shown in Table 11)

reveals the seasonality, as well as indicating the distribution, of rainfall. Map 5 shows the distribution of mean annual rainfall. December to March generally is the period of lowest rainfall, with May to August receiving the highest monthly totals.

Snowfalls

As the Bureau of Meteorology does not record the snow depths at weather stations, the only available data are those collected privately at the alpine resorts. Regular snow falls above 950 m; areas above 1200 m have snow cover throughout winter (LCC 1973).

Temperature

Temperature regimes vary across the study area, from alpine to coastal. Seasonality of temperatures is common throughout; highest temperatures occur in February and the lowest in June or July. Table 12 shows, this pattern, reflected in the mean daily maximums and minimums for a number of stations.

Altitude, local topography, and distance from the coast influence temperatures. Alpine areas experience extreme low temperatures in winter; when the Mt Baw Baw weather station was in operation, it recorded mean monthly temperatures below 0°C during June and July (LCC 1973). In contrast, the coastal and plains areas, such as Cape Schanck and Scoresby, have the lowest range of mean monthly temperatures about 8°C and 6°C respectively (see Table 12).

Areas in the north of the study area experience the highest summer temperatures, as indicated by the data for Mangalore and Lake Eildon.

Climatic Change and the Greenhouse Effect

The condition and composition of Earth's atmosphere exert a fundamental influence on the world's climate. Some atmospheric gases allow sunlight to reach the Earth's surface and act to trap a portion of the outgoing radiation reflected from the surface. As a result of human activities, the concentrations

MEAN ANNUAL RAINFALL



LEGEND

ISOHYET (mm)



STUDY AREA



1 : 1 000 000



Kilometres

 Land Conservation Council
Victoria

Table 11
MEAN RAINFALL BY MONTH (mm)

Month	Rainfall station								
	Cape Schanck	Melbourne	Scoresby	Mt St Leonard	Wonthaggi	Mangalore	Rubicon	Lake Eildon	Warragul
January	41	48	52	84	47	39	70	45	62
February	40	47	52	72	44	28	54	40	51
March	54	52	56	87	63	38	74	55	71
April	63	57	73	106	80	43	117	62	85
May	77	58	101	138	101	66	188	80	97
June	77	49	67	106	94	49	186	95	94
July	78	49	78	119	97	59	226	95	93
August	73	50	85	142	99	69	219	98	105
September	60	59	56	136	86	59	158	80	104
October	70	67	89	131	86	49	149	81	108
November	57	60	82	132	68	47	114	67	91
December	52	59	73	122	60	43	87	55	82
ANNUAL	750	655	894	1375	925	589	1642	853	1043
Year commenced	(1879)	(1855)	(1948)	(1953)	(1911)	(1947)	(1943)	(1887)	(1888)
Number of years recorded:	102	134	41	36	77	31	45	100	101

Source : Bureau of Meteorology data, Melbourne Office, 1989

of these gases have been increasing, causing a greater amount of heat radiation to be trapped, and thus probably causing Earth's temperature to rise. The main greenhouse gases are carbon dioxide, methane, nitrous oxide, chlorofluorocarbons (CFCs), halons, and tropospheric ozone (Victoria 1989).

Prior to the Industrial Revolution, the greenhouse gases remained relatively stable for several thousand years. Our burning of fossil fuels, large-scale deforestation, and the release of artificial gases have generated large quantities of greenhouse gases. Carbon dioxide (CO₂) has increased by 23% since pre-industrial times, methane (CH₄) by 110% and nitrous oxide (N₂O) by 8% (Pearman

1988 pp. 3--21). Over the next 50 years the estimates of the increases for these gases above the pre-industrial level are 45--115% for CO₂, 200--500% for CH₄, and 25--60% for N₂O. Chlorofluorocarbons (CFCs) did not exist in the atmosphere prior to the 1930s; the two key ones now have an annual rate of increase of 5%. Over the next 50 years CFCs are expected to increase by 300%.

Although no link between greenhouse gases and a warmer world climate has yet been scientifically proved, there is considerable consensus in the scientific community on the potential for the effect to occur. The timing and rate of change to the climate system

Table 12
TEMPERATURE - MEAN DAILY MAXIMUM AND MINIMUM (°C)

Month	Weather station									
	Cape Schanck	Melbourne	Scoresby	Mount St Leonard	Wonthaggi	Mangalore	Rubicon	Lake Eildon	Warragul	Noojee
January										
MAX	21.4	25.8	25.8	22.7	23.7	29.3	23.5	28.2	25.9	24.7
MIN	14.0	14.0	13.2	11.0	12.5	13.9	12.2	12.3	12.5	10.1
February										
MAX	22.1	25.6	26.6	23.7	24.7	29.3	23.9	29.0	26.2	25.6
MIN	14.9	14.3	14.1	12.2	12.9	14.2	12.7	12.6	13.3	9.5
March										
MAX	20.7	23.8	23.9	20.5	22.5	26.1	20.5	25.1	23.9	22.7
MIN	14.1	13.0	12.7	11.0	12.0	12.4	10.9	10.7	11.7	9.9
April										
MAX	18.0	20.2	19.9	15.9	19.4	21.3	15.5	20.5	19.8	18.7
MIN	12.3	10.6	10.5	8.8	10.1	8.8	8.1	7.9	8.9	7.5
May										
MAX	15.3	16.6	16.3	12.2	16.6	16.5	10.8	15.9	16.0	15.0
MIN	10.4	8.4	8.6	6.9	8.3	6.2	5.5	6.2	6.6	5.7
June										
MAX	13.0	13.9	12.7	9.3	13.8	13.4	8.3	12.2	13.5	11.6
MIN	8.4	6.7	6.3	4.6	6.1	3.7	3.4	3.9	4.8	3.3
July										
MAX	12.2	13.3	14.1	8.4	13.2	12.4	6.9	11.5	12.9	11.4
MIN	7.5	5.8	5.8	3.6	5.7	3.0	2.3	3.4	3.8	1.7
Years of record	24	134	24	21	18	30	29	18	18	7

Source: Bureau of Meteorology data, Melbourne Office, 1989

remain the most difficult aspects of greenhouse to predict.

Climatic changes resulting from the greenhouse effect are currently predicted to include:

- * an increase in global mean temperature, with changes to temperature regionally
- * change in the incidence of extreme events - for example, cyclones, floods, droughts, and heat waves
- * changes in rainfall patterns
- * a rise in global mean sea level
- * some melting of ice

Victoria's draft strategy for a response (Victoria 1989) gave the following projections:

- * temperatures possibly 2--4°C higher in winter and summer, possibly with higher evaporation, drier soil, and less run-off
- * wetter summers
- * greater rainfall intensity
- * reduced snowfalls and shorter snow seasons
- * sea-level rises of 10--30 cm, possibly increasing to 20--70 cm by the year 2080
- * wave patterns and storm frequency/intensity may alter

Although the exact timing of the greenhouse effect and its impacts are uncertain, progressive effects are expected over the next 20--50 years. The degree of disturbance across the study area will vary, depending on local circumstances and conditions. Aspects to be affected will include ecosystems,

coasts, primary production, water resources and water-harvesting, and urban settlements.

Greenhouse and Nature conservation

The existing system of Nature conservation parks and reserves depends on an implicit assumption that our current climate will continue and the areas will thus retain a capacity for such conservation. Public lands primarily designated for flora and fauna conservation currently cover about 10% of Victoria and represent ecosystems in a natural condition, which have become disjunct and dispersed among modified environments (Mansergh and Bennett 1989).

Rapid climatic change occurring as a result of the greenhouse effect would greatly affect native flora and fauna, and reduce the certainty of effectiveness of existing Nature conservation reserves. Climatic change will alter the perturbation regime, producing changes in flora composition, species dominance, and ecosystem structure (Pearman 1988 pp. 361--74). Such changes in distribution will involve movement, expansion, contraction, and elimination. Those species having disjunct ranges or distributions face habitat losses and extinction.

Within the existing parks and reserves, the land types will continue to represent the range of geological, geomorphological, and soil types within the State. However, climatic changes after an area was designated as a reserve may result in an alteration to the composition of the flora and fauna species. As a result, reserves will reflect changes in biotic conditions.

Other associated factors influencing Nature conservation include fire and its effects on biota, predators, introduced species, disease, habitat fragmentation, and the absence of critical resources.

Species considered most at risk are those with one or more of the following characteristics:

- * small and/or genetically impoverished populations
- * poorly dispersed species, annual plants, alpine species
- * peripheral or disjunct populations

- * coastal species
- * montane and alpine species

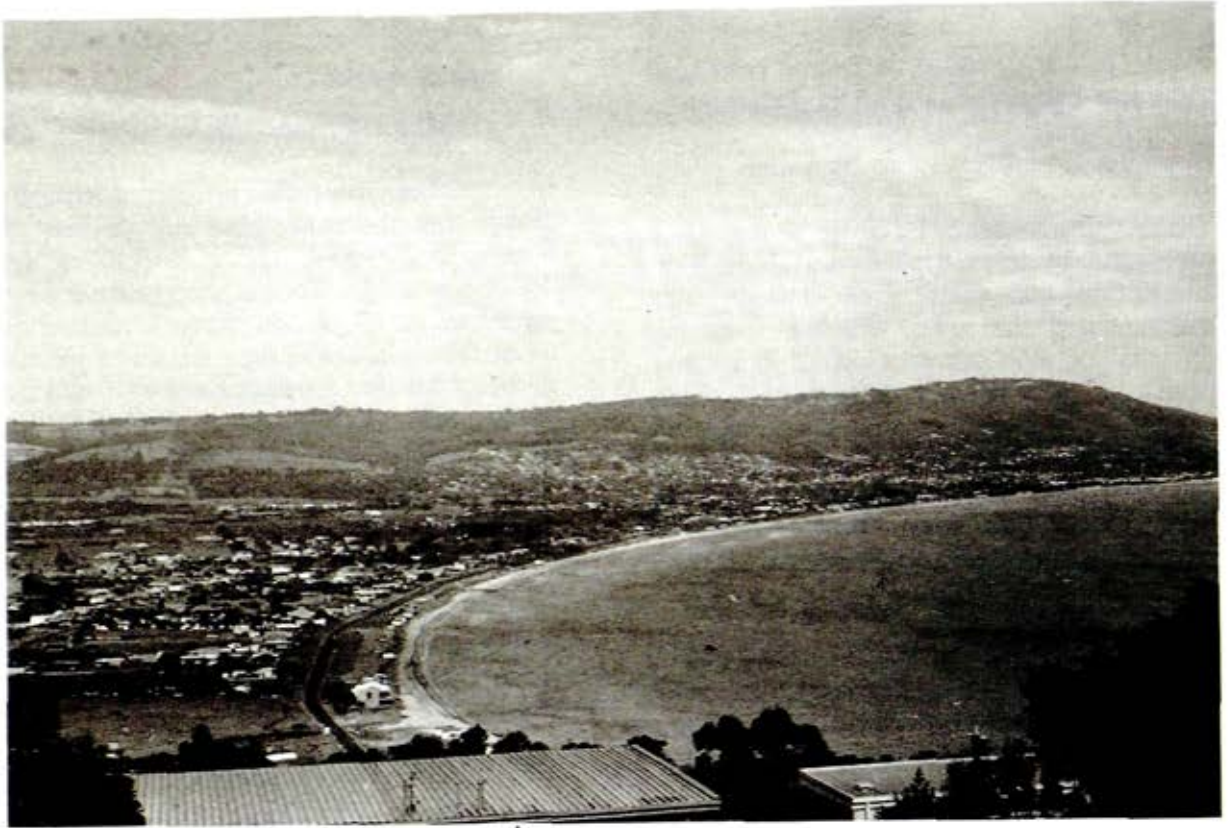
Uncertainties about the effects of climatic change and the consequent complexities of Nature conservation create difficulties for decision-making. Several themes have been identified for flora and fauna conservation under these circumstances. Retaining genetic diversity has the greatest chance of success where the reserves cross climatic and latitudinal gradients. Increased resilience in the parks and reserves can be achieved by gaining an optimum environmental reserve system, and further encouragement of conservation practices on private land could enable species protection when biotic distributions move beyond conservation areas. State forests have a role in providing habitat and habitat linkages outside the reserve system. Avoiding further fragmentation or elimination of native communities and implementation of regional corridors would also help.

Coastal impacts of the greenhouse effect

Sea-level rise is the most comprehensively researched coastal phenomenon in relation to the greenhouse effect; potential impacts on the marine environment have received little attention. A range of other climatic changes would accompany sea-level rise and would also affect coastal areas.

Research has yet to confirm how a rise in temperature would influence sea levels, or how different elements would contribute to any changes in levels. A combination of local, regional, and global factors will determine sea-level changes at any specific locality. An expansion of the volume of the near-surface waters, due to rising surface temperatures decreasing its density, is likely to be the major contributor to sea-level rise, while partial melting of snowfields, ice-sheets, and glaciers will make a minor contribution in the shorter term (Bolin *et al.*, 1986 pp. 323--59).

Estimates on the magnitude of sea-level rises vary. Estimated rises over this century, on a global scale, are 12 +/- 5 cm. Bolin *et al.* (1986) projected that a rise of 1.5--5.5°C would result in sea-level rises of 20--165 cm. Under one CSIRO scenario, an atmospheric temperature rise of 2--4°C would lead to a



Sea-level rises could threaten coastal areas along Port Phillip Bay with inundation.

sea-level rise of 20--140 cm (Pearman 1988), although the upper estimate has now been revised to 60 cm.

Those locations at risk within the study area have yet to be identified, although work on Port Phillip Bay (MPE 1988) and other studies have begun. The current best estimate proposed is an average rate of global mean sea-level rise of about 6 cm per decade, amounting to a rise of 20 cm by 2030. Inundation impacts will depend on cross-shore gradient, affecting permanent sea-level inundation and shoreline retreat (Pearman 1988). Higher-frequency events associated with waves, tides, flooding, and storm surges will cause inundation some metres above sea level.

Northern Western Port, where the inter-tidal mudflats and coastal zone ecosystems are highly sensitive to tidal inundations, will be especially at risk. Shoreline retreat will also erode the public land foreshore reserve, much of which abuts private lands. Losses of coastal zone vegetation, beaches, and inter-tidal flats, especially in Port Phillip Bay and Western Port, could be permanent. On the more steeply sloping beaches, increased erosion is likely to result in the loss or

significant reduction to foredunes behind many beaches.

Most measurements of sea levels have involved tide gauges, which cannot distinguish eustatic sea-level movement from land margin movement. It has been argued that existing tidal gauges (especially in the Southern Hemisphere) and geodetic surveys have not provided sufficient evidence of sea-level change to date. A number of other parameters have been suggested as being suitable for measuring this, including changes in shoreline and salt-marsh vegetation, enlargement of estuaries and lagoons, new coastal wetlands, and upward migration of zoned shore organisms.

A number of monitoring, planning, and research activities have been proposed for coastal areas in the government's Greenhouse Strategy (OCE 1990).

Alpine climatic change

A report on alpine climate (Ruddell *et al.* 1990) stated that long-term records of snow cover suggest no statistically significant trends. Climatic fluctuations occurred at the decade time scale, but were not sustained in

the long term. Analysis revealed that snow cover related well to variables such as winter temperature and precipitation, but that few records exist that can be used to establish climatic trends in alpine country (that is, above 1400 m).

Government action

A strategy, 'Greenhouse: Meeting the Challenge' (DCE 1990), describes the Victorian government's response, which covers actions in five fields:

- * research into atmosphere conditions and the impact of the greenhouse effect, climatic and sea-level monitoring
- * limiting greenhouse gas emissions
- * education and community awareness
- * planning to accommodate climatic change
- * national co-ordination

The actions to limit greenhouse gas emissions and slow down the potential impacts include a staged phase-out of ozone-depleting substances (CFCs and halons) by the mid 1990s. An (interim) target for reduced CO₂ levels was set at a 20% reduction of CO₂ levels from the 1988 levels by 2005. Implementing energy-demand management measures has begun, as have investigations of transport-fuel conservation and efficient electricity generation and transmission. 'Tree Victoria', a major revegetation program, has significant implications for land use and Nature conservation, as well as contributing to a showing of the greenhouse effect. Under the program, it is planned to plant 100 million trees by the year 2010. A proposed planning scheme amendment requiring permits to clear native vegetation on private land has also been introduced.

Long-term planning will be necessary to allow for potential changes in urban development, flora and fauna conservation, coastal areas, agriculture and forestry, water resources, and tourism.

The ozone layer

Ozone is a natural constituent of the upper atmosphere, where it functions as a shield

protecting the Earth against exposure to harmful ultraviolet rays from the sun by reducing these rays to safe levels at the Earth's surface.

Discovery of a hole in the ozone layer above the Antarctic in 1984 has given cause for great concern that other holes could similarly appear in other parts of the world. Depletion of the ozone layer results in increased quantities of solar ultraviolet radiation reaching the earth's surface. Some ultraviolet reaches the Earth's surface normally, where it causes a range of human health problems - sunburn, forms of skin cancer, and some eye conditions. The effects of increased ultraviolet penetration are currently unknown; however, an escalation in human health problems is likely, crop productivity and the health of livestock would probably diminish, and major ocean food chains could be severely damaged (Hare 1988, Gribben 1988).

Ozone depletion is the outcome of human agency. Chlorofluorocarbons (CFCs) and halons (artificial chemicals containing chlorine or bromine), released through a variety of human-induced sources are the primary causes of ozone loss. In Australia, CFCs are used in refrigeration and air-conditioning, aerosol propellants, plastic foams, and cleaners in the electronics industry (Hare 1988). In its response to the Greenhouse issue, the Government is committed to introduce specific controls to achieve a phase-out of CFCs and halons by 1998 (DCE 1990).

References

- Australia, Commonwealth Bureau of Census and Statistics (1973). *Victorian Year Book*.
- Bolin, B., Doos, B.R., Vager, J., and Warrick, R.A. (eds) (1986). 'The Greenhouse Effect, Climatic Change and Ecosystems.' Scope 29. (John Wiley: Chichester.)
- Department of Conservation and Environment (1990). 'Greenhouse: Meeting the Challenge. The Victorian Government's Statement of Action.' (Victorian Government Printing Office: Melbourne.)
- Gribben, J. (1988). The ozone layer. *New Scientist, Inside Science* No. 9, 5 May.

Hare, B. (1988). Ozone: no time for half measures. *Habitat*, 16 1:6--9.

Intergovernmental Panel on Climate Change Working Group 1 (1990). 'Scientific Assessment of Climate Change. Report to the Panel', 25 May 1990.

Land Conservation Council (1973). 'Report on the Melbourne Study Area.' (Victorian Government Printing Office: Melbourne.)

Mansergh, I., and Bennett, S. (1988). Greenhouse and wildlife management in Victoria. *Common Ground* 1 (2): 14--19.

Ministry for Planning and Environment (1988). 'Port Phillip Coastal Study.'

(Victorian Government Printing Office: Melbourne.)

Pearman, G.I. (ed.) (1988). '*Greenhouse: Planning for Climatic Change.*' (CSIRO: Melbourne/E.J. Brill: Leiden.)

Ruddell, A.R., Budd, W.F., Smith, I.N., Keage, P.L., and Jones, R. (1990). 'The South East Australian Alpine Climate Study.' (University of Melbourne and the Alpine Resorts Commission: Melbourne.)

Victoria, government (1989). 'The Greenhouse Challenge. The Victorian Government's Response Draft Strategy.' (Victorian Government Printing Office: Melbourne.)

6. WATER RESOURCES

This chapter broadly describes the surface water resources of the study area, by river basin, covering stream flow and yield, and water quality. A section on groundwater, provided by the Department of Manufacturing and Industry Development, is also included. Chapter 17 describes water harvesting and use, and its associated issues.

Surface Waters

River basins

An amalgamation of river and stream catchments forms a river basin, which is a convenient unit for describing and analysing water resources. Six basins, as designated by the Australian Water Resources Council (AWRC 1976), lie either wholly or partly within the study area and are recognised by all water authorities.

The largest watercourses in the study area, as measured by stream flow, are the La Trobe, Thomson, and Yarra Rivers. A list of the major ones within each basin is given in Table 13.

Watercourses in the Goulburn River basin drain to the Murray River, while those of the Thomson and La Trobe basins drain to the Gippsland Lakes. Waters from the Yarra, Bunyip, and South Gippsland River basins flow to the sea, into Bass Strait, Port Phillip Bay, or Western Port Bay. All the basins are shown on Map 6, and four are divided by the study area boundary. In the Goulburn River basin the majority of the upper catchments, including Eildon Reservoir, lie within the study area, which also includes the upper Thomson River and upper catchments of the La Trobe basin.

In South Gippsland basin, the two easternmost rivers and part of the upper catchment of the Tarwin River are within the study boundary. All of the Yarra and Bunyip River basins are included.

The study area does not contain any large, natural fresh-water bodies: water storages comprise the largest expanses. Intertidal

areas and wetlands are distributed around the coastal fringe, notably Western Port. Wetland studies have been conducted in the South Gippsland, upper Yarra, La Trobe, and most of Bunyip River basins.

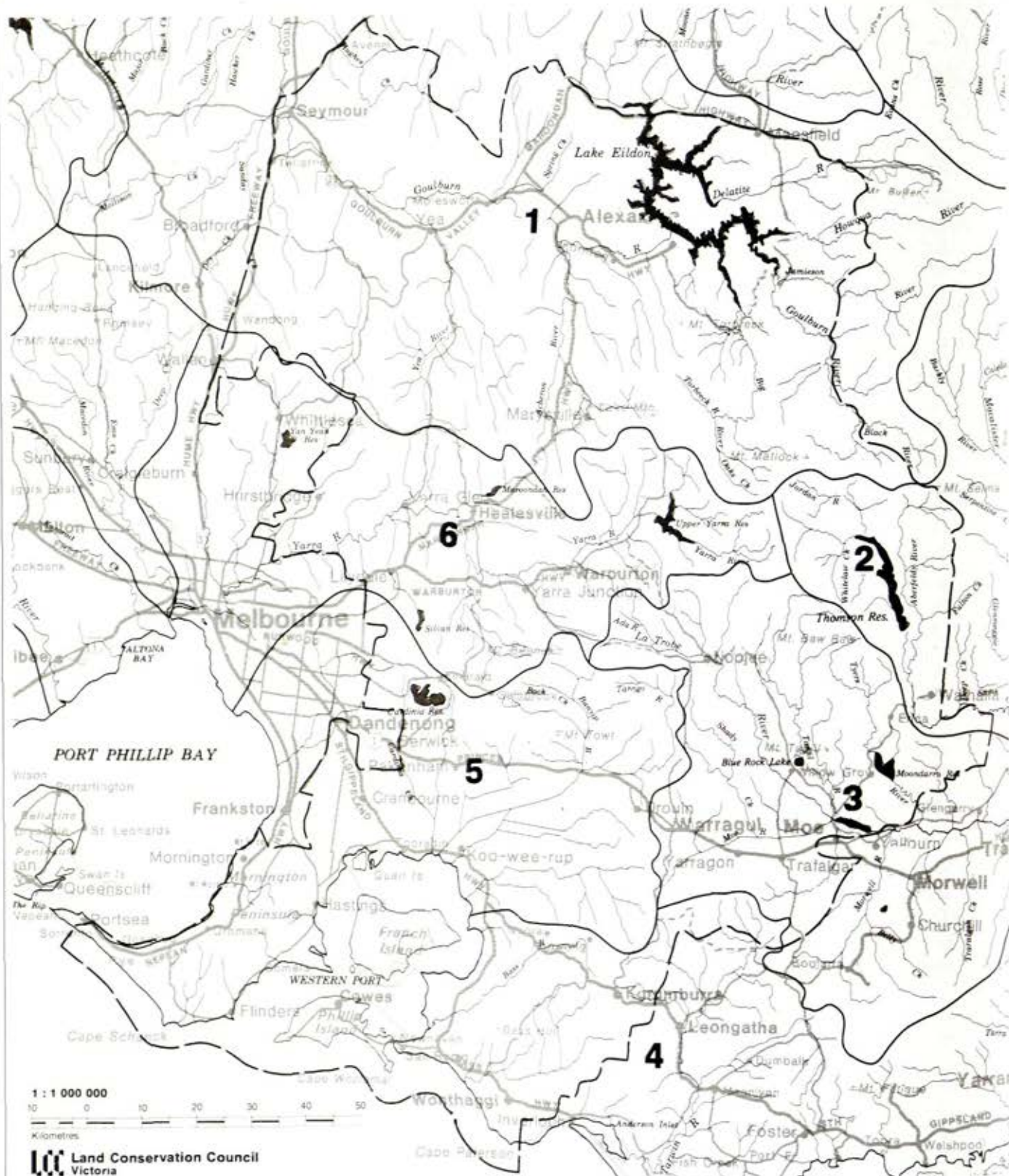
Table 13

MAJOR WATERCOURSES IN STUDY AREA

Basin	Watercourse
Goulburn	Acheron River Big River Delatite River Goulburn River Howqua River Jamieson River King Parrot River Murrindindi River Rubicon River Yea River
Thomson	Aberfeldy River Jordan River Thomson River
La Trobe	Ada River La Trobe River Moe River Tanjil River Tyers River
South Gippsland	Bass River Powlett River
Bunyip	Bunyip River Dandenong Creek Lang Lang River Paterson River Tarago River
Yarra	Little Yarra River O'Shannassy River Plenty River Watts River Woori Yallock Creek Yarra River

Stream flow and yield

Measurement of stream flow over time constitutes a basic element in determining the character of a watercourse. Base flows vary continually, and are disrupted by drought and



LEGEND

- Rivers and streams
- Lakes and reservoirs
- Drainage basin boundaries
- 4** Drainage basin numbers
- Boundary of study area

KEY TO BASINS

- | | |
|-------------|--------------------|
| 1. GOULBURN | 4. SOUTH GIPPSLAND |
| 2. THOMSON | 5. BUNYIP |
| 3. LA TROBE | 6. YARRA |

Notes:

1. Major rivers and streams are shown, but the small map scale has resulted in not all 3rd order streams being shown.
2. The drainage basins shown as those used by the Australian Water Resources Council. They are major river catchments or groups of catchments.

low flows, or by high flows and floods. Both the yield of a watercourse and the patterns of stream flow, especially extreme events (drought and flood) are critical to the in-stream environment and also to floodplain and riparian ecosystems. Stream flow is a major determinant of geomorphic change. Both the exploitation of water resources and environmental protection require knowledge of stream flow and catchment yields.

Table 14 gives selected stream flow information for a number of the larger watercourses. It does not cover the major watercourses as many have no gauging stations and several have insufficient data to derive an accepted mean result. Mean annual stream flow provides a useful relative measure of stream size, but the variability of stream flow also needs to be considered.

Most Australian rivers and streams, including those of the study area, are characterised by great variability and a marked seasonality of flow, as indicated in Table 14. It is not uncommon for the record maximum monthly flow to exceed 50% of the mean annual discharge. Stream flow can vary greatly on a daily, monthly, or yearly basis. Examination of flows at a single gauging station reveals the extent of variation. Tonga Bridge Gauging Station, upstream of Eildon Reservoir on the Delatite River, has a record mean maximum daily flow of 26 800 ML and a record minimum annual flow of 39 600 ML (SRWSC 1984): the record monthly discharge at the same site is 105 000 ML, which approaches the mean annual flow of 131 000 ML (SRWSC 1984).

In most cases, the range between maximum and minimum flows can be expected to increase with the period of record, as a greater number of extreme events are recorded.

Extreme variability is common, although the data in Table 14 indicate actual flows, which reflect the influence of changes due to water storage and extraction. Few of the larger watercourses remain unaffected by water storages, an issue covered in Chapter 17.

Much of the variation in stream flow reflects the seasonality of flow. Most rivers and streams carry the greater proportion of their annual flow in winter and spring. A major effect of water storages is the disruption of this seasonality. Under natural conditions,

the July–September period accounted for 52% of the Goulburn River's annual flow, with a mere 5% in January–March. Since the operation of Eildon Reservoir, the winter flows account for 33% and the summer flows have risen to 23% of annual stream flow (DWR 1989).

Water quality

Measurements of the physical, chemical, and biological characteristics of water are used to assess its quality. Although this varies under natural conditions, any significant and persistent loss of water quality harms aquatic ecosystems and reduces the value of the resource. Water quality influences various uses of the resource, including human consumption, industrial, recreational, agricultural, scientific, and educational.

Across the study area, catchment conditions and water quality generally coincide. Forested, undisturbed catchments retain high water quality, while agricultural and urbanised catchments have lowered water quality and riverine conditions. Land-use practices resulting in erosion and export of nutrients and toxicants, urban run-off, and point-source discharges of pollutants are the major causes of loss of water quality.

Physico-chemical parameters are most commonly used for the regular analysis of water quality. They include turbidity (a measure of light scattering), suspended solids, conductivity (a measure of salinity), nutrient levels (usually nitrogen and phosphorus), pH, temperature, and dissolved oxygen. Elevations, especially of a persistent nature, of any of these parameters from background levels usually indicate changes in water quality. Biological monitoring offers important insights into aquatic conditions, but complexity and expense limit its application.

Describing surface water quality involves assessing characteristics that can be highly variable. Changes over time (such as in stream flow) often significantly influence water quality measured at any monitoring point, but it also alters naturally along the length of a watercourse. Assessing water quality is therefore a complex task, involving numerous measurements to understand the variations in different parameters, and assessing quality against the natural conditions expected for any particular reach.

Table 14

**MEAN ANNUAL DISCHARGE, MAXIMUM AND MINIMUM MONTHLY DISCHARGE
FOR SELECTED WATERCOURSES**

Watercourse	Gauging station (RWC)	Period of record (to 1981)	Mean annual discharge (ML)	Maximum monthly discharge (ML)	Minimum monthly discharge (ML)
Basin 5 - Goulburn					
Acheron River	Tagerty (209)	1945-	337 000	112 000	1 220
Big River	Jamieson (227)	1958-	330 000	153 000	1 460
Delatite River	Tonga Bridge (214)	1947-	131 000	105 000	379
Goulburn River	Seymour (202)	1957-	2 650 000	871 000	23 900
Goulburn River	Trawool (201)	1908-1909	2 520 000	1 070 000	20 400
		1925-			
Goulburn River	Eildon (203)	1916-	1 650 000	907 000	235
Goulburn River	Dohertys (219)	1954-	394 000	246 000	377
Howqua River	Glen Esk (215)	1947-1954	200 000	132 000	537
		1955-1956			
		1973-			
Jamieson River	Gerrans Bridge (218)	1954-	246 000	127 000	619
King Parrot Creek	Flowerdale (231)	1961-	35 200	21 800	57
Murrindindi River	Colwells (205)	1939-	59 000	18 500	778
Rubicon River	Rubicon (241)	1922-1928	138 000	60 000	1 610
		1949-			
Yea River	Devlins Bridge (217)	1954	113 000	45 800	267
Basin 25 - Thomson					
Aberfeldy River	Beardmore (213)	1963-	83 000	95 300	0
Aberfeldy River	Lily Creek (100)	1972-	37 400	19 000	111
Thomson River	Cooper Creek (208)	1929-1950	353 000	172 000	1 720
		1952-			
Thomson River	Narrows (210)	1953-	241 000	88 500	1 570
Thomson River	Thomson Adit (103)	1973-	69 700	21 700	899
Basin 26 - La Trobe					
La Trobe River	Yallourn (400)	1919-	631 000	456 000	9 080
La Trobe River	Willow Grove (204)	1924-	226 000	77 200	2 330
La Trobe River	Noojee (205)	1925-1931	112 000	27 100	1 860
		1957-			
Moe Drain	Trafalgar East (402)	1957-	112 000	62 000	72
Moe River	Darnum (209)	1949-1960	51 200	23 600	128
		1960-			
Narracan Creek	Thorpdale (218)	1955-	25 000	9 880	261
Tanjil River	Tanjil South (216)	1955-	150 000	48 700	1 630
Toorong River	Noojee (219)	1924-1933	42 000	8 930	833
		1957-			
Tyers River	Boola (006)	1958-	60 200	62 500	104
Basin 27 - South Gippsland					
Bass River	Loch (219)	1966-	17 500	9 250	0
Bass River	Forbes South (231)	1973-	59 300	32 500	14
Powlett River	Foster Creek (236)	1979-	Insufficient data		
Foster Creek	Dam Site (238)	1979-	Insufficient data		
Basin 28 - Bunyip					
Bunyip River	Iona (213)	1962-	106 000	51 900	97
Bunyip River	Bunyip (200)	1907-1952	153 000	93 600	1 800
		1953-1963			
Bunyip River	Tonimbuk (212)	1962-	27 700	8 870	87
Bunyip River	Headworks (207)	1948-	7 630	4 120	4
Dandenong Creek	Dandenong (204)	1924-1967	49 600	39 300	8
		1968-			
Basin 29 - Yarra					
Blue Jacket Creek	Coranderrk Weir (119)	1958-	372	83	5
Don River	Launching Place (220)	1967-	5 390	1 560	44
L. Yarra River	Yarra Junction (214)	1963-	45 600	12 200	595
Plenty River	Mernda (216)	1964-	15 400	25 400	0
Woori Yallock Creek	Woori Yallock (215)	1963-	95 300	38 400	367
Yarra River	Mill Grove (212)	1963-	171 000	93 700	1 300
Yarra River	Warrandyte (200)	1891-1933	751 000	459 000	1 560
		1959-			
Yarra River*	Heidelberg (135)	1965-	428 000	266 000	1 550

* Downstream of study area

Source: State Rivers and Water Supply Commission (1984).

The following description makes qualitative assessments, ranging from excellent, good, moderate, poor, to degraded. These terms are based on those used in the 1988 State of the Environment Report 'Victoria's Inland Waters' (OCE 1988) using basic physico-chemical data. Published RWC (1990) data, current to 1987, are used to exemplify selected water quality parameters. Readers seeking current data are directed to the Rural Water Commission and the Environment Protection Authority, which have unpublished data available.

Goulburn River basin

Most of the larger watercourses above Eildon Reservoir are within forested catchments: they include the Jamieson, Howqua, Goulburn (above Eildon Reservoir), Big, Rubicon, and Acheron Rivers. Yea and Delatite Rivers have substantial lower reaches in cleared agricultural lands, as does the Goulburn River below Eildon Reservoir.

Water quality is generally excellent in the forested areas: turbidity is low (mean values less than 5 NTU); salinity is low (mean values below 90 μS per cm); pH is close to neutral on the Delatite, upper Goulburn, Howqua, Jamieson, Murrindindi, and Rubicon Rivers. Turbidity in the Goulburn

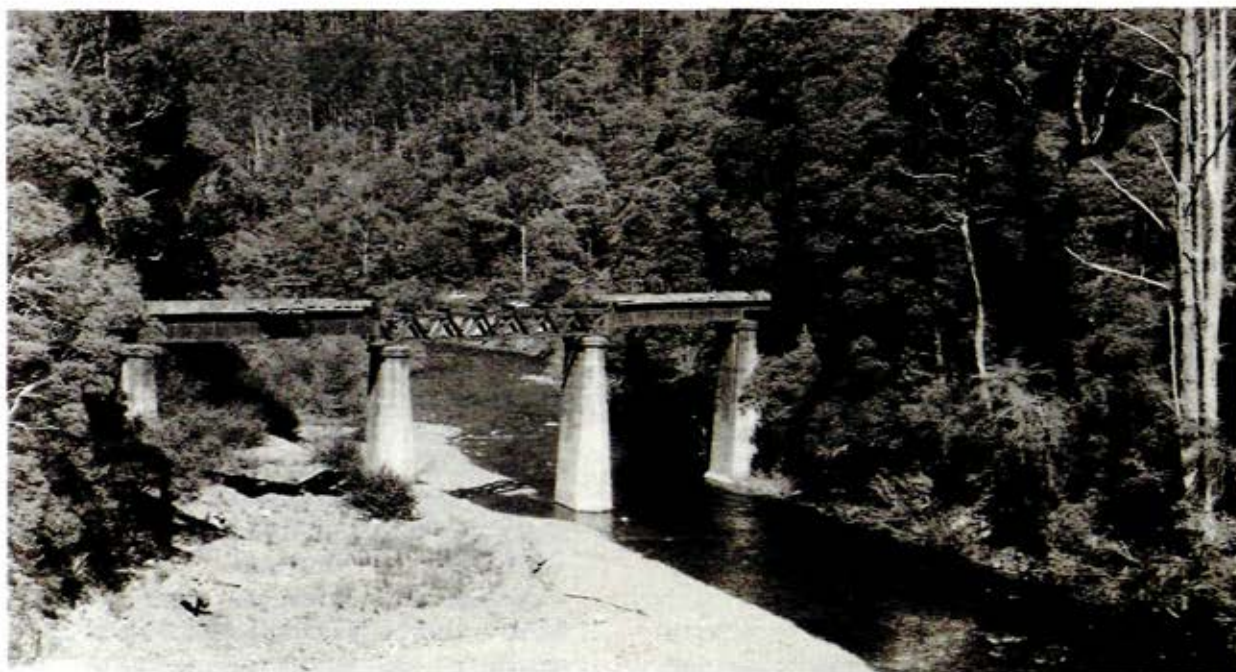
River increases slightly downstream from Eildon Reservoir to Seymour, but remains relatively low there, as is salinity. The nutrients phosphorus and nitrogen are at moderate to good levels, although a trend of increasing phosphorus has been evident.

Big River has excellent clarity, nutrients, and other physico-chemical measurements. Relatively high turbidity levels on the lower reaches of the Yea River have reduced its water quality.

Mercury contamination has been recorded in the upper Goulburn, and its tributaries Morning Star and Raspberry Creeks (Ealey *et al.* 1983, EPA 1984), an outcome of gold mining last century. Fish and drinking water from Eildon Reservoir have, on some occasions, exceeded the levels recommended for safe consumption (EPA 1984).

Thomson River basin

Water quality in the Thomson River has been influenced by the effects of the Thomson Reservoir. Salinity levels are low (mean values below 70 μS per cm), pH is close to neutral, and levels of the nutrients nitrogen and phosphorus are also low (mean values total phosphorus 0.038 mg per L). Turbidity data suggest high levels during peak stream



Thomson River

flows (90% of 18 NTU at the Narrows station). Examination of trends in these data suggests that, following completion of the Reservoir, high turbidity levels downstream of the storage and associated with its construction, are now in decline.

Data on turbidity, salinity, pH, and dissolved oxygen for the Aberfeldy River are indicative of excellent water quality.

La Trobe River basin

While the headwaters of the northern basin are forested, the area south of the La Trobe River and the larger valleys and plains are predominantly cleared agricultural lands. Above Willow Grove, water quality is excellent to good, with low turbidity, low salinity, and a pH close to neutral. However, quality declines along the length of the La Trobe, particularly in the reach downstream of Willow Grove to Thoms Bridge, just beyond the study area, where turbidity, suspended solids, salinity, and the nutrients phosphorus and nitrogen all increase significantly. For example, mean salinity increases from 87 to 285 μS per cm, mean turbidity from 5 to 19 NTU, and mean total phosphorus from 0.016 to 0.083 mg per L.

The Moe River is in poor condition for much of its length. It has high turbidity (mean value 26 NTU), relatively high salinity (mean value 307 μS per cm), high phosphorus (mean value total phosphorus 0.554 mg per L), and high nitrogen (mean nitrate and nitrite as N 1.44 mg per L), indicative of poor water quality.

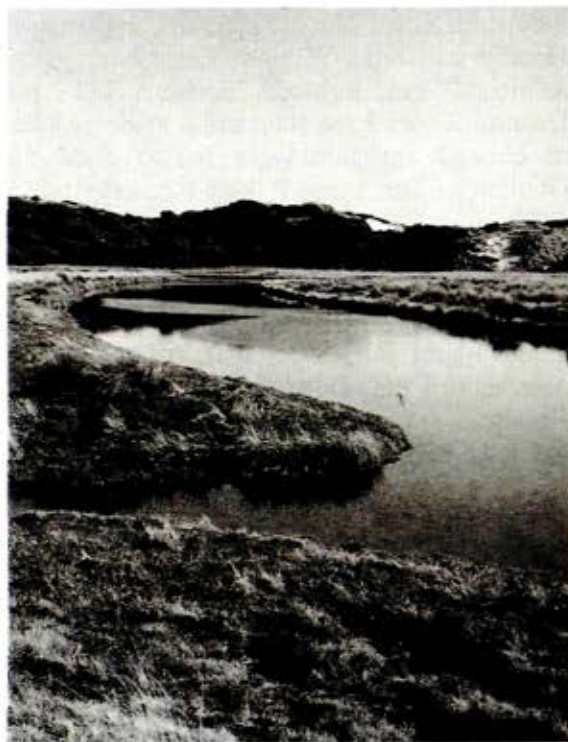
South Gippsland basin

Very little of this basin carries native vegetation; most is cleared agricultural land. Comprehensive monitoring on the Bass River at Glen Forbes South shows high turbidity on occasions (90% of 33 NTU), high salinity (mean value of 744 μS per cm), and fairly high levels of the nutrients phosphorus and nitrogen (mean value total phosphorus 0.09 mg per L). Monitoring on the Powlett River indicates fairly high salinity and turbidity levels.

Bunyip River basin

Clearing is extensive across the plains and foothills, which are used for agriculture, with

forest cover across the headwaters. Bunyip River exhibits an increasing level of turbidity and salinity downstream along its length; turbidity levels are occasionally relatively high in the lower reaches (90% value 37 NTU), as are nutrient levels. Lang Lang River similarly has high turbidity levels (mean value 21 NTU), with high suspended solids and relatively high levels of the nutrients phosphorus and nitrogen. On the basis of their turbidity, salinity, pH, and dissolved oxygen, Tarago River and Toomuc Creek have moderate water quality. Cardinia Creek has recorded very high turbidity levels (mean value 39 NTU), resulting in degraded water quality.



Powlett River

Yarra River basin

As the high-elevation areas are largely within forested water supply catchments, water quality is excellent. Clearing has been extensive in the foothills and plains in the lower reaches, with a resulting decline in water quality. Salinity, pH, and dissolved oxygen are indicative of excellent to good water quality at McMahon's, Millgrove, and Warburton. However, turbidity and suspended solids levels at Warburton are high (mean value 16 NTU), as are the levels of the nutrients, phosphorus (mean value total phosphorus 0.132 mg per L), and nitrogen

(mean value nitrate and nitrite as N 0.544 mg per L). Further downstream of Launching Place, Healesville, Spandonis Reserve, and Warrandyte, the nutrient levels increase. Between Spandonis Reserve and Warrandyte, nutrient increase is marked (notably phosphorus) due to urban run-off and point-source discharges. Suspended-solids levels also tend to increase downstream, especially below Warrandyte - although a trend towards some improvement appears to be occurring.

Watercourses in cleared areas are characterised by relatively high turbidity, some with higher salinity levels, and occasionally low levels of dissolved oxygen, indicative of poorer water quality. Such watercourses include Diamond Creek, Plenty River, and Watsons Creek. Those draining forested areas, such as the Don River at Launching Place, have higher water quality.

Biological monitoring of the Yarra River using macro-invertebrates indicated considerable deterioration of the fauna progressively downstream (Pettigrove 1988). These changes were associated with water quality decline and the physical characteristics of individual sites - such as water depth and riparian vegetation.

Groundwater

Groundwater refers to all water found below the Earth's surface. The more permeable saturated geologic units beneath the surface such as sand, gravel and limestone are called aquifers and the water in them can be tapped by bores.

Water moves slowly through these aquifers with input by recharge from rainfall and output by discharge to the land surface, streams, and the sea.

The available resource depends on the hydraulic characteristics of the aquifers, the rate of recharge, and the composition of the groundwater. Further, the behaviour of groundwater can play an important role in the environment in maintaining wetlands or where it comes close to the surface, causing salinity.

For convenience the groundwater resources of the Melbourne region are discussed in terms of groundwater basins and provinces; They differ from surface-water catchments,

because the surface-water flow pattern does not necessarily coincide with the groundwater flow pattern.

Four groundwater basins or provinces underlie the study area - Port Phillip basin, Western Port basin, Gippsland basin, and the Highlands province.

Port Phillip basin

The basin underlies and surrounds Port Phillip Bay. The onshore thickness of its sediments is up to 280 m - with the exception of the Nepean Peninsula, where maximum thickness exceeds 1000 m.

The Cainozoic sequence contains several aquifers, the most important of which are sand, gravel, and limestone of the Werribee Formation, Fyansford Formation, Bridgewater Formation, and the Brighton Group.

Major extractions occur south-east of Melbourne, for watering golf courses and market gardens, and west of Melbourne for use in industry. The resource is not used to supplement the supply for Melbourne because of limited yield and variable quality, although in times of water restrictions, groundwater is used extensively for the watering of public parks and private gardens in the south-eastern suburbs. Particularly in the western suburbs, the shallow groundwater is polluted by waste-disposal practices.

Western Port basin

Like the Port Phillip basin, Western Port basin has a sequence of Cainozoic sediments - up to 300 m thick.

Although less than 1000 sq.km in area, groundwater in the Western Port basin has high use. More than 10 000 ML are extracted annually, principally for market gardening and irrigation. Increased use of groundwater for irrigation during the 1950s and 1960s caused a drop in the potentiometric surface, centred around Dalmore--Cora Lyn; indeed, the potentiometric surface there lies below sea level, creating the potential for saline water intrusion from Western Port Bay.

In order to manage the groundwater resource on a sustainable basis, the Western Port basin was proclaimed a Groundwater Conservation

Area in 1971, which limits the extraction of groundwater in order to prevent overuse and degradation of the resource.

Gippsland basin

This thick sedimentary basin lies in the eastern part of the study area. It contains a large storage of good-quality groundwater (usually less than 1000 mg per L Total Dissolved Solids).

Some regional decline of the potentiometric surface of the main sand aquifer, the La Trobe Valley Group, has been caused by dewatering of the brown coal open-cut mines in the La Trobe Valley and off-shore extraction of petroleum.

Highlands province

Covering approximately one-third of Victoria, the southern portion lies within the study area. It is composed of folded rocks and intrusives. The major aquifer is in the weathered fracture zone at depths up to 70 m. Alluvial aquifers are an important water source in the Acheron and Goulburn River valleys.

References

- Australian Water Resources Council (1976). 'Review of Australia's Water Resources 1975.' (Australian Government Publishing Service: Canberra.)
- Baker, D.J., Lakey, R.C., and Evans, R.S. (1986). Management Options for the Western Port Groundwater Basin. *Proceedings, Australian Water Resources Council, Fourth Conference Brisbane* pp.124--59.
- Consulting Environmental Engineers (1986). 'Water Quality in Victorian Streams. Basins 1--38.' (Report to the Department of Water Resources.)
- Department of Water Resources (1989). 'Water Victoria: A Resource Handbook.' (Victorian Government Printing Office: Melbourne.)
- Ealey, E.M.H., Deacon, G.B., Calder, B.A.W., Bird, G.J., Bos-Van der Zalm, C.H., and Roper, W.G.C. (1983). Mercury in the food web of Raspberry Creek. *Environment Protection Authority, Publication No. 153.*
- Environment Protection Authority (1984). Mercury survey of the upper Goulburn River system. *Environment Protection Authority, Publication No. 195.*
- LaTrobe Valley Water and Sewerage Board (1986). 'The La Trobe River Basin. Water Resources and Aquatic Environment - A Review.' (LaTrobe Valley Water and Sewerage Board: Traralgon.)
- Lawrence, C.R. (1982). Groundwater resources. In Duncan, J.S. (ed), 'Atlas of Victoria', pp.36--8. (Victorian Government Printing Office: Melbourne.)
- Office of the Commissioner for the Environment (1989). 'State of the Environment Report 1988 - Victoria's Inland Waters.' (Victorian Government Printing Office: Melbourne.)
- Pettigrove, V.J. (1988). Biological monitoring of the Yarra River using macroinvertebrates. *Environment Protection Authority Scientific Report Series, 88/104.*
- Rural Water Commission (1991). 'Victorian Surface Water Information to 1987', 4 vols. (Victorian Government Printing Office: Melbourne.)
- State Rivers and Water Supply Commission (1984). 'Victorian Surface Water Information to 1982', Vol. (Victorian Government Printing Office: Melbourne.)

7. FLORA

The current distribution and condition of native vegetation in the study area reflects the effects of European settlement. Most of the plains and foothills have been cleared of their native vegetation, principally for agriculture, but also for urban, industrial, recreational, mining, road, and other uses. While the landscape of private land is predominantly agricultural, public land has generally retained a native vegetation cover, predominantly in the forests of the Central Highlands. In addition to the forests, woodlands, and native grasses, wetlands - such as Koo-Wee-Rup, Dalmore, and Tobin Yallock Swamps - have been cleared and drained. Natural drainage regimes have also been altered through catchment clearance, water storage, wetland drainage, river straightening, levee construction, riparian vegetation clearance, and other activities.

Public land contains the bulk of native vegetation, but much of it has been subject to a range of land uses and other factors that have influenced the extent, composition, and condition of vegetation communities.

Native vegetation on public land is an essential environmental resource, providing environmental, economic, social, scientific, and aesthetic values to the community. This chapter describes the vegetation communities within the study area, provides an analysis of the conservation status of each one and discusses those factors that influence the conservation values of flora.

Vegetation Community Descriptions

The following description of the major vegetation communities of the study area is based on the analysis of floristic vegetation surveys undertaken by the Flora and Fauna Survey Group, Resource Assessment Branch of the Department of Conservation and Environment. It represents a synthesis of data gathered during a range of regional and localised studies conducted since 1979, with additional information gathered in the course of this study, particularly for northern areas.

The floristic vegetation map (Map 7) was produced using aerial photograph inter-

pretation and field checking. Its scale has necessitated a substantial amount of simplification and stylisation of community boundaries.

In order to simplify presentation, the following description groups vegetation communities. It attempts to group vegetation communities that occur in the same broad geographical areas, or that display some other gross similarities.

It is important to note that the intensity of sampling undertaken for this study is sufficient only to identify and describe the major, common vegetation communities. Moreover, vegetation communities seldom occur in discrete stands; rather, they merge into one another, sometimes over a considerable distance.

Substantial variation in the structure and species composition of similar vegetation communities may occur from area to area. Although some attempt has been made to describe such variation, the lists of characteristic species presented for each community are indicative rather than absolute.

Sub-alpine Vegetation

Sub-alpine vegetation occurs on and around the mountain tops of the study area, including the Baw Baws, Lake Mountain, the Federation Range, and Mounts Bullfight and Torbreck.

High precipitation (around 1400 mm per annum), low temperatures (mean monthly averages from 0°C to 13°C, and exposure to high winds are prominent environmental factors. While no portion of the study area is truly alpine, in the sense of occurring above the tree-line, winter snowfalls are frequent here, with a layer of snow remaining for up to 4-5 months. Cold air drainage into gully-heads produces local extremes of cold.

Most of these mountains are weathered granite or granodiorite peaks. Soils range from peats and organic loams at the highest elevations to friable brown to red-brown gradational and uniform soils on the slopes. They are mainly free-draining, although the

accumulation of organic material in the depressions produces peaty, waterlogged soils, which may have complex profiles.

These mountain-tops are typically broad, with shallow-sided gully-heads between the ridges and spurs. They carry the four major vegetation communities described here.

Dry sub-alpine shrubland

A sparse to dense dry shrubland occurs on north-facing slopes and in saddles on the Baw Baw Plateau, often in the vicinity of granite tors. The shallowness of the soils overlying the granite may inhibit the establishment of trees and even shrubs on these sites.

Characteristic shrubs include dusty daisy-bush (*Olearia phlogopappa*), alpine orites (*Orites lancifolia*), cascade everlasting (*Helichrysum secundiflorum*), and Muellers bush-pea (*Pultenaea muelleri*). The ground layer, which may be quite dense if the shrubs are sparse, is characterised by mountain woodruff (*Asperula gunnii*), short-stem sedge

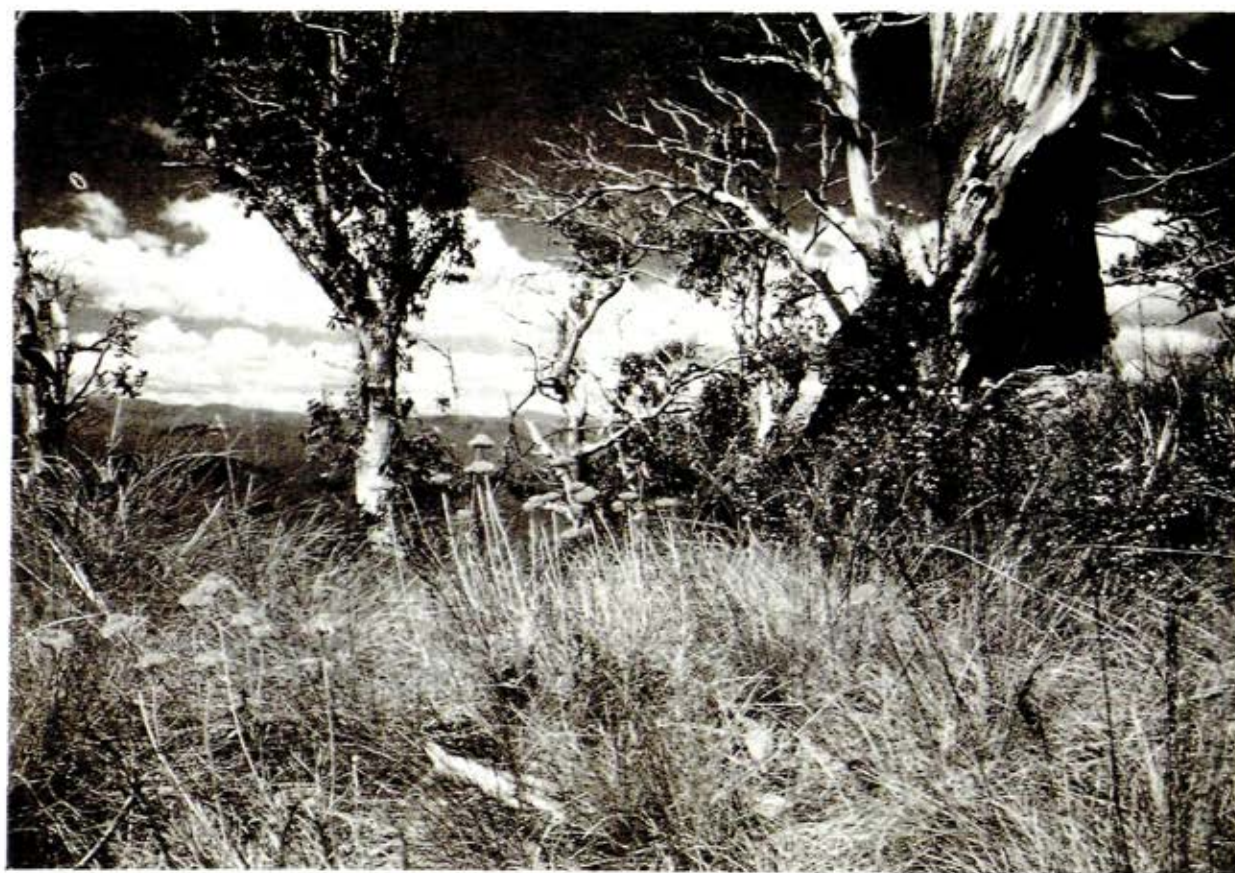
(*Carex breviculmis*), silver daisy (*Celmisia asteliifolia*), alpine wallaby-grass (*Danthonia nudiflora*), and Australian caraway (*Oreomyrrhis eriopoda*).

Fire may have been a factor in generating this community, which contains a curious mixture of herbs of higher altitudes in conjunction with shrubs normally from lower altitudes. The patchiness of the shrub layer reinforces this conclusion.

Damp sub-alpine heathlands

This intermediate band usually occurs between dry sub-alpine shrubland and wet sub-alpine heathland, or on raised areas within the latter.

The dense shrub layer includes alpine star-bush (*Asterolasia trymalioides*), alpine grevillea (*Grevillea australis*), scaly everlasting (*Helichrysum hookeri*), snow heath (*Epacris petrophila*), and alpine orites. The soils, which are deeper and wetter than those of dry sub-alpine shrubland, support a



Sub-alpine woodland

ground layer that includes spreading rope-rush (*Empodisma minus*), soft tussock-grass (*Poa hiemata*), mountain woodruff, and alpine podolepis (*Podolepis robusta*).

Wet sub-alpine heathland

The wettest sites in the depressions and gully heads of the Baw Baw Plateau, Lake Mountain, and Mt Bullfight support an open to very dense heathland characterised by the following shrubs: candle richia (*Richea continentis*), swamp heath (*Epacris paludosa*), alpine baeckea (*Baeckea gunniana*), drumstick heath (*Epacris breviflora*), and mountain daisy-bush (*Olearia algida*).

This vegetation community would include most sites commonly known as alpine or sphagnum bogs. The deep, peaty, sodden soils are usually covered by a layer of sphagnum moss (*Sphagnum* spp.). Other characteristic ground-layer species include spreading rope-rush, matted nertera (*Nertera granadensis*), alpine astelia (*Astelia alpina*), and mountain gentian (*Gentianella diamensis*). The underlying soils accumulate organic material due to slow rates of decomposition, which can be attributed to low temperatures and anaerobic conditions.

Large volumes of water are retained in the moss and peaty soil, seeping downslope until small trickles and streams form. Frequently, the increased erosional power of the stream at the outlet of the bog has produced a steeper-sided descending gully. These gullies often support montane riparian thicket (see below).

Sub-alpine woodland

This community forms a woodland or forest on slopes above 1200 m, and on relatively free-draining soils. Usually dominated by snow gum (*Eucalyptus pauciflora*), the understorey may variously consist of a rich suite of grasses and herbs, or a dense layer of woody shrubs such as Muellers bush-pea, alpine oxylobium (*Oxylobium alpestre*), alpine pepper (*Tasmannia xerophila*), and lilac berry (*Trochocarpa clarkei*).

An interesting variant of this community is found on Mt Useful, where the ash-mallee (*Eucalyptus kybeanensis*) occurs with alpine wattle (*Acacia alpina*), drooping beard-heath (*Leucopogon gelidus*), and a rare, as-yet-unnamed species of broom-heath (*Monotoca*

sp. aff. *elliptica*). Another unusual record is that of spinning gum (*Eucalyptus perriniana*), which occurs north of Mt Whitelaw.

Montane Vegetation

Montane vegetation occurs along the Great Dividing Range and its northward extensions, the Blue, Royston, Federation, and Terrible Ranges. South of the Divide, the Baw Baw and Toorongo Plateaux support substantial areas of this vegetation type. These communities generally occur between 900 and 1200 m.

The climate of these ranges is characterised by relatively low temperatures (monthly means between 5°C and 15°C), high rainfall (mean annual rainfall between 1000 and 1400 mm) and moderate to high exposure to winds. Insolation levels depend strongly on aspect. Snow falls regularly in winter, but does not persist as a layer throughout the winter. The tendency for the upper slopes to be shrouded in mist for lengthy periods may indicate that the effective precipitation is particularly high.

Montane vegetation occurs typically on the upper slopes and in gullies of deeply dissected valleys. Such terrain provides sites with a wide range of physical conditions. The deep gully-heads are among the most protected sites available, particularly with respect to fire frequency, fire intensity, and evaporation.

The montane areas coincide with diverse igneous geologies ranging from Devonian granite and granodiorite around Baw Baw and Toorongo to Devonian rhyolite and rhyodacite, which extends from the Upper Yarra to the Cerberean Range. Extensive areas of uplifted Devonian marine sediments (principally siltstone, claystone, and sandstone) also support montane vegetation - for example, on the watershed between the Big, Yarra, and Thomson Rivers. Soils include shallow stony soils on steep, exposed slopes, and friable brownish gradational soils on more protected ones. Four major vegetation communities are included.

Montane dry woodland

The drier, more exposed aspects of the mountain slopes support montane dry

woodland, a woodland or forest from 15 to 25 m in height.

Characteristic trees include broad-leaf peppermint (*Eucalyptus dives*), candlebark (*E. rubida*), and narrow-leaf peppermint (*E. radiata*). Snow gum (*E. pauciflora*) is often present at higher altitudes. Other notable eucalypts found in this community include brittle gum (*E. mannifera*), which is at the western limit of its distribution, and the uncommon bogong gum (*E. chapmaniana*) both of which are found in the Woods Point--Upper Goulburn area.

The characteristic shrubs here include common cassinia (*Cassinia aculeata*), moth daisy-bush (*Olearia erubescens*), and gorse bitter-pea (*Daviesia ulicifolia*), with prickly starwort (*Stellaria pungens*), spiny-headed mat-lily (*Lomandra longifolia*), pink-bells (*Tetratheca ciliata*), austral bracken (*Pteridium esculentum*), grey tussock-grass (*Poa sieberiana*), and Tasman flax-lily (*Dianella tasmanica*) frequently present in the ground layer.

This community is closely related to damp sclerophyll forest, with which it intergrades between 800 and 1000 m.

Montane damp forest

The more protected mountain slopes support a tall forest up to 40 m in height, dominated in its lower altitudinal range by mountain grey gum (*Eucalyptus cypellocarpa*), messmate (*E. obliqua*), narrow-leaf peppermint, and occasionally manna gum (*E. viminalis*). At higher altitudes, pure stands of alpine ash (*E. delegatensis*) often dominate the community.

Montane damp forest features an open to rather dense layer of tall shrubs, among which silver wattle (*Acacia dealbata*), blackwood (*A. melanoxylon*), mountain hickory wattle (*A. obliquinervia*), elderberry panax (*Polyscias sambucifolia*), blunt-leaf bitter-pea (*Daviesia mimosoides* var. *laxiflora*), and rough coprosma (*Coprosma hirtella*) are prominent.

Characteristically, grasses and herbs, in the ground layer include bidgee-widgee (*Acaena novae-zelandiae*), sword tussock-grass (*Poa ensiformis*), mountain cotula (*Leptinella filicula*), derwent speedwell (*Parahebe*

derwentiana), common lagenifera (*Lagenifera stipitata*), and ivy-leaf violet (*Viola hederacea*). Mother shield-fern (*Polystichum proliferum*) is common in moister sites.

Montane wet forest

The most protected sites, usually south-facing slopes and gullies, carry montane wet forest. Here soils are deep, fertile, and well-drained. The canopy may grow to more than 60 m, and consists of pure or mixed stands of alpine ash and shining gum.

Manna gum may be a codominant in the Blue and Royston Ranges, while significant occurrences of Tingaringy gum (*Eucalyptus glaucescens*) and Errinundra shining gum (*E. sp. aff. nitens* [Errinundra]) are recorded from montane wet forest on the Baw Baw Plateau.

On the north-eastern face of the Baw Baw massif, mountain ash (*E. regnans*) ascends to approximately 1200 m in association with species characteristic of both montane wet forest and wet sclerophyll forest (see below). This unusually high-elevation occurrence may be a response to the tempering effect of the massif on the prevailing south-westerly winds, or to soil temperature variation due to insolation.

The tall second storey of montane wet forest commonly includes myrtle beech (*Nothofagus cunninghamii*) and forest wattle (*Acacia frigescens*), which grow above a dense layer of soft tree-ferns (*Dicksonia antarctica*). At ground level, hard water-fern (*Blechnum wattsii*), bat's-wing fern (*Histiopteris incisa*), and mother shield-fern are characteristic.

Although this community is closely related to wet sclerophyll forest, the floristic distinction lies in the substitution of most of the characteristic shrubs and trees. Notably absent in montane wet forest are broad-leaved shrubs such as hazel pomaderris (*Pomaderris aspera*), blanket-leaf (*Bedfordia arborescens*), musk daisy-bush (*Olearia argophylla*), austral mulberry (*Hedycarya angustifolia*), and tree lomatia (*Lomatia fraseri*), and the rough tree-fern (*Cyathea australis*).

On the north-eastern face of the Baw Baw massif, mountain ash (*Eucalyptus regnans*)

ascends to approximately 1200 m in association with species characteristic of both montane wet forest and wet sclerophyll forest (see below). This unusually high-elevation occurrence may be a response to the tempering effect of the massif on the prevailing south-westerly winds, or to soil temperature variation due to insolation.

The presence of myrtle beech in the second storey reflects the strong association between montane wet forest and cool temperate rainforest. In protected sites, especially following a long fire-free period, understorey stands of myrtle beech may achieve a degree of canopy closure sufficient for them to be considered cool temperate rainforest, despite the presence of emergent eucalypts.

Montane riparian thicket

Dense thickets of mountain tea-tree (*Leptospermum grandifolium*) occur along drainage lines in montane and sub-alpine areas. Montane riparian thicket is associated with a number of other vegetation communities, often arising at the outlets of sub-alpine heathlands, and descending to intergrade with cool temperate rainforest or riparian thicket at lower altitudes.

The canopy of this community may vary in height up to approximately 15 m. Cool temperate rainforest dominants, myrtle beech and southern sassafras (*Atherosperma moschatum*), are frequently subdominant.

Soils are similar to the sodden, peaty soils of the wet sub-alpine heathland. A thick substrate of sphagnum is often present. The ground layer flora includes alpine water-fern (*Blechnum penna-marina*), tall sedge (*Carex appressa*), forest sedge (*C. alsophila*), pretty grass-flag (*Libertia pulchella*), and hard water-fern. The Baw Baw berry (*Wittsteinia vacciniacea*), although considered rare, is frequently encountered as a low shrub. It is endemic in the Victorian Central Highlands.

An unusual variant of this community occurs at Bellel Creek, south-east of Marysville, and at the Xylophone Bridge on the Murrindindi River. Here, mountain tea-tree is locally absent, but the ferns, herbs, and sedges of the understorey remain to produce curious open bogs. The sequence of events leading to the establishment of such vegetation is unclear, although such sites frequently occur

immediately upstream of the confluence of two streams.

Moist Forests

Moist forests occur throughout the study area, but are concentrated in the high-rainfall foothill or mountain country in the upper catchments of the Yarra, Goulburn, Thomson, and La Trobe Rivers, generally between 100 and 1000 m in elevation. Extremes of temperature are uncommon, and annual rainfall averages exceed 1000 mm. Deeply dissected valleys separated by broad ridges are the typical topographic feature.

These forests occur on friable brownish gradational soils derived from Devonian or Silurian sediments or acidic igneous rocks, with the exception of some riparian communities, which occur on sandy, silty, or gravelly alluvial soils. They include six vegetation communities.

Cool temperate rainforest

This type of rainforest occurs in protected gully heads, on surrounding slopes, and along streams throughout the wetter, mountainous parts of the study area. Moisture and the absence of fire are the key determinants of its distribution.

It is dominated by myrtle beech and southern sassafras, which typically form a more or less continuous dense canopy up to 40 m in height. Scattered emergent eucalypts may be present. Blackwood may form part of the closed rainforest canopy in some stands, but it is also widespread in other vegetation communities.

The understorey features an array of ferns, including soft tree-fern, hard water-fern, and mother shield-fern. The moist, sheltered conditions allow a number of epiphytic fern species to flourish, including kangaroo-fern (*Microsorium diversifolium*), filmy ferns (*Hymenophyllum* spp.), and long fork-fern (*Tmesipteris billardieri*). Mosses and liverworts are abundant.

Several rare species occur in some cool temperate rainforest stands in the upper Bunyip River catchment, notably tall astelia (*Astelia australiana*), oval fork-fern (*Tmesipteris ovata*), and bristly shield-fern (*Lastreopsis hispida*).

Wet sclerophyll forest

Mountain ash usually dominates wet sclerophyll forest, forming the tallest forests in the study area. The community occupies the protected slopes of the ranges, plateaus and outlying hills, which tend to have abundant rainfall and deep, rich, well-drained soils, and offer some degree of fire protection.

The canopy may grow to 80 m in height. Beneath it, a second storey of trees including silver wattle and blackwood may reach 35 m. The third storey comprises broad-leaved shrubs such as hazel pomaderris (*Pomaderris aspera*), blanket-leaf (*Bedfordia arborescens*), musk daisy-bush (*Olearia argophylla*), austral mulberry (*Hedycarya angustifolia*), tree lomatia (*Lomatia fraseri*), and banyalla (*Pittosporum bicolor*) grow to 20 m in height.

A dense layer of soft tree-fern and rough tree-fern (*Cyathea australis*) to 5 m is characteristic. The moist, shaded ground layer supports mother shield-fern, hard water-fern, shade nettle (*Australina pusilla*), and white elderberry (*Sambucus gaudichaudii*). In the wettest fern-gullies, shiny shield-fern (*Lastreopsis acuminata*), and mother spleenwort (*Asplenium bulbiferum*) are common.

Of particular note are the extensive areas in the Central Highlands where two extreme fires in succession (such as in 1926 and 1939) have led to the development of thickets, usually of silver wattle or blackwood, without a eucalypt overstorey. The interval between these fires was insufficient to allow eucalypt seed stores to be replenished.

While extremely severe and widespread fires, such as those on Black Friday 1939 and Ash Wednesday 1983, may completely raze vast areas of forest, other less-severe fires can produce a variety of localised effects that result in the development of mixed-age stands of mountain ash. Although not extensive, these stands are common.

Wet sclerophyll forest species may also occur in stands that are transitional between this community and cool temperate rainforest, having a consistent, dense understorey of myrtle beech. They tend to do so in forests at the upper limit of elevation for this community, usually 700–1000 m. The transition

to rainforest will continue only in the absence of fire or other major disturbance.

The following rare species are associated with wet sclerophyll forest in the study area: butterfly orchid (*Sarcochilus australis*) and gully grevillea (*Grevillea barklyana*) in the Bunyip River area, and shiny phebalium (*Phebalium wilsonii*) in the O'Shannassy Catchment.

Damp sclerophyll forest

This is a widespread vegetation community occupies a range of sites on a variety of soils and aspects. It occurs from 200 to 1000 m in elevation. It differs from wet sclerophyll forest in that it has a simpler structure without a distinct tree-fern layer, its characteristic shrubs usually have smaller, tougher leaves, and the ground layer is much drier, supporting more herbs and grasses. Messmate and mountain grey gum are the characteristic dominants in the overstorey, but mountain ash, manna gum, silvertop (*Eucalyptus sieberi*), and eurabbie (*E. globulus* ssp. *bicostata*) may be locally dominant.

The species comprising the shrub layer of damp sclerophyll forest vary across the study area, although the following are widespread: hazel pomaderris, prickly coprosma (*Coprosma quadrifida*), bootlace bush (*Pimelea axiflora*), prickly moses (*Acacia verticillata*), and snow daisy-bush (*Olearia lirata*).

The ground layer is similarly variable across the study area, but characteristic species include common ground-fern (*Culcita dubia*), ivy-leaf violet, rough tree-fern, mountain clematis (*Clematis aristata*), cinquefoil (*Geranium potentilloides*), and tall sword-sedge (*Lepidosperma elatius*).

Riparian thicket

Dense thickets of woolly tea-tree (*Leptospermum lanigerum*) and/or scented paperbark (*Melaleuca squarrosa*) occur on broad beds of smaller streams or on the regularly flooded terraces of larger streams and rivers. Soils are usually sandy or gravelly, but with high silt levels.

Woolly tea-tree occurs throughout the study area, while scented paperbark is confined to areas south of the Divide.



Cool temperate rainforest

The ground layer is usually dominated by tufts of fishbone water-fern (*Blechnum nudum*), in association with soft tree-fern, red-fruit saw-sedge (*Gahnia sieberiana*), sedges (*Carex* spp.) and spreading fan-fern (*Sticherus lobatus*). In the upper reaches of the La Trobe River, on Pioneer Creek, this community includes tall astelia (*Astelia australiana*), a vulnerable species in the lily family (Liliaceae).

Although riparian thicket is structurally very similar to montane riparian thicket, it tends to intergrade with cool temperate rainforest. Cool temperate rainforest occupies the better-drained, fire-protected sites which are associated with the steeper slopes and deeper gullies, while montane riparian thicket occurs in the high altitude peaty drainage lines. Riparian thicket is found on the lower elevation stream banks and terraces.

Riparian forest

Riparian forest is a tall forest of river banks and alluvial terraces. It tends to occur along quite swift-flowing streams. It is normally dominated by manna gum (*E. viminalis*), with silver wattle (*Acacia dealbata*), blackwood

(*A. melanoxylon*), hazel pomaderris (*Pomaderris aspera*), Victorian christmas-bush (*Prostanthera lasianthos*) and prickly coprosma (*Coprosma quadrifida*) in the shrub layer.

An abundance of moisture combined with fertile, well-drained soils explains the strong floristic links with wet sclerophyll forest. The richness of the understorey of riparian forest is noteworthy, with a wide variety of terrestrial species as well as a suite of semi-aquatic plants. Usually present are fishbone water-fern (*Blechnum nudum*), tall sedge, mother shield-fern, swamp club-sedge (*Isolepis inundata*), small-leaf bramble (*Rubus parvifolius*), and soft tree-fern.

Environmental weeds are a common component of riparian forest. The variety of factors responsible include the natural pattern of disturbance through flooding, the amenable environment, and the history of human activity along rivers.

Swampy riparian forest

Swamp gum (*Eucalyptus ovata*) usually dominates swampy riparian forest, although mealy stringybark (*E. cephalocarpa*) and

messmate may also be present, particularly in the La Trobe, Bunyip, and Tarago River catchments.

The second storey includes blackwood, woolly tea-tree, hazel pomaderris and, south of the Great Dividing Range, scented paperbark.

Common plants in the ground layer include soft tree-fern, red-fruit saw-sedge (*Gahnia sieberiana*), water-ferns (*Blechnum* spp.), tall sword-sedge, common reed (*Phragmites australis*), and brooklime (*Gratiola peruviana*). Showy willow-herb (*Epilobium pallidiflorum*), which is considered to be depleted, may be present if the area is not grazed.

Swampy riparian forest occurs on saturated river flats, sometimes adjacent to a swiftly flowing river. The sites are regularly flooded. Soils are silt-rich river sands and gravels, although sites with heavier clay soils may also support swampy riparian forest. The community has strong affinities with riparian thicket, riparian forest, and swamp heath.

The many variants of this community include the stand of Buxton gum (*E. crenulata*) on river flats beside the Acheron River south of Buxton, where the atypical understorey combines elements of wet heathland and floodplain wetland complex, as well as many of the usual swampy riparian forest species listed above.

Dry Forests

Dry forests occur on the foothills and slopes of the higher ranges throughout the study area, from 50 to 1000 m. Annual rainfall varies across the area where they grow, but generally averages 5000--1000 mm.

In predominantly wet areas, dry forests occur exclusively on exposed aspects, usually north-east to north-west. They may occupy all aspects in drier areas, but typically occur on slopes in the dissected catchments of the Yarra, La Trobe, and Goulburn Rivers.

The varied underlying geologies include Devonian and Silurian marine sediments, Devonian granites and granodiorites, and Devonian volcanics (rhyolite and rhyodacite).

These forests are found on shallow stony soils, acidic duplex soils, yellow gradational soils, and leached sands.

They include seven major vegetation communities.

Herb-rich foothill forest

Forest of this type grow mainly in the northern part of the study area. The canopy is usually 20 to 35 m tall, and commonly includes narrow-leaf peppermint, eurabbie, manna gum, and candlebark. Messmate may occur, especially where the community intergrades with shrubby foothill forest in the Black Range and Mt Disappointment areas.

The sparse low shrub layer consists normally of two species: common cassinia and silver wattle.

By contrast, the forest has a dense and species-rich ground layer. This frequently contains the following species: kidney-weed (*Dichondra repens*), weeping grass (*Microlaena stipoides*), common lagenifera, bidgee-widgee, cinquefoil, ivy-leaf violet, grey tussock-grass, soft tussock-grass (*Poa morrisii*), austral bear's-ears (*Cymbonotus preissianus*), and prickly woodruff (*Asperula scoparia*). Austral bracken is usually present, and may tend to dominate the ground layer following frequent disturbance, particularly by fire.

Shrubby foothill forest

Similar in structure to herb-rich foothill forest, shrubby foothill forest has a more dense and varied shrub layer, but tends to lack a diverse ground layer. It is widespread on higher slopes, particularly between 400 and 900 m elevation, both north and south of the Great Dividing Range.

The dominant trees are messmate and narrow-leaf peppermint, although silvertop, mountain grey gum, and scent-bark (*E. aromaphloia*) may occur in the Walhalla area.

A wide variety of shrubs characterise this community across its range. Common among these are narrow-leaf wattle (*Acacia mucronata*), dusty miller (*Spyridium parvifolium*), handsome flat-pea (*Platylobium*

formosum), prickly bush-pea (*Pultenaea juniperina*), rough bush-pea (*P. scabra*), varnish wattle (*Acacia verniciflua*), common cassinia (*Cassinia aculeata*), shiny cassinia, hop goodenia (*Goodenia ovata*), and pink-bells.

The ground layer includes ivy-leaf violet, common raspwort (*Gonocarpus tetragynus*), and grey tussock-grass. Forest wire-grass (*Tetrarrhena juncea*) and austral bracken are commonly present, and sometimes dominant.

Heathy foothill forest

Although closely related to the two previous communities, heathy foothill forest tends to occur at lower elevations, on yellowish gradational soils and leached sands of low fertility. Examples are found mainly on the lower slopes in the La Trobe, Bunyip, and Tarago River catchments. It differs from the two previous communities by having an understorey with close affinities with heathy woodlands and heathlands.

The canopy includes silvertop, yertchuk (*Eucalyptus considiniana*), and messmate.

Occasionally, white stringybark (*E. globoidea*) and brown stringybark (*E. baxteri*) are present.

Its shrub layer has quite variable density and species composition but normally includes prickly tea-tree (*Leptospermum continentale*), golden bush-pea (*Pultenaea gunnii*), wiry bauera (*Bauera rubioides*), bushy hakea (*Hakea sericea*), common heath (*Epacris impressa*), and broom spurge (*Amperea xiphoclada*). Patches of hairpin banksia (*Banksia spinulosa*) are common.

The ground layer features forest wire-grass, austral bracken, thatch saw-sedge (*Gahnia radula*), blue dampiera (*Dampiera stricta*), small grass-tree (*Xanthorrhoea minor*), and trailing goodenia (*Goodenia lanata*).

Heathy foothill forest frequently occurs in conjunction with heathy woodland, wet heathland, and swamp heathland (see below).

Valley forest

This community is restricted to the lower slopes and valleys of the foothill country to



Herb-rich foothill forest

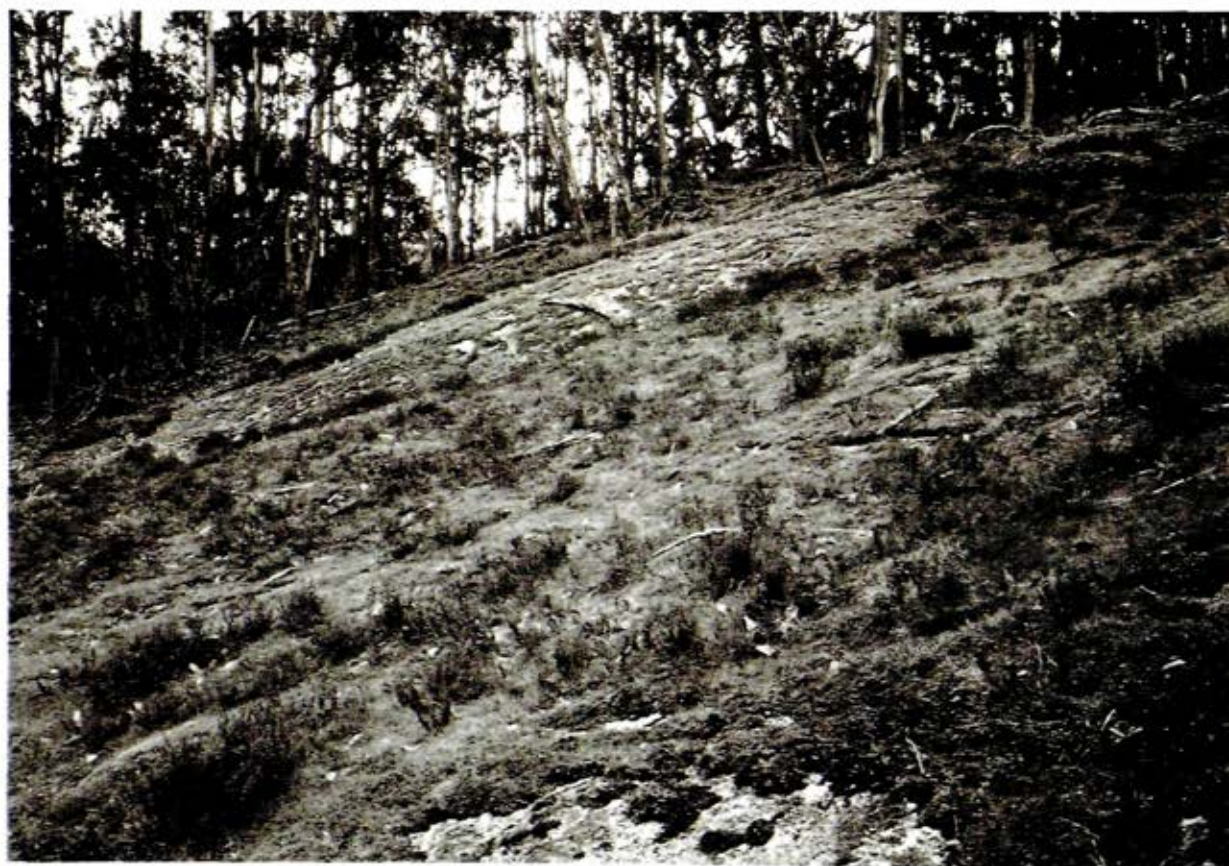
the north-east of Melbourne, usually on acidic duplex soils and on southerly aspects.

Its overstorey is dominated by a mixture of red box (*Eucalyptus polyanthemos*), red stringybark (*E. macrorhyncha*), long-leaf box (*E. goniacalyx*), and yellow box (*E. melliodora*). In low-lying sites, often adjacent to seasonally inundated areas, swamp gum may be present.

The shrub layer tends to be rather sparse, often comprising a scattering of burghan (*Kunzea ericoides*), cherry ballart (*Exocarpos cupressiformis*), black wattle (*Acacia*

mearnsii), sweet bursaria (*Bursaria spinosa*), and common cassinia. Sweet pittosporum (*Pittosporum undulatum*), although possibly indigenous to the study area, is an invasive environmental weed in this community. Also commonly present as a weed is monterey pine (*Pinus radiata*).

A rich array of native grasses and herbs occur in the low ground layer. Weeping grass, kangaroo grass (*Themeda triandra*), grey tussock-grass, and silvertop wallaby-grass (*Chionochloa pallida*) are common, in association with kidney-weed, common maidenhair (*Adiantum aethiopicum*), and ivy-leaf violet.



Granite outcrops in rocky outcrop shrubland

Heathy dry forest

Three localities within the study area - the Kinglake area, upper Goulburn Valley, and upper Thomson Valley - carry heathy dry forest. In most places, it tends to occur on shallow stony soils of low fertility, with poor water-retention capabilities. However, some

sites around Kinglake appear to lie on the margins of acidic duplex soils, which may explain some floristic differences there.

Generally, heathy dry forest is dominated by a low canopy of broad-leaf peppermint. It may also include messmate, long-leaf box, and mealy stringybark near Kinglake or, in

the upper Thomson Valley, stunted mountain grey gum, silvertop, and yertchuk. In the upper Goulburn Valley, broad-leaf peppermint often occurs at higher elevations with candlebark, indicating the close links between this community and montane dry woodland. In fact, these two communities may intergrade for considerable distances on northerly slopes.

The understorey of heathy dry forest features a number of species of the Australian heath family, the Epacridaceae, including prickly broom-heath (*Monotoca scoparia*), common heath, daphne heath (*Brachyloma daphnoides*), and common beard-heath (*Leucopogon virgatus*).

In the Kinglake area, other understorey species include rosy baeckea (*Baeckea ramosissima*), wire rapier-sedge (*Lepidosperma semiteres*), austral grass-tree (*Xanthorrhoea australis*), the rare creeping grevillea (*Grevillea repens*), cat's claws grevillea (*G. alpina*), silver banksia (*Banksia marginata*), and bushy hakea.

In the upper Goulburn and Thomson Valleys, common species, in addition to the heaths mentioned above, include narrow-leaf bitter-pea (*Daviesia leptophylla*), gorse bitter-pea, and narrow-leaf wattle. (These legumes are prolific post-fire colonisers, producing large quantities of hard-coated seeds that remain in the soil. If fires occur too frequently in heathy dry forest, they may become dominant at the expense of the heaths.) Cluster-flower geebung (*Persoonia confertiflora*), dwarf geebung (*P. chamaepeuce*), heath milkwort (*Comesperma ericinum*), and common hovea (*Hovea linearis*) are also common here.

Throughout the range of heathy dry forest, silvertop wallaby-grass is a common, often dominant, member of the ground layer. Its dominance at some sites may reflect that the site has remained unburnt for a long period. Clearly, fire regimes are of great importance to the understorey species composition.

A number of vegetation communities are closely allied to heathy dry forest. Stands of vegetation intermediate between this and dry sclerophyll forest are common. The Coranderrk Aqueduct south of Healesville winds through vegetation intermediate between this and heathy woodland (see below).

Dry sclerophyll forest

This community occurs on relatively exposed aspects, often on moderately fertile acidic duplex soils. It is best developed in the hills to the north-east of Melbourne and in the foothills of the Goulburn Valley between Jamieson and Seymour.

Dry sclerophyll forest is dominated by the same suite of eucalypts as valley forest, with which it is often associated. These are red box, red stringybark, long-leaf box, and yellow box.

It has an open, grassy understorey rich in species. Commonly present are grey tussock-grass, silvertop wallaby-grass, Velvet wallaby-grass (*Danthonia pilosa*), plume-grasses (*Dichelachne* spp.), grey guinea-flower (*Hibbertia obtusifolia*), purple coral-pea (*Hardenbergia violacea*), stinking pennywort (*Hydrocotyle laxiflora*), blue pin-cushion (*Brunonia australis*), green rock-fern (*Cheilanthes austrotenuifolia*), cotton fireweed (*Senecio quadridentatus*), and common raspwort.

Some stands of dry sclerophyll forest have an unusual feature: dense thickets of burgan. These may form following a particular sequence of fire events and, once established, prevent the previously dominant eucalypts from regenerating. They are frequently associated with a rich orchid flora. Good examples occur in the Cathedral Range State Park. Burgan thickets may also occur with a suite of understorey species common to valley forest, especially in riparian or rocky gorge situations.

Dry sclerophyll forest is prone to invasion by a wide range of environmental weeds, particularly herbs and grasses. Fire frequency is likely to be quite high at sites supporting this community. If unburnt for long periods (more than 25 years), tussock grasses will tend to predominate.

Rocky outcrop shrubland

Rocky outcrops are frequently of botanical interest because they contain a range of microhabitats, from highly exposed rock-faces to damp, sheltered crevices.

Rather than being a consistent vegetation community, rocky outcrop shrubland

commonly includes a number of rock-adapted species, with a suite of those distinctly different from the surrounding vegetation that can tolerate the outcrop environment. For this reason, it is pertinent to discuss the vegetation of a number of prominent rocky outcrops in the study area separately. This is not a complete list, nor does it suggest any significance ranking.

Seven Acre Rock (in the headwaters of the Bunyip River) supports scattered mountain grey gum and silvertop, with lemon bottlebrush (*Callistemon pallidus*) and long-leaf wax-flower (*Eriostemon myoporoides*).

Ben Cairn, west of Mt Donna Buang, supports similar vegetation except that the dominant eucalypt is brown stringybark. Of note in this area is the stand of dwarf silver wattle (*Acacia nano-dealbata*) and the presence of alpine westringia (*Westringia senifolia*).

The Cathedral Range consists of a steeply uplifted sedimentary rock, which supports vegetation with affinities to the surrounding dry sclerophyll forest. Stunted examples of red stringybark, broad-leaf peppermint, and, rarely, snow gum occur along the crest. Common shrubs include round-leaf mint-bush (*Prostanthera rotundifolia*), fairy wax-flower (*Eriostemon verrucosus*), and lemon bottlebrush. The ground layer includes a wide range of grasses and herbs characteristic of dry forests.

Murchison/Strath Creek Falls (in the north of the Mt Disappointment State forest) has a broad, exposed rocky hillside to the east that supports a sparse shrubland of black wattle, clustered everlasting (*Helichrysum semipapposum*), kangaroo grass, and a variety of herbs of dry sites.

Outcrops of granite occur frequently along the slopes above the Goulburn River in the Yea-Seymour area. On protected sites, these carry a dense, low moss-bed or herbfield, which may be very species-rich.

Plains Vegetation

Plains vegetation occurs on the basalt plains immediately to the north of Melbourne, and on the alluvial plains of the Yarra, Goulburn, and Plenty Rivers. Most of these have a mean annual rainfall of 700 to 1000 mm,

occurring predominantly in winter, with hot, dry summers being typical.

Soils vary substantially, ranging from grey clays, black clays, and shallow gradational soils derived from basalt to reddish calcareous duplex soils on alluvium.

Five communities and one community complex are included.

Box woodland

Within the study area, open, grassy woodland dominated by grey box (*E. microcarpa*) is restricted to the lower slopes and upper terraces of the Goulburn River. Around Alexandra, the best examples can be seen along road reserves. The relatively fertile soils there have led to a dramatic reduction in the extent of box woodland through clearing for agriculture. It is, however, widespread in northern and western Victoria.

A variant of this community that includes white box (*E. albens*), red box, and yellow box occurs sporadically along the Goulburn Valley from near Merton to Trawool. This variant has affinities with dry sclerophyll forest, and is reminiscent of dry forests of north-eastern Victoria.

The understorey of box woodland is dominated by wallaby-grasses (*Danthonia* spp.) and spear-grasses (*Stipa* spp.), with a scattering of hedge wattle (*Acacia paradoxa*).

Due to the fertility of the soils, a history of grazing, and proximity to agricultural land, stands of box woodland usually contain a suite of introduced grasses, herbs, and woody shrubs.

Plains grassy woodland

The most common components of this community are the grassy woodlands dominated by river red gum (*E. camaldulensis*), occurring on seasonally waterlogged clays and clay loams.

These soils may be alluvial, or derived from either sedimentary rock or basalt. Plains grassy woodland may occur on lower slopes or swampy river flats, from Cardinia Creek in the south-east to the Goulburn Valley in the north and the basalt plains around Wallan in the west.

A curious variant occurs in the Yan Yean catchment, where candlebark and a lowland ecotype of snow gum dominate a characteristic understorey.

Plains grassland

Dominated by kangaroo grass, plains grassland is a tussock grassland with a scattered and much depleted distribution, mostly on fertile, basalt-derived soils. It once occurred from Melbourne in the east to the Hamilton district in far south-western Victoria, but has largely been cleared or grossly modified for agriculture.

In addition to kangaroo grass, characteristic species include pink bindweed (*Convolvulus erubescens*), common bog-sedge (*Schoenus apogon*), lemon beauty-heads (*Calocephalus citreus*), sheep's burr (*Acaena echinata*), and common wallaby-grass (*Danthonia caespitosa*). The presence of a wide variety of environmental weeds, mainly grasses and herbs, is a feature of the remnants of this community.

It is important to note that kangaroo grass is widespread, being a characteristic species of several other vegetation communities. It should therefore not be assumed that all patches of kangaroo grass constitute plains grassland.

Plains grassland is restricted in the study area to isolated occurrences, mainly on private land around Somerton, on the outskirts of metropolitan Melbourne. It occurs on public land at Epping Cemetery.

Floodplain riparian woodland

The community comprises the woodland vegetation that typically occurs along the banks of the larger rivers of the study area, including the Goulburn, Yea, Acheron, and Yarra Rivers. It frequently occurs in conjunction with one or more floodplain wetland communities.

River red gum forms a tall, woodland canopy over a medium to tall shrub layer including silver wattle, tree violet (*Hymenanthera dentata*), river bottlebrush (*Callistemon sieberi*), and river tea-tree (*Leptospermum obovatum*). The ground layer features common tussock-grass (*Poa labillardieri*) on the drier, elevated banks, with club-sedges

(*Isolepis* spp.), rushes (*Juncus* spp.), common reed, and water-ribbons (*Triglochin procera*) occupying the saturated or inundated soils at the water's edge.

Environmental weeds form a major component of this community in virtually all stands. Willows (*Salix* spp.) and a wide variety of pasture grasses are ubiquitous.

Grassy wetland

Small, seasonally flooded depressions on fertile, basalt-derived soils carry grassy wetland often as scattered patches among plains grassland. The dominant species include veined swamp wallaby-grass (*Amphibromus nervosus*), brown-back wallaby-grass (*Danthonia duttoniana*), common spike-sedge (*Eleocharis acuta*), small spike-sedge (*E. pusilla*), common tussock-grass, and Australian sweet-grass (*Glyceria australis*).

In the study area, this community is restricted to private land and rail reserves in the Wallan district, and in the headwaters of the Merri and Darebin Creek catchments.

Floodplain wetland complex

The following description of this complex should be considered as provisional. The completion of a current State-wide survey and classification of wetland vegetation will increase our understanding of this community.

Deep, permanent billabongs occur along the floodplains of the Yarra and Goulburn Rivers. Typically, they have a dense fringe of vegetation, but, due to the greater depth of water in the centre, tend to include open water. This open water may support a carpet of duckweed (*Lemna* spp.) and/or azolla (*Azolla* spp.). The fringing vegetation includes tall spike-sedge (*Eleocharis sphacelata*), milfoils (*Myriophyllum* spp.), water-ribbons, cumbungi (*Typha orientalis*), common reed, and rushes.

Shallow, seasonal billabongs that dry out in summer commonly support a herbfield including common spike-sedge, slender knotweed (*Persicaria decipiens*), lesser joyweed (*Alternanthera denticulata*), common blown-grass (*Agrostis avenacea*), and sneezeweeds (*Centipeda* spp.). They may dry out due to

the poorer water-holding capabilities of the clay substrate, or the lack of recharge. Within the study area, such billabongs occur along the Yarra and Goulburn Rivers.

Floodplain wet flats occur on river flats where the river-side levee-banks retain seepage or overflow. Characteristic vegetation includes common reed, marsh club-sedge (*Bolboschoenus medianus*), tassel sedge (*Carex fascicularis*), tall sedge, large bindweed (*Calystegia sepium*), and common tussock-grass.

Heathland Vegetation

Five vegetation communities comprise this category: heathy woodland, wet heathland, swamp heathland, sand heathland and coastal heathland. These all occupy flat or gently undulating areas, on soils of low natural fertility. Trees are usually stunted, often absent, while a dense layer of wiry shrubs is typical.

Heathy woodland

Gentle, north-facing, lower slopes around Gembrook, Tonimbuk, and Moondarra carry heathy woodland. Soils are commonly sandy at the surface, with a clay or coffee-rock impeding layer at some depth. They may be seasonally wet, but dry out in the summer.

A low woodland of narrow-leaf peppermint, mealy stringybark, messmate, and/or yertchuk overtops a shrub layer including hairpin banksia, bushy hakea, furze hakea (*Hakea ulicina*), dagger hakea (*H. teretifolia*), prickly tea-tree, and common heath.

The ground layer includes a number of grass species: wiry spear-grass (*Stipa muelleri*), kangaroo grass, and reed bent-grass (*Deyeuxia quadriseta*). Other ground layer species include thatch saw-sedge, common raspwort, and wattle mat-lily (*Lomandra filiformis*). Small grass-tree is also commonly present.

Wiry spear-grass dominates in some stands, presumably due to a combination of factors relating to fertility and fire frequency. Similarly, the absence of members of the proteaceae (hakeas and banksias) in some stands contrasts with their virtual dominance in others. These species, which rely on seed

germination for post-fire regeneration, may be suppressed by frequent, low-intensity fires, which favour species that resprout from rhizomes (such as wiry spear-grass and thatch saw-sedge).

Wet heathland

This normally occurs in depressions or on lower slopes where soils are saturated for considerable periods of the year, possibly due to the impeding layer in the soil being much closer to the soil surface than is the case for heathy woodland. Species characteristic of wet heathland are therefore those that can tolerate saturated soils.

Mealy stringybark forms a stunted, scattered canopy in some stands, but is absent from others. Scented paperbark, yellow hakea (*Hakea nodosa*), prickly tea-tree, and pink swamp-heath (*Sprengelia incarnata*) form a dense shrub layer. In the ground layer, spreading rope-rush, hair-sedge (*Tetraria capillaris*), square twig-sedge (*Baumea tetragona*), pouched coral-fern (*Gleichenia dicarpa*), and swamp selaginella (*Selaginella uliginosa*) are prominent.

Wet heathland occurs around Bunyip, Hill End, Mt Tanjil, and Moondarra.

Swamp heathland

This tall heathland or scrub dominated by scented paperbark grows on drainage lines of deep, saturated siliceous sands, and is frequently associated with the outlets of wet heathlands.

Other characteristic species include rosemary everlasting (*Helichrysum rosmarinifolium*), red-fruit saw-sedge, soft water-fern (*Blechnum minus*), coral-ferns (*Gleichenia* spp.), centella (*Centella cordifolia*), tassel cord-rush (*Restio tetraphyllus*), and running marsh-flower (*Villarsia reniformis*).

Swamp heathland has significant floristic and structural affinities with low-elevation occurrences of riparian thicket.

Environmental differences segregate its scented-paperbark-dominated stands from swamp-paperbark-dominated swamp scrub. These centre on soils, with the former tending towards sands or sandy clays while the latter occurs on heavy clays.

Swamp heathland grows around Tonimbuk, Woori Yallock, and Moondarra.

Sand heathland

Deep, siliceous sands of low fertility, usually close to the coast, carry sand heathland, which typically has no tree layer. The dense shrub layer commonly includes prickly tea-tree, heath tea-tree (*Leptospermum myrsinoides*), prickly broom-heath (*Monotoca scoparia*), silver banksia, common aotus (*Aotus ericoides*), and common heath.

The ground layer features sand-hill sword-sedge (*Lepidosperma concavum*), thatch saw-sedge, austral grass-tree, and small grass-tree.

Where present, the tree layer comprises scattered coast manna gum (*Eucalyptus pryoriana*), and narrow-leaf peppermint. Sand heathland commonly occurs in conjunction with coastal grassy forest and coastal heathland.

Its largest occurrences are on French Island and the Mornington Peninsula.

Coastal heathland

This community occupies sites on deep sandy soils that remain wet for longer periods than those supporting sand heathland. Reflecting that, the dominant shrubs include scented paperbark, dwarf she-oak (*Allocasuarina pusilla*), scrub she-oak (*A. paludosa*), silver banksia, and prickly tea-tree.

The sedge-dominated understorey includes a number of species of bog-sedge (*Schoenus* spp.), sword-sedges (*Lepidosperma* spp.), thatch saw-sedge, small grass-tree, germander raspwort (*Gonocarpus teucrioides*), bordered panic (*Entolasia marginata*), and common flat-pea (*Platylobium obtusangulum*).

Within the study area, coastal heathland is largely restricted to French and Quail Islands, with isolated examples on the Mornington Peninsula and near Wonthaggi. Most constituent species regenerate readily after fire. However, Meredith (1988) suggests that an average fire interval of 15 to 20 years is most desirable from an ecological perspective, with 8 years as a minimum recommended fire-free period.

Coastal Vegetation

Coastal vegetation occurs around the two major bays, Port Phillip and Western Port, and along the exposed coastline of the Nepean and Mornington Peninsulas, Phillip Island, and the Kilcunda–Cape Paterson area.

A typically moderated maritime climate prevails, with rainfall spread evenly throughout the year and a very low incidence of frost or extremes of temperature. A major climatic factor affecting the vegetation is the action of strong, salt-laden winds, which occur throughout the year.

A wide variety of landforms support coastal vegetation within the study area, including rocky cliffs, sand dunes, sedimentary plains, and sunklands.

Soils range from calcareous sands of the dunes, through leached sands derived from older-marine and riverine deposits of the coastal plains, to acidic duplex soils. Black and grey clays also occur in swampy areas, such as the former Koo-Wee-Rup Swamp.

Seven communities are included.

Coastal grassy forest

A low forest to woodland occurs on flat or undulating areas, particularly on the Mornington Peninsula. Its constituent species suggest affinities with heathy woodland and dry sclerophyll forest, especially in the open, grassy understorey. The dominant trees are narrow-leaf peppermint and coastal manna gum, although swamp gum, messmate, and mealy stringybark occur frequently.

The shrub layer varies from quite dense to almost absent. Where present, it commonly contains black she-oak (*Allocasuarina littoralis*), prickly tea-tree, black wattle, hedge wattle, and cherry ballart.

The diverse ground layer includes semi-shrubs such as common heath, honey-pots (*Acrotriche serrulata*), and cranberry heath (*Astroloma humifusum*), as well as a range of grasses such as kangaroo grass, weeping grass, reed bent-grass, and tussock-grasses. Also represented in the ground layer is a suite of annually resprouting geophytes including greenhoods (*Pterostylis* spp.),

twining fringe-lily (*Thysanotus patersonii*), blue squill (*Chamaescilla corymbosa*), and chocolate-lily (*Dichopogon strictus*).

An apparent frequency of fire here has led in places to a predominance of austral bracken and thatch saw-sedge.

Coastal grassy forest appears to be prone to invasion by introduced species, particularly by shrubs and trees, such as sweet pittosporum, coast tea-tree, coast wattle, boneseed (*Chrysanthemoides monilifera*), mirror-bush (*Coprosma repens*), and myrtle-leaf milkwort (*Polygala myrtifolia*). Introduced climbers including common ivy (*Hedera helix*) and smilax asparagus (*Myrsiphyllum asparagoides*) are also commonly present.

Coastal dune scrub

This broad vegetation community includes a variety of floristic communities. It ranges from the low, sparse vegetation colonising the primary dune, continues across the crest into the dense scrub in the lee of the dune, and also includes the scrub occupying the limestone cliffs of the rocky shores. More detailed studies may result in the classification of some or all of these components as distinct communities.



Coastal dune scrub

Foredunes, immediately inland from the high-tide level, carry the first band of vegetation. It consists of the sand-stabilisers hairy spinifex (*Spinifex sericeus*) and the introduced marram grass (*Ammophila arenaria*), often with beach rocket (*Cakile maritima*), sea celery (*Apium prostratum*), and a groundsel (*Senecio spathulatus*).

Dune tops and low coastal bluffs, particularly along the southern coast of the Nepean and Mornington Peninsulas, support a wind-pruned scrub of a variety of woody shrubs such as coast everlasting (*Helichrysum paraliu*), coast daisy-bush (*Olearia axillaris*), coast wattle (*Acacia sophorae*), white correa (*Correa alba*), sea box (*Alyxia buxifolia*), common boobialla (*Myoporum insulare*), coast tea-tree, cushion-bush (*Calocephalus brownii*), and coast beard-heath (*Leucopogon parviflorus*). The ground layer, commonly includes black-anther flax-lily (*Dianella revoluta* var. *brevicaulis*), blue tussock-grass (*Poa poiformis*), knobby club-sedge (*Isolepis nodosa*), coast sword-sedge (*Lepidosperma gladiatum*), and prickly spear-grass (*Stipa stipoides*).

Swales and secondary dunes carry a taller scrub dominated by coast tea-tree and coast beard-heath, on the inland side of the primary dune. The understorey of this scrub may be quite sparse, but commonly features bower spinach (*Tetragonia implexicoma*), seaberry saltbush (*Rhagodia candolleana*), and small-leaved clematis (*Clematis microphylla*). This vegetation is prone to invasion by species such as myrtle-leaf milkwort, smilax asparagus, and ivy groundsel (*Delairea odorata*).

Coast tea-tree (*Leptospermum laevigatum*) and coast wattle rapidly colonise disturbed areas, particularly on the inland side of their usual distribution. Stands of coastal banksia woodland (see below) have been significantly invaded and reduced in area by these species in association with a suite of introduced plants. Some studies have identified and described this association as a distinct vegetation community.

Moonah scrub forms another floristic unit within coastal dune scrub. The characteristic moonah (*Melaleuca lanceolata*) forms a tall scrub to 10 m. This floristic community currently has a disjunct distribution, which correlates with neutral or alkaline soils,

whether derived from basalt or limestone. Invasion by coast tea-tree and coast beard-heath has reduced its extent. There are scattered occurrences on Phillip Island and the Mornington Peninsula.

Coastal banksia woodland

Although it has a scattered distribution in coastal areas throughout eastern Victoria, coastal banksia woodland has been substantially depleted in the study area by housing and resort development. The coastline of Port Phillip Bay once supported extensive stands, but today it occupies relatively protected sites on old dunes where some organic matter has accumulated in the upper layers of the soil.

Floristically, coastal banksia woodland is related to the scrub of the swales and secondary dunes, where coast tea-tree dominates with the addition of a tall woodland overstorey of coast banksia (*Banksia integrifolia*) and coast manna gum. Once again, the shrub and ground layer include many introduced species such as boneseed, myrtle-leaf milkwort, veldt grasses (*Ehrharta* spp.), hare's tails (*Lagurus ovatus*), soursob (*Oxalis pes-caprae*), and smilax asparagus. Frequent disturbance may also lead to austral bracken becoming very dense in the ground layer.

As previously stated, coastal banksia woodland is being displaced in many areas by coastal dune scrub. This may be related to the increased incidence of fire and other disturbance since human settlement, although this trend has been shown to occur also in areas with a long-term absence of these disturbances (McMahon *et al.* 1987).

Coastal tussock grassland

An open tussock grassland occurs on the exposed cliff tops on the southern coast of Phillip Island. Blue-tussock grass dominates the ground layer, with cushion-bush as the only characteristic woody shrub. Other characteristic species include bidgee-widgee, knobby club-sedge, and black-anther flax-lily.

This community is at the margins of its distribution in the study area, being more extensively represented elsewhere, particularly on the islands of Bass Strait.

Coastal salt-marsh

Like coastal dune scrub, coastal salt-marsh is a broad vegetation community that contains distinct floristic communities as bands or zones in the same location, although not all of the five are necessarily present. It occurs on and immediately above marine and estuarine tidal flats. The main factor affecting the vegetation, and to some extent determining the positioning of the various floristic communities, is the saline environment.

White mangrove (*Avicennia marina*), which forms a distinctive scrub, dominates the most seaward band, where present. Notable occurrences in the study area include Quail Island and the Tooradin area, both in northern Western Port Bay. A variety of marine and estuarine algae may be associated with it.

In the littoral salt-marsh, beaded glasswort (*Sarcocornia quinqueflora*) forms a herbfield on the landward side of mangrove. This succulent herb may occur in pure stands, or in association with austral seablite (*Suaeda australis*) and creeping brookweed (*Samolus repens*). It appears to be well-adapted to the saline conditions, shifting substrate, and the volume of seagrass and seaweed detritus that accumulates at the high-tide level.

Shrubby glasswort (*Sclerostegia arbuscula*) dominates a low shrubland on the landward side of the littoral salt-marsh zone. It too may occur in pure stands or with some or all of the following species: Australian salt-grass (*Distichlis distichophylla*), prickly spear-grass, trailing hemichroa (*Hemichroa pentandra*), austral seablite, beaded glasswort, and creeping brookweed.

Mixed salt-marsh occupies the most landward and elevated zone. It comprises a varied association of species including streaked arrow-grass (*Triglochin striata*), Australian salt-grass, sea rush (*Juncus kraussii*), prickly spear-grass, southern sea-heath (*Frankenia pauciflora*), salt angianthus (*Angianthus preissianus*), rounded noon-flower (*Disphyma crassifolium*), and shiny swamp-mat (*Selliera radicans*). The widespread salt-marsh species of beaded glasswort, shrubby glasswort, austral seablite, and creeping brookweed also frequently occur in this floristic community. The greater floristic

diversity of this zone reflects the better-draining, structured soils, and the greater depth of soil above the saline groundwater level.

Swamp sedgeland

Wet depressions support swamp sedgeland, often in association with coastal grassy forest and coastal heathland. It has been recorded on French Island, around Cranbourne, and in the Point Nepean National Park on the Mornington Peninsula. It is dominated by pithy sword-sedge (*Lepidosperma longitudinale*) and zig-zag bog-sedge (*Schoenus brevifolius*). Common coastal heathland species such as purple-flags (*Patersonia* spp.), swamp selaginella, creeping raspwort (*Gonocarpus micranthus*), and slender dodder-laurel (*Cassytha glabella*) occur frequently. A suite of semi-aquatic species may also occur if sufficient water remains throughout the year.

Swamp scrub

Swamp paperbark (*Melaleuca ericifolia*) forms a tall scrub to 8 m on swampy sites in coastal areas, particularly around the shores of Western Port, where it often grows on the landward side of coastal salt-marsh.

This species frequently takes in a subordinate role in a number of other coastal communities. However, on waterlogged peaty clays, its ability to establish and reproduce by suckers from underground rhizomes can produce such dense scrubs that almost all other species are excluded. Where other species do occur, they are usually those characteristic of the surrounding vegetation, commonly coastal salt-marsh, coastal heathland, or coastal banksia woodland.

As previously mentioned, the ecological factors that segregate swamp scrub from swamp heathland appear to relate to clay content in the soil. In addition, swamp paperbark may be more tolerant of slightly saline conditions.

Factors Affecting Flora Conservation

Public land contains the bulk of native vegetation and plays the major role in the conservation of floral values. Under the

State Conservation Strategy and the *Flora and Fauna Guarantee Act* (1988), the aims for flora and fauna conservation and management include the survival and continued evolutionary development of all Victoria's species (other than pest species), the conservation of their communities, the management of threatening processes, and the maintenance of genetic diversity of flora and fauna.

The following discussion deals with the major activities and processes that may directly or indirectly pose some threat to plant species and vegetation communities. It is not intended to be an exhaustive list. Other flora conservation issues, such as those concerning old-growth forest and rainforest, are described in Chapter 20.

Environmental weeds

Weeds are defined as non-indigenous plant species that have become naturalised in areas of native vegetation, and include Australian native plants not indigenous to a given area. Such weeds are sometimes referred to as environmental or bushland weeds. They include many declared noxious weeds.



Heavy blackberry infestation can replace native species

For the purposes of this discussion, two broad categories of environmental weeds can be recognised:

- (a) background weeds, which occur over extensive areas but which are rarely dominant; the presence of these species does not normally threaten indigenous species, and
- (b) swampers, which tend to occur in dense, often localised swards, out-competing and replacing indigenous species.

Weed species in either category can be controlled or eradicated in a given area with sufficient resources. However, the second category are usually given the highest priority where weed management resources are limited.

Given the extent of the weed problem in native vegetation on public land and the limited resources available to deal with it, the most efficient approach may be to operate on a site by site basis, with sites of biological significance given priority, so that the management of a variety of weeds can be co-ordinated with other efforts to maintain or enhance the sites' biological values.

Some of the major environmental weed species of native vegetation in the study area are dealt with below, according to the vegetation categories in which they commonly occur. This is not a complete list.

Sub-alpine vegetation

The relatively low occurrence of weeds reflects the environmental extremes here. A prominent weed of sub-alpine woodland is the English broom (*Cytisus scoparius*), which appears to be proliferating unchecked, especially on Mt Matlock.

Montane vegetation

English broom is also a problem species in montane vegetation, as is blackberry (*Rubus fruticosus* spp. agg.), which grows in dense patches in saddles and gully-heads - for example, around Royston River and Snobs Creek.

Moist forests

Common moist forest weeds include Japanese honeysuckle (*Lonicera japonica*), holly (*Ilex aquifolium*), common ivy, cherry-plum (*Prunus cerasifera*), sycamore maple (*Acer pseudoplatanus*), poison-berries (*Cestrum*

spp.), Himalayan honeysuckle (*Leycesteria formosa*), holly, and blackberry. While not particularly widespread, many of these species become pests where private gardens adjoin native forest, as in the Dandenong Ranges. Also, while they may not grow in dense stands, scattered outliers can develop into problem sites. The most widespread weed species of moist forest are cat's ear (*Hypochoeris radicata*) and spear thistle (*Cirsium vulgare*), which usually occur as background weeds.

Riparian forest is among the most weed-prone of the vegetation communities. Blackberry is the most obvious problem species, but blue periwinkle, tutsan (*Hypericum androsaemum*), Darwins barberry (*Berberis darwinii*), wood-sorrels (*Oxalis* spp.), and species of willow (*Salix* spp.) may become established, particularly where the riparian forest adjoins agricultural land or townships.

Several grasses may also proliferate on moist river flats: Yorkshire fog (*Holcus lanatus*), cocksfoot (*Dactylis glomerata*), canary-grasses (*Phalaris* spp.), and sweet vernal-grass (*Anthoxanthum odoratum*).

Dry forests

The drier forests, particularly those with relatively fertile soils, may contain a large suite of introduced grasses and herbs, most of which are intractable. One that may respond to management is St John's wort (*Hypericum perforatum*), a noxious weed that also infests native vegetation, and that is especially prominent in the Eildon district. Other troublesome species, particularly around the urban fringe of Melbourne, are Monterey pine, sweet pittosporum, and cotoneaster (*Conoteaster* spp.).

Hair-grasses (*Aira* spp.), fescues (*Vulpia* spp.), bromes (*Bromus* spp.), and quaking-grasses (*Briza* spp.) are common weedy grasses in dry forests. A number of herbs such as cat's ear (*Hypochoeris radicata*), species of centaury (*Centaureum* spp.), and chickweeds (*Cerastium* spp.) also occur, but usually as background weeds.

Two New South Wales species of *Acacia*, cootamundra wattle (*Acacia baileyana*) and early black wattle (*A. decurrens*), have become naturalised and are also spreading in



Riparian forest is prone to weed infestation

dry forest areas. Sallow wattle (*A. longifolia*) is another native species that has become naturalised outside its natural range.

Plains vegetation

Vegetation communities occurring on drier, fertile plains are subject to invasion by a wide range of intractable weeds.

Of these, the most prominent include sweet briar (*Rosa rubiginosa*), hawthorn (*Crataegus monogyna*), fennel (*Foeniculum vulgare*), spear-grass (*Nassella neesiana*), rye-grasses (*Lolium* spp.), Yorkshire fog (*Holcus lanatus*), cocksfoot (*Dactylis glomerata*), canary-grasses (*Phalaris* spp.), fescues (*Vulpia* spp.), sweet vernal-grass (*Anthoxanthum odoratum*), bromes (*Bromus* spp.), and quaking-grasses (*Briza* spp.).

Heathland vegetation

Heathland communities and heathy woodland tend not to be vulnerable to weed invasion,

probably due to very low natural fertility of their soils. However, two species may pose problems: maritime pine (*Pinus pinaster*) and coast tea-tree.

Coastal vegetation

Largely due to the long history and extent of disturbance, coastal areas are particularly prone to invasion by introduced species. Notable among the problem species are the woody shrubs boneseed, myrtle-leaf milkwort, smilax asparagus, and mirror-bush. Coastal areas are also prone to invasion by introduced grasses, such as veldt grasses (*Ehrharta* spp.) and hare's tails (*Lagurus ovatus*), and although normally considered background weeds, may become locally abundant. Another introduced species, marram grass, has been widely planted to stabilise coastal sand dunes. It is now well established and spreading.

Two Australian native species can become weeds in coastal vegetation: coast tea-tree,

which normally would be confined to coastal dune scrub, but frequently extends into adjoining vegetation and bluebell creeper (*Sollya heterophylla*) which is a pest in the Arthurs Seat area.

Pathogens

Cinnamon fungus

Although present in the study area, cinnamon fungus (*Phytophthora cinnamomi*) has yet to display the impact on native vegetation that has occurred in the Brisbane Ranges, Otway Ranges, Wilsons Promontory, and Gippsland. Species characteristic of heathland or heathy woodland vegetation appear to be most susceptible to the fungus, with members of the Proteaceae (hakeas, banksias, grevilleas) and grass-trees (*Xanthorrhoea* spp.) being most noticeably affected. A range of vegetation communities within the study area are potentially susceptible, but the extent of any current infection is unknown.

Myrtle wilt

This disease affects myrtle beech. First documented in 1973, and known to occur in Tasmania and southern Victoria, it is associated with infection by a native fungus, *Chalara australis*. The result of infection is wilting and leaf-fall, beginning with the crown. Mature trees appear to be most susceptible. Most infected trees die, usually 12 to 30 months after the appearance of early symptoms. Small, isolated stands appear most vulnerable.

A correlation between the occurrence of myrtle wilt and disturbance from timber-harvesting and roading has been documented, and it would appear that these activities may accelerate the spread of *Chalara australis*. However, undisturbed stands may also be affected.

The presence and extent of myrtle wilt in the study area, and the threat it poses to cool temperate rainforest, have not been studied, but a suspected case has been reported from Tyers River.

Pest Animals

The impact of grazing by rabbits on native vegetation has not been studied in detail, but

is considered to be high. It is most noticeable in plains vegetation and dry forests. Indirect impacts may also occur through the spread of weeds, and through soil degradation associated with warrens.

Foxes act as a wide-ranging dispersal agent for blackberry, particularly where roads provide ready access to unaffected areas.

Native birds and bees pollinate large numbers of native plants. Introduced species of birds and the introduced honey bee can displace their native counterparts, which may affect the composition of native vegetation. Introduced birds can carry the seeds of environmental weeds with fleshy fruit (such as blackberry, hawthorn, and cherry laurel).

Human Activities

Timber-harvesting

This is widespread in the study area, especially in moist forests. Its effects on native vegetation are the subject of scientific study and much community debate. Principally, it maintains the harvested vegetation in relatively early successional stages, and results in substantial short-term soil disturbance.

Such changes may have ramifications for the harvested forests, and the adjacent vegetation, with regard to fire, soil structure and nutrient levels, water quality and yield, exposure to wind, changes in micro-climate, and the spread of pathogens and weeds.

Scientific studies into the impacts of timber-harvesting on vegetation have been undertaken. The Department of Conservation and Environment has an ongoing program of research, the Silvicultural Systems Project, to investigate these issues and recommend on any necessary improvements. The Board of Works has undertaken and reported on the results of long-term catchment studies into forest hydrology. Refer to Chapter 20 for further discussion.

Road construction and maintenance

A network of roads, both public and restricted, has been developed in areas supporting native vegetation to provide access for a variety of purposes, including timber-harvesting, recreation, mining, fire

protection and suppression, and water production.

The effects of roading may include changes to micro-climates, and changes to soil and drainage - similar in some ways to those associated with timber-harvesting. Most roads involve the permanent loss of vegetation, and new road construction, alignment, or upgrading can involve the clearance of substantial areas. The road site alters drainage, and run-off can create erosion and lower water quality in receiving waters.

In some places, the location of roads adjacent to watercourses leads to significant and continuing disturbance to stands of cool temperate rainforest, often within prescribed buffer strips.

Roads provide access to native vegetation for recreation and other activities, which may add to the incidence of wildfire in these areas. By contrast, they also allow access for fire-suppression activities. Roads may also accelerate the spread of weeds and pest animals.

Fire

Considerable controversy has raged over the role of fire in native vegetation for some years. Meredith (1988) provides a review of this subject. Fire is generally accepted to be involved, along with other factors, in the natural maintenance of vegetation. It is believed to have been used by Aborigines as a tool to assist hunting and food-gathering, although this is likely to have occurred mainly in grasslands and grassy woodlands rather than in the densely forested areas.

European settlers deliberately extended the use of fire to all areas, largely for purposes related to mining and agricultural activities.

Today, fire is used in the management of native vegetation for human use and protection - for example, to reduce fuel, to regenerate pastures, to stimulate fodder species, to suppress fire, and to control pest plants and animals. It is occasionally used to maintain or create habitat conditions for flora or fauna conservation.

The important ecological aspects of the fire regime to which any stand of vegetation is



Wildfire in eucalypt forest

exposed are intensity, seasonality, and frequency. The degree of variability within the regime over long periods is also important. Natural (non-human) causes of fire are few, with lightning being the by far the dominant one. Our knowledge of fire regimes prior to European settlement is currently poor.

Vegetation communities and their constituent species respond to fire in a variety of ways. Plants may:

- * resprout from lignotubers, roots, epicormic buds or other vegetative parts (e.g. eucalypts, some woody shrubs, most ferns, many grasses and sedges)
- * regenerate from seeds stored in woody fruits or in the soil (e.g. various wattles and peas, herbs, and some grasses)
- * recolonise the site, either by seeds or vegetatively, from adjacent vegetation (e.g. some members of the daisy family, mistletoe).

Fire-sensitive vegetation communities and their constituent species may also use one or more of these mechanisms to recover from fire. For example, mountain ash is killed by fires of moderate intensity, but recolonises using seed held in the canopy. A mountain ash-dominated wet sclerophyll forest may fail to regenerate if fire occurs more frequently than the time it takes for the regrowth trees to produce adequate seed. The result may be a fire-induced shift in the floristic composition of the site, either to a thicket of,

for example, silver wattle, or to a more fire-tolerant vegetation community such as damp sclerophyll forest.

Rainforest development is closely related to the fire regime. If a rainforest area is burnt, the dominant species, myrtle beech, may resprout from epicormic buds on the roots, butt, or trunk. However, species from the surrounding vegetation may recolonise the site more successfully than the rainforest species. Under these circumstances, the forest that becomes established is drier and more flammable than rainforest, and is not only more likely to carry further fires, but more likely to re-establish following subsequent fires.

In this way, the more fire-tolerant vegetation community can reinforce its occupation of the site, and only a fire-free period lasting several centuries would create conditions suitable for the redevelopment of cool temperate rainforest.

The fire-induced changes in floristic composition of a site may also involve the promotion, loss, or reduction of particular species, without the total replacement of the vegetation community. This is commonly the case in communities such as heathy woodland, where frequent low-intensity fires may favour resprouting species such as wiry spear-grass at the expense of obligate seed regenerators such as banksias and hakeas. Other prominent examples include the predominance of austral bracken and forest wire-grass in shrubby and heathy foothill forest following frequent low-intensity burning.

Frequent fires of moderate intensity in heathy dry forest may also favour leguminous species such as bitter-peas and narrow-leaf wattle at the expense of the slower-growing, later-maturing species of the Epacridaceae. Extensive areas of this community in the study area are relatively species-poor and dominated by legumes.

The role of seasonality of fire has been demonstrated in sand heathland into which coast tea-tree has invaded. Autumn burning favours this species, which produces large volumes of short-lived seed after summer flowering. Spring burning favours the characteristic heath tea-tree, which can retain seed in its woody fruit for many years.

As evidence regarding the responses of vegetation communities and individual species is progressively gathered, it will be possible to manage fire in these communities so that flora conservation goals are better satisfied.

Mining

Although mining activity was once far more widespread in the study area, today its impacts tend to be localised.

Open-cut mining for construction materials such as sand, clay, gravel, and rock has a severe, long-term but localised impact on the vegetation.

Underground mining for gold continues, but at a much reduced rate, mainly near Woods Point. Historically, the greatest impact of this mining was indirect, through the development of settlements, which in turn was associated with clearing of forests, the spread of weeds, increased incidence of fire, and earthworks, particularly along streams. Similar consequences followed from alluvial mining and dredging.

The accidental spillage of effluent containing various toxins into streams remains a cause for concern, although its impact on vegetation is largely unknown.

Eductor dredging formerly damaged a number of watercourses in the study area, but was banned in 1990. The mining and extractive industrial activity adjacent to watercourses and illegal eductor dredging, can have an impact on riparian vegetation, mainly through increased turbidity and sedimentation, and through erosion and the spread of weeds.

Recreation

A wide variety of recreational activities are undertaken in the study area, with many focused on areas of native vegetation. Activities that potentially threaten flora values are principally those that disturb the ground cover. Of particular concern are the more sensitive vegetation communities, which include the sub-alpine, coastal, and riparian ones.

Sub-alpine soils are vulnerable to erosion, and recover slowly from disturbance; the

hydrology of alpine bogs is delicate and sensitive to changes in local drainage. Activities associated with alpine resorts, horse-riding, vehicle use, and camping can result in soil erosion and/or vegetation disturbance.

Riparian areas provide the focus for many water-dependent and water-enhanced activities, including picnicking, camping, walking, fishing, swimming, and canoeing. Using riparian areas or gaining access to water bodies can disturb vegetation, cause erosion, and introduce weeds.

Coastal vegetation is vulnerable to disturbance. A multitude of tracks traversed coastal dunes in the vicinity of popular beaches in the study area, frequently resulting in dune erosion. Salt-marsh and mangrove vegetation has been disturbed by coastal facilities and recreational activities.

The environmental implications of recreation, and the effects of particular activities, are described in Chapter 13.

Climate change

Although some debate remains about the direction and rate of human-induced climate change, the moderate to extreme predictions have considerable implications for conservation of flora. A warmer climate, changed rainfall patterns, and a higher sea level would be likely to favour some species and communities at the expense of others. The current distribution of communities could alter under such conditions, together with the limits of distribution. Changes to the conservation status of some species could occur.

Water production

The impact of water production on native vegetation centres around the construction of dams and weirs, the associated roading and tunnelling, and the total and permanent loss of vegetation in the inundation area. In addition, the altered flow regimes downstream of dams may affect riparian and floodplain communities.



*Ski slopes on the summit of Mt Baw Baw
Alpine Resort*

Almost all the major rivers of the study area have been dammed: the Goulburn, Yarra, Rubicon, Tarago, Tyers, Tanjil, and Thomson Rivers and Cardinia Creek. The gentle topography of the Yea, Acheron, and Murrindindi Rivers and King Parrot Creek probably precludes them from future damming, but the Aberfeldy, Big, and upper Goulburn Rivers have the potential to be dammed.

Clearing for agriculture and urban development

It is now unusual for large parcels of public land to be alienated for agriculture or housing, or cleared. In addition, only a small percentage of public land is currently cleared, with the clearing mostly having taken place many years ago.

However, it is important to reflect on the extent to which clearing of land for these purposes in the past has substantially affected our ability to conserve native vegetation communities by establishing reserves. The communities most affected are those on the fertile plains, along river valleys, and in the vicinity of the Melbourne metropolitan area. Specifically, these communities include plains grassy woodland, plains grassland, floodplain riparian woodland, floodplain wetland complex, box woodland, coastal banksia woodland, coastal grassy forest, and swamp scrub.

Conservation Status

The following section broadly describes the distribution of each vegetation community and makes a qualitative assessment of its current conservation status.

Assessment of conservation status is a complex task that involves consideration of many factors, one of which is the current level of protection. Different public land uses confer different levels of protection to floral values. Areas that have Nature conservation as the primary purpose for the recommended use receive the highest level of protection; they include reference areas, national and State parks, flora reserves, and flora and fauna reserves. However, the conservation reserve system cannot achieve protection of floral values in isolation; all public lands with such values have a role in floral conservation. A large number of other

public land uses protect floral values to some extent, but may also allow exploitative uses and conservation values may be necessarily compromised. Important and notable exceptions in the study area are the catchments under Board of Works control, where the current policy of controlled uses in these areas confers high levels of protection of floral values. The effectiveness of a particular land-use recommendation to protect floral values by management prescription depends on the effectiveness of management practice.



Creating this agricultural land at Wonthaggi involved clearing heathland and coastal vegetation

Conservation status assessment involves the extent, current level of protection, and representation of vegetation communities. The Land Conservation Council considers that the reserve system should include adequate representation of all major plant communities, and this has become an important consideration in its recent deliberations about parks and other reserves. While it is not possible to protect all variations of vegetation associations, it is necessary to recognise the diversity and variability within each plant community and identify an optimal set of regional variants. Assessment of the relative extent of a representative sample should include consideration of the reduction of some communities since European settlement (that is, representation of the current or 'original' extent).

Dry sub-alpine shrubland

The major occurrences, and best examples, of dry sub-alpine shrubland are on the Baw Baw Plateau, and are reserved within the Baw Baw National Park. Pressure from passive recreation poses a minor threat to this community.

Damp sub-alpine heathland and wet sub-alpine heathland

These two communities, which normally occur together, are found on the Baw Baw Plateau in reserved land. Further west, unreserved examples occur on Lake Mountain and Mt Bullfight. At its western limit, this complex grows in the headwaters of Storm Creek, north of Mt Margaret, where its relatively low elevation, makes the stand noteworthy. Other noteworthy stands occur in the Myrree area in the headwaters of the Thomson, Yarra, and Toorongo Rivers. These stands are unreserved. The major impacts come from the risk of severe fire, and any physical disruption likely to alter drainage patterns.

Sub-alpine woodland

This community grows on the Baw Baw Plateau, Lake Mountain, and Mounts Torbreck, Bullfight, Matlock, Terrible, Duffy, Selma, and Useful. A small, unusual stand occurs on Mt Ritchie. Only the Baw Baw instances are reserved. Major threats to sub-alpine woodland come from inappropriate fire regimes, localised ski resort development in the case of Lake Mountain, and the spread of weeds.

Montane dry woodland

Such woodland occurs mainly in the eastern mountains, both north and south of the Great Dividing Range. A small area is reserved within Eildon State Park, but on the whole this community is poorly reserved. It faces the minor threat that too-frequent burning may affect the grassy and herb-rich understorey.

Montane damp forest

Extensive areas of montane damp forest occur usually above 900 m in the upper Yarra, upper Thomson, upper Goulburn, and Big River catchments, and extend north of

Marysville to the upper slopes of the Cerberean Ranges. This community was particularly devastated by the 1939 fires, and today very few areas of mature or old-growth forest remain.

Small areas are reserved within the fringes of Baw Baw National Park, with minor stands in reference areas within the Upper Yarra, O'Shannassy, and Watts River water catchments.

Montane damp forest is harvested for timber. It is sensitive to frequent, intense fires.

Montane wet forest

This forest covers considerably more restricted area than montane damp forest, being concentrated on protected slopes south of the Divide and around Lake Mountain. The best examples occur in the O'Shannassy water catchment. Other valuable sites include the headwaters of the Taggerty River, and some parts of the Toorongo Plateau.

Small stands are included in Baw Baw National Park and the Mt Gregory and Watts River Reference Areas. This community is especially sensitive to fire. It is harvested for timber.

Montane riparian thicket

This community occupies drainage lines above 800 m around Baw Baw and in the proposed Lake Mountain State Park. It is reserved in Baw Baw National Park, but lower-elevation examples are unreserved.

The major threats to montane riparian thicket centre around excessive sedimentation and changes to water flow regimes. As it usually grows in stream headwaters, timber-harvesting may take place in close proximity, exposing these stands to physical disturbance and damage from regeneration burning.

Cool temperate rainforest

Such rainforest occurs throughout the higher-elevation wet forests of the study area. Small stands are reserved in the Baw Baw National Park, and in the Deep Creek, Wallaby Creek, and Watts River Reference Areas.

This community is unusual in that efforts to protect it have centred on management

prescriptions rather than reservation. These ban harvesting or deliberate burning, and require buffer areas to be maintained around stands. Buffer widths range from 20 m around 'linear', usually streamside, tracts to 40 m around larger, 'non-linear' stands. As a result, the reserves listed above represent only a small proportion of the area covered by cool temperate rainforest in Melbourne District 2 which, it should be noted, contains by far the majority of stands of the community in Victoria.

Biologically significant stands of this rainforest occur in the Board of Works water catchments, the headwaters of the Yea, Taggerty, Royston, Acheron, Torbreck, Murrindindi, Tanjil, Tyers, Toorong, Ada, and Bunyip Rivers, and Pioneer Creek.



Wet sclerophyll forest, much of which is 1939 regrowth

The major threats to cool temperate rainforest are inadequate protection from fire, wind, and physical disturbance (for example, road construction or the falling of trees). These events create gaps in the rainforest canopy that are too large or exposed for the

rainforest species to recolonise. The result is the reversion to non-rainforest species or, in the case of roads, a permanent gap. The size of buffer required to give long-term protection to rainforest, and the sorts of activities that should be permitted within these buffers, have yet to be established scientifically. Other threats include soil erosion, weed invasion, and the effects of pathogens.

Wet sclerophyll forest

Protected mountain slopes in the high-rainfall zone support large areas of this community. Much of this zone was burnt in 1939. As a result, the majority of stands are 50-year-old regrowth.

Old-growth and older regrowth stands are often small and scattered. By far the best are located in the Board of Works catchments, with large stands in the O'Shannassy catchment, and smaller ones in Wallaby Creek, Maroondah, and Watts River catchments. Other noteworthy stands of old-growth wet sclerophyll forest are scattered around the Baw Baw Plateau, in the upper Bunyip River catchment, parts of Dandenong Ranges National Park, and isolated pockets in the Cerberean Ranges.

Reserved areas of wet sclerophyll forest include small stands in Dandenong Ranges National Park and Kinglake National Park, others within a number of reference areas in the Board of Works Catchments, Hawthorn Creek Reference Area, and a small patch in Baw Baw National Park, south of Mt Erica. The viability of both of the national parks for wet sclerophyll forest is somewhat doubtful given their high use for recreation, small size of stands, and their proximity to urban areas with their attendant problems regarding introduced species. These reserved stands amount to a small percentage of the total covered by this community in the study area.

Beyond the study area, wet sclerophyll forest occurs in eastern Victoria, mainly south of the Great Dividing Range, and in the Otway Ranges. Since the clearing last century of the extensive areas of wet sclerophyll forest in South Gippsland, certain stands in the study area have gained pre-eminence for their conservation values, largely based on their ecological maturity, integrity, and lack of disturbance.

Major threats to the forest come from frequent fire, environmental weeds, and the possible impact of long-term intensive timber-harvesting and associated roading.

Damp sclerophyll forest

Extensive tracks in the foothill and mountain country of the study area carry damp sclerophyll forest. Examples are reserved in Kinglake National Park, Stony Creek Reference Area in the Silver Creek Catchment, Bunyip State Park, Dandenong Ranges National Park, the lowland extension of Baw Baw National Park, and the Walsh Creek Reference Area in the Upper Yarra Catchment. These reservations represent only a small proportion of the total area the community covers.

Damp sclerophyll forest is harvested for timber. It is relatively fire-tolerant, but due to its moist understorey, fires are infrequent. Other threats are minor.

Riparian thicket

Found both north and south of the Great Dividing Range, the best examples of riparian thicket are on the Murrindindi River, in the headwaters of Starvation Creek, and in the upper Bunyip and upper Tarago catchments. It is unreserved on public land. Changes to drainage patterns, particularly associated with roading, are the major threats here.

Riparian forest

This community is widespread along the middle to upper reaches of rivers throughout the study area. Best examples include the upper Yarra, upper Goulburn, upper Thomson, Big, Torbreck, Taponga, Jamieson, Howqua, Tyers, and upper Acheron Rivers, and sections along the Watts, Murrindindi, Yea, Tanjil, Little, and La Trobe Rivers.

Small areas of riparian forest are reserved in Cathedral Range State Park and Eildon State Park. Disturbed but valuable examples occur in Warrandyte State Park and in the Plenty Gorge.

Alluvial mining and recreation activities such as fishing and camping, if concentrated on particular areas, can pose minor threats to

riparian forest. River reserves are subject to a variety of uses and conservation values may be compromised.

Swampy riparian forest

Growing in scattered locations throughout the study area, swampy riparian forest is reserved in the Silver Gum Flora Reserve at Buxton, in Moondarra State Park, and in Bunyip State Park. The best unreserved stands occur along Big, Torbreck, and Murrindindi Rivers, and White's Creek.

Changes to the drainage regime and weed invasion post the main threats.

Herb-rich foothill forest

The distribution of this community is centred around the foothills and alluvial terraces of the Goulburn Valley and its tributaries. Examples are reserved in Cathedral Range State Park, Switzerland Ranges Flora Reserve, Eildon State Park, Fraser National Park, and the Gobur, Caveat, and Yarrck Flora Reserves.

Frequent low-intensity fire poses a minor threat.

Shrubby foothill forest

The higher slopes of foothills of the Great Divide, in the centre of the study area, carry shrubby foothill forest. Small areas are reserved in Bunyip State Park, Dandenong Ranges National Park, Kinglake National Park, and in the lowland extension of Baw Baw National Park.

The major threat comes from frequent fire, which may alter the species composition.

Heathy foothill forest

This forest type occupies relatively infertile soils in the Bunyip, Tarago, and La Trobe River catchments. It is reserved in Moondarra State Park, French Island State Park, and Bunyip State Park. The floristic composition of the overstorey and understorey of heathy foothill forest may change with frequent burning. One of the dominant eucalypts, silvertop, has been shown to increase in abundance at the expense of other species when fire frequency is relatively high.



Heathy dry forest

Valley forest

The community is restricted to the lower slopes and valleys in the foothills to the north and east of Melbourne. Kinglake National Park and the Reference Areas in Yan Yean Water Catchment include representative examples. Weeds are the major threat to valley forest, which has been drastically reduced in extent by agricultural and urban development.

Heathy dry forest

Of the three variants of heathy dry forest described earlier, only the Kinglake type is well represented in flora conservation reserves (Kinglake National Park).

Both the upper Goulburn and upper Thomson variants are poorly reserved, although the lowland extension of Baw Baw National Park contains some stands of the latter. Valuable examples of the upper Goulburn variant include one at Moonlight Spur, and another near the junction of Stander Creek with the upper Goulburn River, east of Woods Point.

Additional valuable stands in the Thomson Valley are found around Swingler and Mormon Town, near Walhalla. High-quality examples of this community also occur in the Upper Yarra Catchment. Frequent burning may also be detrimental to heathy dry forest.

Dry sclerophyll forest

This community is widespread from Kinglake to Jamieson. It is well represented in conservation reserves, including Kinglake National Park, Cathedral Range State Park, Eildon State Park, and Fraser National Park. An unreserved variant of dry sclerophyll forest grows south of the Thomson River and west of Toongabbie.

The community often contains many environmental weeds, which appear to be the major threat to it.

Box woodland

Apart from stands on the lower slopes and alluvial plains of the Goulburn River valley,

small, disturbed examples of box woodland occur in the McKenzie Flora Reserve near Alexandra. This community has been substantially depleted, and is poorly reserved in the study area.

Plains grassy woodland

This woodland occurs on the basalt plains to the north of Melbourne, and on alluvial plains along the Goulburn and Yarra Rivers and their tributaries. It is rarely found on sedimentary geologies.

It is poorly represented on public land, occurring at Yan Yean (in a disturbed form) and in the Epping and Yan Yean Cemeteries. Weed invasion and grazing pose the greatest threat.

Plains grassland

With the exception of a small example in the Epping Cemetery, plains grassland does not occur on public land in the study area.

An action plan for the management of this much-depleted community has been prepared by the Department of Conservation and Environment, and is being implemented. The remaining examples are commonly disturbed by grazing and weed invasion.

Floodplain riparian woodland

Woodland of this type is restricted to river banks and billabongs in the valleys of the Yarra, Goulburn, Yea, and the Acheron Rivers, and Hughes, King Parrot, and Dabyminga Creeks.

Most of these stands are surrounded by agricultural land. Generally, they fall within river reserves, which, despite being public land, are often grazed or used as watering points by stock. Many are partially or completely cleared. The majority are in poor condition. Weed invasion and erosion of banks are the major threats.

Grassy wetland

Although not known to occur on public land in the study area, grassy wetland is believed to occur on government-owned railway reserves in the Wallan area. Grazing and associated weed invasion pose the major threats to it.

Floodplain wetland complex

Examples of this complex are found on alluvial plains in the Yarra and Goulburn Valleys, but many are disturbed by weeds and grazing. The best examples are scattered in the river reserves along the Goulburn River between Eildon and Seymour, although valuable examples also occur along the Yarra and Little Yarra Rivers near Yarra Junction and Yarra Glen.

Heathy woodland

A band of heathy woodland straddles the lower foothills to the south of the Great Dividing Range, from the Cardinia-Gembrook area eastwards to north of Moe. Representative examples are reserved within Bunyip State Park and Moondarra State Park.

Fire regimes play an important role in determining the species composition and abundance in this community. Flora conservation, both inside and outside biological reserves, would be assisted by maintaining a full range of fire regimes (including unburnt areas), and monitoring any floristic changes, in order to increase our understanding of this interaction.

Wet heathland

This community is scattered throughout a range similar to that of heathy woodland, with which it usually occurs in conjunction. The wet heathland occupies wetter depressions and lower slopes. It is well reserved in Bunyip State Park and Moondarra State Park.

The major threat to the community comes from changes to drainage, although it may also be prone to infection by cinnamon fungus.

Swamp heathland

Often associated with both wet heathland and swampy riparian forest, swamp heathland has a disjunct distribution. The most noteworthy stands occur along Woori Yallock and Cockatoo Creeks, in Bunyip State Park and Moondarra State Park.

Sand heathland

This community is found on French Island, Mornington Peninsula, and around Grantville



Coastal dune scrub at Woolamai Beach, Phillip Island, has been eroded by pedestrian traffic from the access road

and Wonthaggi. It once had a far wider distribution, which clearing for agriculture has reduced. It is reserved in French Island State Park, Point Nepean National Park, and a number of flora and fauna reserves on the eastern side of Western Port.

Appropriate management of this community should include careful, monitored use of planned fire in order to maintain a range of fire age classes. This may also be relevant for habitat management for fauna species. A minor threat is posed by invasion by coast tea-tree (*Leptospermum laevigatum*), although careful application of fire may also assist in its control.

Coastal heathland

Such heathland - found on the Mornington Peninsula, French Island, scattered around Western Port, and near Wonthaggi - has been substantially reduced in area since European settlement. It frequently occurs with sand heathland. French Island State Park and Point Nepean National Park include representative examples. The Wonthaggi heathland reserve, although not secure, also contains valuable examples.

Appropriate fire regimes are again required to maintain species and structural diversity (see previous section on fire). Maritime pine (*Pinus pinaster*) and coast tea-tree (*Leptospermum laevigatum*) may become troublesome weeds.

Coastal grassy forest

The community has been greatly depleted by the development of agriculture and settlements throughout the coastal region. It was once far more widespread, particularly on the Mornington Peninsula and around Western Port. It is represented in the Point Nepean National Park. Weed invasion presents the major threat.

Coastal dune scrub

Most of the coastline of study areas, except the salt-marsh, mangrove, and mud-flats in Western Port, once carried coastal dune scrub. Point Nepean National Park contains some of the least disturbed examples.

The community is threatened by weed invasion, and by soil erosion where recreation has caused the loss of vegetative cover.

Coastal banksia woodland

Disturbed examples of the much-depleted coastal banksia woodland occur along the Port Phillip Bay foreshore between Mt Eliza and Portsea. The best remnants on public land are a disturbed stand in the Point Nepean National Park, north of Cape Schanck, and a more extensive and natural stand in the Commonwealth Naval Area at Sandy Point, on the shores of Western Port.

Weed invasion has caused widespread degradation.

Coastal tussock grassland

This community is confined to the southern cliffs on Phillip Island, on public land, but not within a conservation reserve. The best example is believed to be in the vicinity of Native Dog Creek.

Coastal salt-marsh

The main examples of coastal salt-marsh in the study area are around the northern shores

of Western Port, on the northern shores of French Island, and, to a lesser extent, Phillip Island. It is reserved in French Island State Park. Most other major occurrences are unreserved. Incidental protection is provided in some wildlife reserves (Quail Island, Rhyll Swamp), but some important stands around Western Port are unprotected and vulnerable.

The major impacts on this community come from rabbit-grazing, oil pollution, and uncontrolled access. In the long term, rising sea levels pose a major if unpredictable threat.

Swamp sedgeland

This occurs in association with sand heathland and coastal heathland, in near-coastal locations from Mornington Peninsula to Wonthaggi. Representative examples are reserved in Point Nepean National Park, the Royal Botanic Gardens Annexe at Cranbourne, and French Island State Park.

Swamp scrub

The community has been severely depleted by the draining and clearing of swamps, particularly, the Koo-Wee-Rup Swamp. The remnants are mostly stands fringing salt-marsh on French Island (where they are reserved), and around the northern shore of Western Port. Few of the original extensive swampy stands remain, most being small and on private land. Of these, many are likely to be cleared or further degraded in the near future.

Clearing, fragmentation, and draining of swamps are the major threats to swamp scrub.

The Role of Isolated Blocks of Public Land

Generally speaking, opportunities exist within the major blocks of public land for the creation of reserves to cater for the conservation of vegetation communities in the sub-alpine, montane, moist forest, dry forest, and heathland vegetation categories.

Isolated blocks of public land are often significant for flora conservation because they tend to occur in regions that have been largely cleared for other land uses. In the study area, this is true for the vegetation



Coastal salt-marsh has been greatly reduced in area - a remnant mangrove

communities of the coastal districts and fertile plains.

River reserves are particularly valuable because they perform a secondary role as wildlife corridors. Unfortunately, the condition of most river reserves in the study area is poor and unlikely to improve without active management.

Rare and threatened species

All plant species recorded in the study area are listed in Appendix III, with the rare and threatened species listed in Appendix IV.

References

- Ealey, E.H.M. (ed.) (1984). Fighting fire with fire. Graduate School of Environmental Science, Monash University, Melbourne.
- Ferguson, I.S. (1985). Report of the Board of Inquiry into the Timber Industry in Victoria. Volume II: Commissioned Papers. Department of Conservation, Forests and Lands, East Melbourne.
- Gill, A.M. (1975). Fire and the Australian flora: A review. *Australian Forestry* 38(1): 4-25.
- Gill, A.M., Groves, R.H., and Noble, I.E. (eds.) (1981). Fire and the Australian Biota. (Australian Academy of Science: Canberra.)
- Groves, R.H., and Burdon, J.J. (eds.) (1986). Ecology of Biological Invasions: an Australian perspective. (Australian Academy of Science: Canberra.)

Gullan, P.K., Cheal, D.C., and Walsh, N.G. (1990). Rare or Threatened Plants in Victoria. Victorian Department of Conservation and Environment, East Melbourne.

Gullan, P.K., Forbes, S.J., Earl, G.E., Barley, R.H., and Walsh, N.G. (1985). Vegetation of south and central Gippsland. *Muelleria* 6: 97--145.

Gullan, P.K., Parkes, D.M., Morton, A.G., and Bartley, M.J. (1979). Sites of Botanical Significance in the Upper Yarra Region. Ministry for Conservation. Victorian Environmental Study Program No. 246.

Howard, T.M. and Ashton, D.H. (1973). The distribution of *Nothofagus cunninghamii* rainforest. *Proceedings of the Royal Society of Victoria* 86(1): 47--76.

Kile, G.A., Packham, J.M., and Elliott, H.J. (1989). Myrtle wilt and its possible management in association with human disturbance of rainforest in Tasmania. *New Zealand Journal of Forestry Science* 19(2/3): 256--64.N

Marks, G.C. and Smith, I.W. (1991). The Cinnamon Fungus in Victorian Forests. *Lands and Forests Bulletin* No. 31, Victorian Department of Conservation and Environment.

Melbourne and Metropolitan Board of Works (1980). Water Supply Catchment Hydrology

Research. Melbourne and Metropolitan Board of Works Reports Nos. MMBW-W-0010, MMBW-W-0011, MMBW-W-0012.

Meredith, C. (1988). Fire in the Victorian environment: a discussion paper. A report to the Conservation Council of Victoria, Melbourne.

McMahon, A., Carr, G.W., and Bedgood, S.E. (1987). The vegetation of public land in the Balcombe Creek catchment, Mornington Peninsula. Unpublished report on file at the Shire of Mornington.

Molnar, C.D., Fletcher, D., and Parsons, R.F. (1989). Relationships between heath and *Leptospermum laevigatum* scrub at Sandringham, Victoria. *Proceedings of the Royal Society of Victoria* 101: 77--87.

Opie, A.M., Gullan, P.K., Van Berkel, S.C., and Van Rees, H. (1984). Sites of Botanical Significance in the Western Port Region. Ministry for Conservation Victoria. Victorian Environmental Study Program No. 328.

Richardson, R.G. (ed.) (1988). Weeds on public land - an action plan for today. *Proceedings of a symposium presented by the Weed Society of Victoria and the School of Environmental Science.* (Weed Society of Victoria: Melbourne.)

8. FAUNA

Melbourne Area, District 2, has very diverse vertebrate fauna, containing over 60% of those species currently known in Victoria. Few of the species known to occur in the study area at the time of European settlement have become extinct. However, the study area contains a large proportion of the State's threatened species, which makes it important for the general conservation of many of these. For example, it contains the entire range of Victoria's two faunal emblems - Leadbeaters possum and helmeted honeyeater - both of which are classified as endangered. Its proximity to metropolitan Melbourne has contributed to the alienation and clearing of a variety of habitats. In addition, current land-use practices continue to degrade the landscape, affecting both the status and distribution of the fauna.

Since Council's 1973 descriptive report on the Melbourne area, we have increased our knowledge of the fauna, and of the habitat requirements of many significant species. Information provided in this chapter describes the mammals, birds, reptiles, and amphibians of the region.

Its preparation, undertaken by the Wildlife Branch of the Department of Conservation and Environment (DCE), involved extensive field surveys and the collation of existing information. Field work was conducted between August 1988 and November 1990, predominantly in the Central Highlands, to expand the knowledge of particular areas and/or species. The Wildlife Branch conducted concurrent surveys in the Greater Melbourne area which have identified sites of zoological significance. Data on wetland bird species has been incorporated from the DCE Wetland Unit.

Earlier studies to identify sites of zoological significance have been conducted in the Upper Yarra region (Fleming *et al.* 1979), Western Port catchment (Andrew *et al.* 1984), and Gippsland Lakes catchment (Mansergh and Norris 1982, Norris *et al.* 1983). Other studies have concentrated on smaller areas such as Western Port (Loyn 1975), Boola Boola State Forest (Loyn *et al.* 1980), and Acheron Valley (Brown *et al.* 1989), or on particular habitats such as mountain ash

forests (Loyn 1985, Macfarlane 1988). Extensive research on the ecology of particular species, Leadbeaters possum (Smith 1980, Lindenmayer 1989), has also been undertaken.

Data from these investigations, and many more, have been entered on the Atlas of Victorian Wildlife, which now contains more than 100 000 records of mammals, birds, reptiles, and amphibians for the Melbourne Area, District 2. This extensive data-base has been used to assess the distribution, abundance, and conservation status of fauna there.

The present study, undertaken for the Land Conservation Council, had four major aims:

- * to provide a comprehensive list of vertebrate species present in the study area
- * to determine habitat utilisation by fauna in relation to vegetation communities
- * to collect information on distribution and status of significant species
- * to identify areas of importance for the conservation of the vertebrate fauna in the study area

This chapter, and associated appendices, provides a full list of vertebrate species that have been recorded in recent times in the study area. Appendix V tabulates habitat utilisation by each species in relation to the seven broad vegetation communities identified in the flora chapter, and discusses the distribution and abundance of each one. Appendix VI lists the significant and notable species for the study area and provides information on their distribution, abundance, conservation status, and population trend. Later sections of the chapter present short accounts of the significant and some of the notable species and discuss historical changes that have occurred since European settlement, as well as factors that continue to affect the distribution and status of fauna. Those attributes of the environment that are particularly important for the conservation of the vertebrate fauna in the study area are highlighted.

An additional section gives a summarised description of fresh-water fish, and a general discussion on the influences on fish conservation. A short section on invertebrates, prepared for Council by Mr P.J. Vaughan, has also been added.

Common names have been used throughout the text, except for several species of reptile that do not have accepted ones. The scientific and common names of all species are given in Appendix V: those for mammals follow Menkhorst (1987); for birds Emison *et al.* (1987); and for reptiles and amphibians the Atlas of Victorian Wildlife (Cogger 1986) except for *Litoria spenceri*, *Austrelaps ramsayi*, *Lamphropholis*, and *Sphenomorphus*). Because of the many taxonomic changes in recent years, many species names used in this report differ from those listed in Council's 1973 report. To enable the reader to make use of that earlier information, these changes are documented in Appendix VII.

Historical Changes to the Vertebrate Fauna

Being close to Melbourne, the study area has more historical faunal information than many other parts of the State. This is especially true for regions such as the Mornington Peninsula, Western Port, and the Dandenongs. However, only limited information is available for much of the Central Highlands.

The first published comment on the fauna was made by George Bass when he entered Western Port in 1798. He was impressed by the large numbers of waterfowl, and commented that 'black swans went by in hundreds of a flight, and ducks, a small but excellent kind, by thousands, and the usual wildfowl were in abundance'. In 1855 William Blandowski, the first government zoologist of Victoria conducted two excursions reporting on the fauna: one to the Mornington Peninsula; the other to the eastern side of Western Port and to Phillip and French Islands.

By far the most comprehensive historical description of the fauna was written by Horace Wheelwright (1862), an Englishman who became a professional hunter in the area between Port Phillip Bay and Western Port, between 1853 and 1857. He described all of

the species with which he was familiar in his book 'Bush Wanderings of a Naturalist', and gave a comprehensive record of the fauna and its local abundance at the time. Andrew *et al.* (1984) provide a list of more than 200 identifiable species, with a quote from Wheelwright for each indicating abundance, and a comment on the present status of the species if it has changed markedly.

Some parts of the study area have changed drastically since European settlement as a result of habitat destruction or modification. This has affected the composition of the fauna and also the abundance and distribution of the remaining species. Some species are now extinct in the study area, others have decreased in abundance, while some have benefited from the alterations. The range of some species has contracted and distribution changed.

Mammals

Compared with other parts of the State, such as the Mallee, where large numbers of mammal extinctions have occurred, this area has fared reasonably well, as only two species, here the eastern quoll and Tasmanian pademelon, have become extinct here. The eastern quoll, which no longer occurs on the Australian mainland, was described by Wheelwright as 'one of the commonest of all the bush animals ...'. By the 1940s it had disappeared from almost the whole of its former mainland range.

The Tasmanian pademelon was recorded in the 'Narracan Hills' (south of the La Trobe Valley) last century. Wheelwright noted that 'I never met with the wallaby on the mainland in these parts, but I believe they are common in certain places further inland: they abound however, in the scrub on Phillip Island, in Western-port Bay. The wallaby is very common in Van Diemen's Land, and on certain islands in the strait.' Unfortunately there are no museum specimens of this species from the study area to confirm these observations, and it is now extinct on the mainland.

Several species reported by Wheelwright have decreased in numbers. The eastern grey kangaroo was so abundant on the Mornington Peninsula that he believed '... it seems as if they could never be shot out; although as the country becomes more peopled, their

numbers must decrease. During the two seasons I shot here, I am certain considerably more than 2000 kangaroos were killed by our party and another within a very limited distance ... At present the kangaroo appears to be regarded as nuisances in the bush, and every means are used to exterminate the race, they are snared, shot, and run down with hounds just for the sake of killing them and the carcasses left to rot in the forest.' It appears that population levels declined rapidly, as only 40 years later the kangaroo had practically disappeared from this area.

Wheelwright described the potoroo as '... excellent eating and common throughout the whole bush.' This species is no longer found on the Mornington Peninsula, but still occurs on French and Phillip Islands.

The range of Leadbeaters possum has contracted significantly. It was originally described from specimens collected in 1867 '... in scrub on the banks of the Bass River, Victoria' (McCoy 1867). Another specimen was collected from the edge of the Koo-Wee-Rup Swamp, south of Tynong. By 1921 Spencer feared the species was extinct: '... the destruction of the scrub and forest in the valley of the Bass River has resulted in the complete extermination of one of our most interesting marsupials, the little opossum-like *Gymnobelideus leadbeateri*' (Spencer 1921). Not until 1961 was the species re-discovered near Marysville, but it is now known to be widely distributed throughout the montane ash forests of the Central Highlands.

Koala abundance has fluctuated markedly. Some evidence suggests that at the time of European settlement this marsupial was relatively uncommon. However, rapid increases were observed shortly afterwards, and it has been suggested that the increase correlated with the decrease of hunting pressure by the declining Aboriginal population. The numbers increased dramatically, with some areas reported as having one or more koalas in every manna gum tree. Shooting (both commercially and for 'sport'), clearing of the forests, and bushfires drastically reduced the animals, until in the 1920s it seemed they had disappeared from most of Victoria except for a few localities in South and West Gippsland. One of these was an area between Grantville and Corinella. Koalas did not occur naturally



Koala

on any of the islands in Western Port, but in the 1870s and 1880s local fishermen released small numbers on French and Phillip Islands. These multiplied rapidly and in the 1930s thousands of koalas were removed and released into other parts of the State from where they had disappeared. As a result of these re-introductions, the Victorian population increased from approximately 500 in 1925 to many thousands in the 1950s. Early in the 1930s, 165 koalas from French Island were released onto Quail Island in the north of Western Port. In 1944, 1176 animals were removed when it was found that the population had built up to such high numbers that they were stripping the trees of foliage, killing many of them. Now only a very small population remains on Quail Island. Koalas are still being removed from French Island for release elsewhere in the State. The Phillip Island population, however, is very low and declining steadily.

While most species have declined in the study area since European settlement, the eastern horseshoe-bat could have increased its range as a direct result of human activities. It is restricted to areas that contain suitable roost sites in the form of naturally occurring caves, or artificially constructed equivalents such as

mineshfts. In Victoria, its former distribution probably did not extend west of East Gippsland. No natural caves suitable for it have been found in the study area, and there are no historical records. It was first recorded in central Victoria in 1977 and is now known to occur in a number of mineshfts around Mount Disappointment--Kinglake--Eildon.

Many species of mammal and bird were introduced into Victoria last century, to 'enhance' the Australian bush and to provide the new settlers with familiar sights and sounds. Numerous reserves established here for the propagation and release of introduced animals included Phillip Island, Gembrook, and Quail Island. The 13 introduced mammal species that now occur in the study area form a significant component of the fauna and have varying effects upon the native fauna.

One natural phenomenon has had a major effect on the fauna of the Central Highlands - the devastating 1939 bushfires. Prior to this, the forests were of various age classes, with large areas of old-growth forests. As a result of the 1939 fires, extensive areas of ash forests became predominantly single-age stands, and this has modified the distribution and abundance of many forest-dependent species.

Birds

Both distribution and abundance of many native species of bird have changed greatly since European settlement. Six species have become extinct in the region, and many more have undergone major reductions in their distribution. A few species have become more common since settlement, and 12 species of introduced birds have established substantial feral populations within the study area. The declines in native species have been caused primarily by the clearance of native vegetation, drainage of swamps, alteration to fire regimes, timber-harvesting, and, in a few cases, hunting and egg-collecting.

Wheelwright's 1862 documentation of the birds of the upper Mornington Peninsula makes the extinction of the six species apparent. The pied goose is one that no longer occurs naturally in south-eastern Australia, due to the drainage of breeding

swamps, poisoning, and shooting by settlers. However, Wheelwright commented that it was 'the common wild goose' there, while Australian bustards, although uncommon breeding residents, '... generally came into our district as stragglers, but an odd couple or so bred in the heather'. Wheelwright further noted that broilgas '... generally frequent the open swamps and wet plains in small companies ... I once found a nest in a swamp near us.' He cited reports of glossy black cockatoos as being 'not uncommon' near Point Nepean where they fed on the seeds of drooping she-oak. Ground parrots were '... common in the long grass in the plains, on the heather and often in low tea-tree scrub ... We used to find them during the whole year frequenting different localities at different times.' The reef heron was observed last century in Western Port, but has not been reported since. The turquoise parrot was a regular summer migrant in small flocks, but is now only recorded as a vagrant.

Hunting has also had a significant impact on the abundance of some species, such as ducks. Wheelwright commented, 'I do not believe that any country in the world is better adapted as a home for the waterfowl than Australia ... When I first came into this country the balmy days of the duck shooter were in their zenith; the fowls and buyers plentiful the shooters scarce ... But this did not last long. The duck shooters of that day ... never heeded the morrow and not one laid up for a rainy day. As the birds became scarcer the shooters increase ...'. By the turn of the century ducks were considered scarce on the Mornington Peninsula (Shepherd 1903).



Black duck

While many species have declined, some native birds have dramatically increased in numbers - mainly those that can utilise farmland, and particularly the ibis and spoonbills. In commenting on the straw-necked ibis, Wheelwright noted 'Occasionally an odd ibis is killed here ... The real home of the ibis is, however, far inland; and it is only when the up country is heavily flooded that they visit the districts near the coast.' By 1900 they appear to have increased slightly, but Shepherd (1903) still considered them unusual: 'A good many flocks of Straw-necked Ibis were occasionally observed during last winter and early spring - an unusual occurrence owing probably to the dry conditions in the interior.' The sacred ibis is a recent addition to the Western Port region and is not mentioned by either Wheelwright or Shepherd. Counts of up to 4000 straw-necked ibis and 2500 sacred ibis have been recorded in the region.



Straw-necked ibis

Human activities have also affected natural plant communities, and therefore avifauna, in more subtle ways. Timber-harvesting has reduced the suitability of harvested forests for some species of birds, by reducing the availability of hollows used for nesting and roosting. Areas remaining now as remnant vegetation may have changed significantly from the time of European settlement. For example, Robert Brown in 1802 described the vegetation at Point Nepean as grassy, with scattered coast banksia, or drooping she-oak, and wirilda wattle. At this time, the coast tea-tree grew in a narrow band just above high-water mark. Coast tea-tree now dominates substantial areas of Point Nepean National Park, and appears to have colonised areas depleted of the larger trees by firewood-collecting. These changes have

been to the detriment of some species (like the glossy black cockatoo) and have probably benefited others (such as New Holland honeyeater).

Reptiles and amphibians

Early accounts of the fauna of the study area rarely included information on reptiles or amphibians. Where they were mentioned it was often only in general terms, and it is difficult to determine species identity. Wheelwright recorded snakes as being extremely abundant: 'I do not believe any part of the world can be more infested with these reptiles in the summer season'. He commented on the hundreds he had shot and how he rarely went out in summer without killing two or three. While not uncommon now, snakes have obviously decreased in numbers.

Frogs were abundant, Wheelwright wrote 'Thousands of small frogs inhabit the swamps, and afford unlimited supply of food to the different aquatic birds.' Draining the extensive swamps, such as the Koo-Wee-Rup Swamp, must have dramatically reduced the availability of frog habitat.

There have been no recent sightings within the study area of two species, first recorded around the turn of the century. The blind snake *Ramphotyphlops proximus* has only been noted prior to 1901, in the Seymour area. The only records of the Blue Mountains tree-frog are from Aberfeldy, collected in 1922. It is not known if these species remain in the study area.

The Vertebrate Fauna

The 477 species of vertebrate (excluding fish) currently known in the study area comprise 79 mammal, 332 bird, 44 reptile, and 22 amphibian species. This high diversity reflects the wide range of landscapes and vegetation categories present, as the study area encompasses parts of four physiographic regions.

- * Eastern Uplands - the dominant physiographic region - incorporate the Central Highlands, and are characterised by tall wet forests of the Great Dividing Range, and drier forests north of the Divide.

- * West Gippsland Plains include the Mornington Peninsula and land around Western Port. The remaining native vegetation is predominantly coastal and heathland.
- * Strzelecki Ranges once contained tall wet forest but are now largely cleared.
- * Volcanic Plains have only a small portion within the west of the study area. It comprises native grasslands and grassy woodlands.

The fauna characteristic of these four regions, and those species that are widespread, are discussed below.

Mammals

A total of 79 species of mammal - 66 native and 13 introduced species - have been recently recorded in the study area. Among them are 2 monotremes, 26 marsupials, and 38 eutherians, including 16 marine mammals. This comprises 72% of the Victorian extant terrestrial mammal fauna. Some groups, such as the bats, are particularly well represented, containing 81% of the Victorian species, while others are less so (for example, only 28% of the Victorian macropods are found in the study area). One species, Leadbeaters possum, is now endemic here, being largely restricted to the montane ash forests of the Central Highlands. While only two species are known to have become extinct since European settlement, a high proportion of the mammal fauna is considered threatened, with 16 species (24%) classified as significant or notable in the area (see Appendix VI).

The Eastern Uplands physiographic region supports a characteristic suite of forest-dwelling species. These include a number of arboreal marsupials (such as mountain brushtail possum, Leadbeaters possum, yellow-bellied glider, and greater glider) that are now largely restricted, in the study area, to this region. While most of the bat species are widespread, several (like the great pipistrelle and Gould's long-eared bat) are restricted to the forests of the Divide. The eastern horseshoe-bat has only been recorded in this physiographic region, centred around the known roost sites. Most records of the tiger quoll, broad-toothed rat, and smoky mouse come from here. Species restricted to

drier forests inland of the Divide in this region include the yellow-footed antechinus and squirrel glider.

While the Strzelecki Ranges would have formerly contained many species in common with the Eastern Uplands, extensive clearing has now largely depleted the mammal fauna of this part of the study area.

Two species are restricted to the West Gippsland Plains - the New Holland mouse and long-nosed potoroo. The swamp antechinus and southern brown bandicoot are also distinctive inhabitants. Grassland and woodland species such as the fat-tailed dunnart and little mastiff-bat are characteristic of the Volcanic Plains region.

While some species are largely restricted to certain physiographic regions, many occur throughout the study area. These include the short-beaked echidna, brown antechinus, common ringtail possum, sugar glider, swamp wallaby, white-striped mastiff-bat, King River epitesicus, and lesser long-eared bat. The bush rat is widespread and common throughout most native vegetation in the study area, except on the Mornington Peninsula although apparently suitable habitat occurs there.

Compared with the surrounding mainland areas, the islands of Western Port have a very depauperate mammal fauna. French Island has no carnivorous marsupials, bandicoots, possums, or large macropods. The long-nosed potoroo, although once generally widespread on the mainland, is now restricted, within the study area, to French and Phillip Islands. Interestingly, one reason the species still occurs in good numbers on French Island is probably the absence of foxes. The only arboreal mammal found on the Island is the koala, which did not occur there naturally, but was introduced late last century (Lewis 1954).

The coastal waters of the study area support a number of marine mammals. A large breeding colony of the Australian fur-seal is located at Seal Rocks, off Phillip Island, and this species frequents the waters off the coast and in Western Port. There are also occasional records of the New Zealand fur-seal on Seal Rocks, although its present Australian distribution is mainly confined to South Australia and Western Australia. The

leopard seal, which usually inhabits the outer fringes of the Antarctic ice-pack and sub-Antarctic islands, occasionally ventures north to the southern coast of Australia, and a number of records describe individual animals hauling out on beaches in the study area. The southern elephant seal also inhabits the southern oceans, with few records on the Australian mainland, but one animal was observed at Seal Rocks in 1967.

Twelve species of whales and dolphins have been recorded the coastal waters of the study area. Some species, such as the common dolphin, bottle-nosed dolphin, southern right whale, and killer whale, regularly use this area. Others such as the pygmy sperm whale, minke whale, fin whale, false killer whale, and long-finned pilot whale, have only been recorded as stranded beach-washed specimens, usually of single animals. A mass stranding of 36 sperm whales occurred at Gunnamatta Beach in 1972.

Since the 1973 LCC report, the identity of several species of bats has been clarified, and these changes are documented in Appendix VII. Taxonomic revision of some groups is still under way. The two recognised forms of the little mastiff-bat have not yet been formally described, but have been listed separately in this report. Since the 1973 report, the eastern horseshoe-bat and common dunnart have now been recorded here.

Birds

Of the 332 species of birds recently recorded in the study area, 12 are introduced. Approximately 235 are resident during the breeding season. Of these species, about 35 breeding migrants arrive in spring, including the rufous whistler and sacred kingfisher. Approximately 30 species are non-breeding migrants that spend either summer (for example many shorebirds from northern Asia) or winter (for example, white-fronted terns and double-banded dotterels from New Zealand). The 28 species considered to be occasional visitors (vagrant) include the broad-billed sandpiper, turquoise parrot, and scarlet honeyeater. A total of 33 species are considered to be either significant or notable in the study area.

The high diversity of bird species reflects the range of landscapes and vegetation categories represented in the four physiographic

regions. The Eastern Uplands has a characteristic fauna of forest-dwelling birds, including the sooty owl, wonga pigeon, brush cuckoo, superb lyrebird, large-billed scrubwren, pilotbird, Lewins honeyeater, and red-browed treecreeper.



Wonga pigeon

Many of the species characteristic of the Eastern Uplands occur in small remnants within the Strzelecki Ranges. However, this region is now dominated by species typical of open areas such as the black-shouldered kite, masked lapwing, welcome swallow, Richards pipit, and Australian magpie.

Along the coast, the West Gippsland Plains contain a wide range of species including: many sea-birds (little penguin, short-tailed shearwater, and Australasian gannet); waders (hooded plover, red-necked stint, eastern curlew); and water-birds (royal spoonbill and pied cormorant). The orange-bellied parrot, king quail, and grey-crowned babbler are restricted, within the study area, to this region. Other characteristic birds have included the blue-winged parrot, calamanthus, tawny-crowned honeyeater, singing honeyeater, and little wattlebird.

Birds characteristic of the small area of volcanic plains include the long-billed corella and plains-wanderer. Many species are widespread throughout the study area. These include brown goshawk, southern boobook, crimson rosella, laughing kookaburra, fantailed cuckoo, grey fantail, flame robin, golden whistler, and grey currawong.

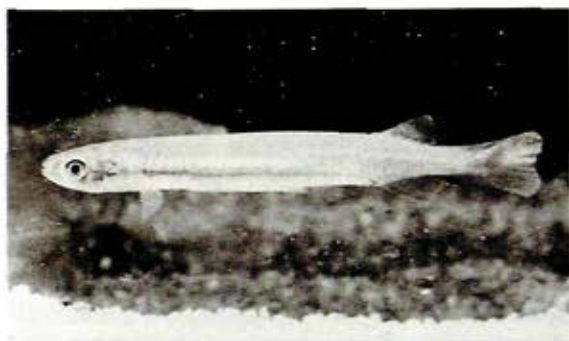
Fish

A State-wide inventory of fresh-water fish studies (DWR 1989) indicated that 19 native

fish species, of the 44 surviving species in Victoria, had been recorded in the study area; these are listed in Appendix VIII which also shows their current conservation status. Seven species are considered to be threatened: Australian grayling, broad-finned galaxias, dwarf galaxias, Macquarie perch, Murray cod, pouched lamprey, and spotted galaxias. In addition, the brown galaxias (which is recognised as a separate taxon, but not described as a species) is endangered.

Appendix VIII includes a separate list of six native species whose probable natural distribution extends to the study area, that are not recorded in the inventory of fish studies. These species may no longer be present in the study area, which is probably true of the trout cod, or may be present but not recorded.

Ten introduced species, of the Victorian total of 14, have been recorded in the study area (DWR 1989); these are also listed in Appendix VIII.



Australian grayling

Reptiles and amphibians

Approximately 40% (44 of 113) of the reptile species currently recognised in Victoria have been recorded in the study area. The best represented group, the skinks (Family Scincidae), comprises 23 species. The next-largest group, the front-fanged snakes (Elapidae) has eight species, followed by the dragons (Agamidae) with five species. Another five families are poorly represented: two fresh-water tortoises (Chelidae), one gecko (Gekkonidae), two legless lizards (Pygopodidae), one goanna (Varanidae), and two blind snakes (Typhlopidae).

A larger proportion, 67% (22 of 33), of Victoria's amphibian species has been recorded in the study area. Nine of the eleven species of tree frog (Hylidae) 13 of the 22 species of southern frog (Myobatrachidae) occur here. Such a high degree of representation of amphibian species may be attributed to the variation in extent and type of wetland present. This broad range of habitats includes high-altitude sphagnum bogs, fast-flowing rocky streams, and low-lying swampy areas, all of which contain their own distinctive amphibian assemblage. For example, the Baw Baw frog has adapted to the harsh and extreme alpine environment on the Baw Baw Plateau, Lesueurs frog is found in drainage lines flowing from the forested mountainous ranges; while the shallow lowland swamps provide suitable habitat for the striped marsh frog.

Relatively few documented accounts have dealt with reptiles and amphibians in the study area, compared with the other vertebrate groups. The pioneering works of Rawlinson (1965 and 1971) are exceptions, and have added greatly to our knowledge of the reptiles of the Melbourne area and West Gippsland. The frog species, tadpoles, and eggs of the Melbourne metropolitan area have been described by Littlejohn (1963), Martin (1965), and Martin *et al.* (1966) respectively. Several studies have concentrated on specific areas. Hutchinson (1979) and Braby (1989) have produced comprehensive lists from the Kinglake area, and Smales (1981) gave a detailed account of species found at the Yellingbo State Nature Reserve, including some of their microhabitat requirements.

Since the Council's 1973 investigation, a number of nomenclature changes have come into effect. To avoid confusion, a brief synopsis of these changes is given in Appendix VII. Some groups are still under taxonomic revision, and two species of lizard currently contain a number of undescribed taxa: the southern water skink, which includes the cool temperate form (CTF) and warm temperate form (WTF); and the grass skink, which also includes two forms (Form A and Form B). These forms have been consistently referred to within the scientific literature and warrant specific status. They will consequently be treated as separate species in this report.

In addition to these changes, two species now known to occur in the study area - the common scaly-foot and Coventry's skink - did not appear on the 1973 inventory.

The Eastern Uplands physiographic region has a number of species restricted to it. The Baw Baw frog, alpine tree frog, Coventry's skink, Spencers skink, mountain dragon, and highland copperhead are all characteristic of its wetter areas. It also contains many species that are largely restricted to the drier forests north of the Divide, including the marbled gecko, three-toed skink, plains froglet, and plains brown tree frog.

As for the mammals and birds, the reptile and amphibian fauna of the Strzelecki Ranges would once have resembled those of the Eastern Uplands but are now largely depleted due to the extensive clearing. The West Gippsland Plains contain the entire distribution, within the study area, of Haswells frog and the common scaly-foot. The swamp skink is largely restricted to this region and the southern foothills of the Eastern Uplands. The volcanic plains contain all the known study area records of two grassland species - the lined earless dragon and the striped legless lizard.

Reptile species that are widespread throughout most regions include the tree dragon, White's skink, garden skink, southern water skink (CTF), blotched blue-tongue lizard, and tiger snake. Widespread frog species include the southern bullfrog, common froglet, southern brown tree frog, and growling grass frog.

A number of species reach their geographic limits within the study area. The Highland copperhead is at the western limit of its range

here, and the Thomson River constitutes the westernmost edge of the Gippsland water dragon's range. One of the blind snakes, *Ramphotyphlops nigrescens*, more commonly found inland of the Great Dividing Range, reaches its southern limit near Yarra Glen. Another species reaching its southern limit, one of the striped skinks, *Ctenotus uber orientalis*, has only once been recorded in the study area, from Mangalore. The Blue Mountains tree frog is known only from three specimens collected in the 1920s from the Aberfeldy River, which is the extreme western limit of its range.

Of the 54 species of reptile and amphibian regarded as endangered or otherwise threatened in Victoria (Baker-Gabb 1990), 10 (18.5%) are known in the study area. The distributions of some species appears to have diminished over the years, and there is no doubt that habitat degradation has had, and continues to have, long-lasting deleterious effects upon many local populations.

Habitat Use by the Vertebrate Fauna

Different species of vertebrate fauna respond differently to various components in their environment. One way to determine patterns of distribution is to examine how the fauna respond to the habitat in which they live. Some species occur in a broad range of vegetation communities, while others have very specific habitat requirements and are found in only one or two. The study area has a wide range of vegetation communities (as described in the flora chapter). To facilitate description of the patterns of use by fauna, these communities have been grouped into seven broad categories, as listed in the legend to Appendix V, which also documents records of each species in vegetation communities and categories in the study area.

This information is drawn largely from the field surveys undertaken by the Wildlife Branch, supplemented by earlier surveys. Unfortunately, some of the earlier records do not provide a sufficiently detailed vegetation description to confidently allocate them to particular communities.

The completeness of a species list for a community depends on a number of variables, including the amount, and season, of sampling, and its extent and distribution



Tiger snake

within the study area. For example, riparian forest is widespread and was extensively sampled during field surveys, resulting in a comprehensive species list. Conversely, sub-alpine heathland complex is not extensive within the study area and received little sampling attention, and therefore the number of species recorded there is likely to be an underestimate. It should be recognised that the absence of a record of a species in a particular community does not necessarily mean that it does not occur there.

The vegetation communities discussed in this chapter may be viewed as an environmental gradient ranging from high-altitude sub-alpine heathland complex to coastal salt-marsh. The boundaries between them are sometimes in-distinct and often reflect ecological zones. Many species (such as brown antechinus, common wombat, eastern yellow robin, white-browed scrubwren, southern water skink (CTF), and common froglet) span a broad range of this environmental gradient, and occupy vegetation communities from sub-alpine to the coastal areas. Conversely, others occur in a very narrow range and have a preference for certain vegetation communities. For example, here the New Holland mouse is restricted to coastal areas in sand heathland, the king quail has been recorded only in coastal heath, the orange-bellied parrot in coastal salt-marsh, and the Baw Baw frog in sub-alpine vegetation.

The communities are derived from an analysis of the floristic composition of vegetation. However, other factors, such as vegetation structure, can also affect the distribution patterns of fauna. For example, Leadbeaters possum occurs in wet sclerophyll forest, but not all areas have the necessary structure, in terms of suitable tree hollows and understorey density, to support this species. Reptiles that rely upon solar radiation as their energy source will choose home sites on the basis of structural components of the overstorey vegetation (related to solar penetration) and the degree of ground cover (related to shelter-sites), rather than the vegetation community itself. Other environmental factors such as topography and prevailing climatic conditions may also influence habitat selection by a particular species.

The occurrence of a species within a community is not a static response. Structural changes over time, due to

processes such as natural plant succession, burning, or timber removal, may alter the suitability of the habitat for a given species.

Sub-alpine vegetation

This includes sub-alpine heathland complex and sub-alpine woodland. Sub-alpine vegetation is not widespread in the study area. Its limited distribution and simple structure, as well as the extreme winter climate, contribute to the generally low diversity and abundance of wildlife.

In contrast to many other groups, it supports relatively abundant small ground mammals. The bush rat and brown antechinus reach high densities. The smoky mouse and eastern pygmy-possum are found in sub-alpine woodland that contains a diverse heathy understorey, and the broad-toothed rat has been recorded in areas with a dense understorey. Seven species of bat have been found here. Common wombats are conspicuous in both summer and winter, and their tracks are frequently seen in the snow.

Many bird species utilising this vegetation category do so seasonally, arriving in spring to feed on the numerous emerging invertebrates, remaining to breed, and leaving again in autumn; flame robin and, Richards pipit are examples. White's thrush, red wattlebird, and white-nosed honeyeater are common in sub-alpine woodland in summer. Species resident in sub-alpine woodland include crimson rosella, striated thornbill, white-eared honeyeater, white-browed scrubwren, grey shrike-thrush, and grey currawong. Australian kestrels are recorded from the open shrublands and heathlands.

With low temperatures and snow coverage during the winter months, few reptile and amphibian species can tolerate these high-altitude conditions; only 12 species have been recorded. One of these, the Baw Baw frog, is totally confined to sub-alpine vegetation. Large numbers of grass skink (Form B) have been observed within sub-alpine woodland on peaks such as Mounts Terrible and Torbreck. White's skink inhabits this vegetation category more rarely.

The alpine tree frog, a montane-adapted subspecies of *Litoria verreauxii*, occurs in isolated populations around the Baw Baw

Plateau and Lake Mountain, at elevations above approximately 1200 m (Watson and Littlejohn 1985). At Mount Baw Baw it is found in ponds in open sphagnum bogs, and it also occurs in fire dams, swamps, and streams in sub-alpine woodland (Norris *et al.* 1983). Its habitat preferences differ markedly from those of the other subspecies, Verreauxs tree frog, which is more commonly found in the mid-altitude and heathy forests.

Montane vegetation

Montane dry woodland and montane forest complex comprise montane vegetation. Montane dry woodland is found at altitudes between 900–1200 m, with snow gum occurring in association with a range of other eucalypts such as broad-leafed peppermint and candlebark.

It supports a more diverse arboreal mammal fauna than sub-alpine woodland, due possibly to the more temperate conditions and the wider range of nesting and foraging sites the additional eucalypts provide. The seven species recorded here include the yellow-bellied glider, which incises the smooth-barked candlebarks with distinctive feeding notches. Montane forest complex usually occurs above 900 m and is dominated by alpine ash and/or shining gum. While it supports a similar arboreal mammal fauna to the montane dry woodland, the abundance is higher in the taller forests. Leadbeaters possum occurs in the forest complex where this meets its specific habitat requirements of nesting sites and dense understorey.

Among the suite of eight bat species occurring at these high altitudes, the King River epitesicus is the most abundant. High densities of bush rats are found in both the drier woodland understorey and the wetter one of the forest complex. The rare and restricted smoky mouse occurs in montane dry woodland with a diverse heathy understorey.

The montane vegetation has a relatively low diversity and density of birds. In the montane forest complex, the avifauna tends to be dominated by a few common forest species such as the crimson rosella, striated thornbill, and white-browed treecreeper. These forests tend to have a simple understorey and thus have a low density of understorey species

such as the brown thornbill and white-browed scrubwren. Uncommon species here include the sooty owl, Australian king parrot, and pink robin. Montane dry woodland provides habitat for species such as the painted button-quail and spotted quail-thrush, which are more typically found in dry forests.



Australian king parrot

Reptiles and amphibians are poorly represented in montane vegetation, with only ten species known. The southern water skink (CTF), Spencers skink, grass skink (Form B), tiger snake, and highland copperhead are typical of this vegetation category. Both the mountain dragon and garden skink occur in the montane dry woodland, but not in the montane forest complex, suggesting a preference for a grassy open understorey.

Moist forests

The category includes cool temperate rainforest, wet sclerophyll forest, damp sclerophyll forest, and riparian forest complex. Moist forests are widely distributed in the study area and occur in a wide range of altitudes, from lowland riparian forest to the mountain-ash-dominated forests at high elevations. Cool temperate rainforest, while limited in extent, occurs mainly in narrow strips along watercourses and in gully heads and only limited survey work has been undertaken.

Mammal diversity is high in moist forests, especially damp sclerophyll forest, and several rare species such as the tiger quoll, white-footed dunnart, and broad-toothed rat

have been recorded. The ferny understorey of cool temperate rainforest supports high densities of the dusky antechinus, a species that is relatively uncommon in other communities. The long-nosed bandicoot is widespread but uncommon, and the swamp wallaby and common wombat are both common.

Moist forests provide important habitats for arboreal marsupials, and 10 species have been recorded in each of riparian forest complex, wet sclerophyll forest, and damp sclerophyll forest. This includes all except one of the species of arboreal mammal recorded in the study area. Leadbeaters possum has its most important habitats in mountain-ash-dominated forests of wet sclerophyll forest and damp sclerophyll forest. Riparian forest complex at high altitudes does not support it, but a population occurs at relatively low altitudes in swampy riparian forest at Yellingbo State Nature Reserve. The common brushtail possum, which is absent from the higher altitudes, occurs in low numbers in these moist forests, whereas the closely related mountain brushtail possum is common here. Other arboreal species characteristic of moist forests are the greater, yellow-bellied, and sugar gliders.

Riparian forest complex supports 12 species of bat, including the significant species large-footed myotis, eastern broad-nosed bat, and common bent-wing bat. The large-footed myotis is restricted to lowland areas with permanent water, over which it forages for aquatic insects and small fish, so most records come from riparian forest complex.



Common bent-wing bat

The distribution of the common bent-wing bat is largely influenced by the availability of suitable roosting sites such as caves, mines, and tunnels. The little forest epitesicus, a species rarely found at high altitudes, occurs in low numbers. The most common species of bat here are the King River epitesicus, large forest epitesicus, and chocolate wattled bat.

Moist forests provide the major habitat for a number of bird species within the study area. Cool temperate rainforest is the most important breeding habitat of the pink robin (Loyn 1985). Rufous fantails migrate from northern Australia and breed primarily in the wet gullies. Moist forests that contain large, hollow-bearing eucalypts are important for a number of species that nest in hollows, such as the sooty owl, which is largely restricted to these forests. Powerful owls require large old eucalypts for nesting and roosting, and may reach maximum densities in old-growth damp sclerophyll forest. Other species restricted to moist forests include the large-billed scrubwren, pilotbird, rose robin, Lewins honeyeater, and helmeted honeyeater. Species most commonly encountered there include the golden whistler, crimson rosella, superb lyrebird, crescent honeyeater, and fan-tailed cuckoo.

These forests contain 33 species of reptile and amphibian, of which 88% occur in riparian forest complex. This community is widespread and incorporates areas with diverse temperature regimes, moisture contents, and soil types, and adjoins a range of other communities. As a result, it contains a diverse assemblage of reptiles and amphibians (for example, delicate skink, weasel skink, black rock skink, White's skink, white-lipped snake, and growling grass frog). Often within a landscape dominated by an even-aged forest, the gully vegetation retains mature hollow-bearing trees. Such trees offer basking sites for large species such as the tree goanna, and may also provide an important resource for developing young.

Stags that emerge above the canopy provide valuable habitat for the arboreal Spencers skink. It uses surfaces exposed to the sunlight for basking and foraging, and may exploit the crevices for shade or shelter and as sites for winter hibernation (Wilson and Knowles 1988). Some of the taller stags, up

to 75 m high, allow this skink to utilise a number of strata within the forest (Rawlinson 1974).

Two amphibians, Lesueurs frog and spotted tree frog, have been recorded only in riparian forest complex and both favour fast-flowing rocky streams. The Gippsland water dragon occurs along the Thomson River. The southern water skink (CTF), Coventry's skink, Spencers skink, Victorian smooth froglet, and tiger snake all require a moist environment and are commonly found within moist forests.

Dry forests

This vegetation category contains the foothill forest complex, dry sclerophyll forest, heathy dry forest, and rocky outcrop shrubland, at altitudes ranging from about 200 to 900 m. Rocky outcrop shrubland only occurs in small isolated locations, and is considered to be not a true community, but a grouping of quite distinct subcommunities. It is not an important habitat for mammals or birds, and was not sampled for these groups. However, it does provide valuable habitat for reptiles, which were investigated.

Mammal diversity is relatively high. The understorey, drier than that of the moist forests, supports lower densities of species such as the bush rat and dusky antechinus, whereas the brown antechinus reaches its highest concentrations here. The white-footed and common dunnarts both occur in dry sclerophyll forest, although not at the same sites. Most of the brush-tailed phascogale records have come from dry sclerophyll forest. The smoky mouse depends on a diverse dry heathy understorey, and is only found in the heathy dry forest within this vegetation category. The foothill forest complex on French Island supports species such as the long-nosed potoroo and swamp rat. The eastern grey kangaroo is commonly observed in dry forests.

The bat fauna of the dry forests is similar to that of the moist forests, except that the large-footed myotis is absent and the eastern horseshoe-bat has been recorded in dry sclerophyll forest where most of the mine-shafts providing suitable roost sites occur.

Within the study area, dry forests provide habitat for many widespread forest-dwelling



An eastern grey kangaroo in Fraser National Park

bird species such as the Australian owl-nightjar, rufous whistler, grey shrike-thrush, yellow-faced honeyeater, and striated thornbill, and thus share a range of species with moist forests. Other species, such as spotted quail-thrush, fuscous honeyeater, and leaden flycatcher, are only found in, or reach their highest densities in, dry forests. Species at the southern edge of their range, and more common north of the Divide, include the black-eared cockatoo, red-capped robin, hooded robin, white-throated gerygone, black-chinned honeyeater, and noisy friarbird.

Cicadabirds appear to be more common in dry forests in the north of the study area than elsewhere. The chestnut-rumped hylacola utilises the heath and understorey found in heathy dry forest.

Diversity of reptiles and amphibians reaches a peak in these forests, where 45 species have been recorded. Unlike the moist forests, these communities have a relatively even distribution of species. Dry sclerophyll forest supports the greatest diversity, with 23

species recorded. This richness may be explained, in part, by a sparser upper canopy that allows greater solar penetration to potential basking sites. The grassy understorey found here is an essential habitat requirement for some species, such as the delicate skink, eastern three-lined skink, and growling grass frog.

Although not widespread within the study area, rocky outcrop shrubland appears to be an extremely valuable habitat for reptiles. Exfoliating granite outcrops, such as near Tallarook, provide ideal shelter-sites for the black rock skink, grass skink (Form A), Cunninghams skink, and little whip snake. The large striped skink is also confined to rocky areas (characterised by the lack of any overstorey) and is usually associated with a grassy understorey. Cunninghams skink relies upon large boulders for refuge and is therefore restricted, in the dry forests, to areas containing this type of microhabitat.

Species more typical of habitats at lower altitudes (such as Bougainvilles skink, lowland copperhead, and eastern small-eyed snake) reach their upper altitudinal limit in dry forests.

Plains vegetation

Four communities comprise this vegetation category. Very little plains vegetation remains on public land, as most has been cleared for agriculture. Box woodland, characterised by grey box, now occurs only as remnants north of the Divide. Plains grassy woodland and floodplain riparian woodland both have an overstorey dominated by river red gum. The latter woodland grows along major rivers and creeks, such as the Goulburn River and King Parrot Creek, while the former occurs away from the rivers, often on volcanic soils, such as throughout the Whittlesea area. In Appendix V these two communities have been grouped together under the name of floodplain riparian woodland. Wetland community complex, which incorporates wetland areas in the north of the study area, has only been assessed for birds.

The composition of the mammal fauna in this vegetation category differs from that found in higher-altitude mountain forests in a number of ways. Several of the arboreal mammals such as the mountain brushtail possum,

yellow-bellied glider, and greater glider are absent, and species such as the common brushtail possum, common ringtail possum, and sugar glider predominate and reach their highest densities here. The rare squirrel glider has only been recorded, in the study area, in box woodland near Seymour.

Floodplain riparian woodland and plains grassy woodland, combined, support a diverse bat fauna, with 12 species recorded. It is the only community in the study area with records of the little mastiff-bat, which is characteristic of areas north of the Divide, and both forms are found here. The large-footed myotis lives in floodplain riparian woodland, where it forages over water bodies. Other significant bat species recorded include the eastern broad-nosed bat and common bent-wing bat.

Plains vegetation has a characteristic avifauna. Woodlands dominated by river red gum on basalt soils immediately north of Melbourne, and along the Goulburn River floodplain, contain permanent wetlands as well as seasonally flooded grasslands and herblands. Characteristic species where river red gum dominates are red-rumped parrot, long-billed corella, whistling kite, dollarbird, and noisy miner. In the study area, wetland community complex is the main habitat for birds such as yellow-billed spoonbill, Baillons crane, and little bittern, as well as providing habitat for widespread species such as grey teal, Pacific black duck, and purple swamphen.

A number of species that are more widespread in northern Victoria are found in box woodland, including western gerygone, peaceful dove, southern whiteface, and black-chinned honeyeater. Common ones here include white-plumed honeyeater, buff-rumped thornbill, and weebill.

Within the study area, the plains vegetation supports 23 reptile and 12 amphibian species. The large number of amphibians may be attributed to the number of wetland sites associated with this vegetation category, which provide a range of habitat, especially where most of the natural vegetation has been left undisturbed and intact. Characteristic species are the grass skink (Form A), three-toed skink, little whip snake, common long-necked tortoise, and striped marsh frog. The little whip snake, although not widespread

here, may be found in large numbers in plains grassy woodland. The grass skink (Form A) is not found in the low-lying swampy areas, and appears to favour open grassy sites. The large striped skink may occupy dry, rocky country with a river red gum overstorey, and often with a grassy understorey. Five species have only been recorded within the floodplain riparian woodland and plains grassy woodland: common spadefoot toad, Perons tree frog, striped legless lizard, eastern bearded dragon, and lined earless dragon. The striped legless lizard is considered vulnerable in Victoria, and the lined earless dragon is endangered. Thus, this vegetation category contains not only a relatively high species richness, but also a number of significant species.



Perons tree frog

Heathland vegetation

Heathy woodland and wet, sand, and coastal heathlands comprise heathland vegetation. Most of these communities have a dense shrubby understorey with, or without, a eucalypt overstorey. Heathy woodland has a floristically rich grassy understorey, and occurs in the foothill country from Cockatoo to Moondarra. Interspersed among it, wet heathland occupies seasonally waterlogged soils. Closer to the coast, sand heathland is widespread, while the coastal heathland is largely restricted to French Island.

The heathy understorey of this vegetation category supports a rich small mammal fauna with characteristic species including the swamp rat, bush rat, brown antechinus, and southern brown bandicoot. The endangered New Holland mouse has only been recorded, in the study area, in three localities, all in sand heathland. The swamp antechinus also has restricted habitat preferences, being found near the coast, in heath or tussock grasslands, except for an isolated inland

record in wet heathland in the Bunyip State Park. The long-nosed potoroo occurs in sand heathland and coastal heathland on French Island.

Arboreal mammal diversity is low in these heath-dominated communities. The common ringtail possum is common and widespread, whereas the yellow-bellied glider has only been found in heathy woodland in the foothills. Koalas are common. Seven species of bat have been recorded, all of which are common and widespread at low elevations.

A characteristic bird fauna uses the shrub layer typical of this vegetation category, feeding on the numerous nectar-producing plants (like the New Holland honeyeater), or finding suitable cover and foraging substrates within the dense shrub layer (like the southern emu-wren, chestnut-rumped hylacola). Clearance of wet heathland appears to have caused a decline in the distribution of the beautiful firetail in the study area. Other uncommon or rare species recorded from wet heathland include Lewins rail, king quail, and brown quail. Species commonly encountered in heathland vegetation include crimson rosella, scarlet robin, grey shrike-thrush, and superb fairy-wren.



Ringtail possums

Of the 27 species of reptile and amphibian recorded heathland vegetation, common ones include the garden skink, tree dragon, common froglet, southern bullfrog and southern brown tree frog. The southern toadlet is a common inhabitant of the heaths south of the Divide. Less frequently encountered species found in sand heathland are the white-lipped snake, growling grass

frog, and metallic skink. Haswells froglet, more commonly found along the eastern Victorian coast, has been recorded in the study area only in heathland vegetation.

Coastal vegetation

This category includes coastal grassy forest, swamp scrub, dry coast complex (incorporating coastal dune scrub, coastal banksia woodland, and coastal tussock grassland), and coastal salt-marsh (including mangroves). Many of these communities occur as small and often linear areas, that are surrounded by several other communities, making it difficult to determine precise habitat utilisation. The faunal lists for some of them may be incomplete.

Two uncommon species of mammal, the swamp antechinus and white-footed dunnart, occur in coastal tussock grassland. Sea caves along the southern coast of the Mornington Peninsula provide roosting sites for the common bent-wing bat. For other species of non-cave dwelling bats, the lack of suitable roosting sites (tree hollows) restricts use of these areas, but individuals roosting nearby are likely to forage here.

The ability of the common ringtail possum to construct nest-like dreys, and so not depend on tree hollows, has allowed it to become the most widespread arboreal mammal. The common brushtail possum and sugar glider are found in coastal grassy forest where tree hollows are more abundant. Very few native mammals utilise coastal salt-marsh; however, the swamp wallaby will forage in this community.

Coastal bird species such as the red-capped plover, hooded plover, and pied oystercatcher feed and nest on the beach and in the foredunes of this vegetation category. On the southern coast of Phillip Island, the extensive areas of dry coast complex contain nesting sites for large numbers of short-tailed shearwaters and little penguins. In coastal dune scrub, the coastal tea-tree provides dense cover for forest birds such as grey fantails as well as two species, the singing honeyeater and spiny-cheeked honeyeater, that (in the study area), specialise in coastal vegetation. Coastal banksia woodland offers abundant foraging opportunities for lorikeets and honeyeaters (such as the little wattlebird).

The extensive coastal salt-marsh in Western Port is the primary habitat of the calamanthus, and also supports Lewins rail and Japanese snipe. On French Island, coastal salt-marsh is used in autumn by orange-bellied parrots, and by the Australian pelican for nesting. Mangrove vegetation is also used by Lewins rail, as well as by black swans, sacred ibis, white-faced heron, and other water- and wading birds, such as grey-tailed tattler. Pied cormorants have nested in mangroves on French Island. Some forest birds such as the brown thornbill also forage in mangroves.

Coastal vegetation provides habitat for 21 reptile and 7 amphibian species. Coastal grassy woodland supports the most diverse herpetofauna, with 77% found here. Species associated with this community include the southern water skink (CTF), delicate skink, weasel skink, eastern small-eyed snake, eastern three-lined skink, and southern toadlet.

The glossy grass skink, listed as a threatened species in Victoria, apparently occupies swamp scrub almost exclusively. Another threatened species with a restricted distribution, the swamp skink, occurs within this community and also inhabits the tidal coastal salt-marsh areas within Western Port. The only other species able to tolerate these tidal conditions are the metallic skink and glossy grass skink. The common scaly-foot, a cryptic legless lizard, occurs as remnant populations in coastal tussock grassland on the Mornington Peninsula, where cracking soils and grassy tussocks appear to be important.

Coastal embayments and oceans

A large number of marine mammals have been recorded in coastal regions of the study area. Seal Rocks, off Phillip Island, supports the largest Victorian breeding colony of the Australian fur-seal. The coastal waters are used by a number of whales and dolphins, some of which, such as common dolphin and bottle-nosed dolphin are resident, while others, such as southern right whale and humpback whale use the area on a seasonal basis.

Western Port has an extensive coastline, large areas of shallow waters, and at low tide substantial mud and sand flats. Together



Australian fur seals at Seal Rocks, Phillip Island

with the inshore ocean waters, it supports a large number and variety of birds. Western Port is used by at least 37 species of wading birds (Loyn 1978), including significant numbers of eastern curlew, double-banded plover, greenshank, grey-tailed tattler, and curlew sandpiper. The coastline is habitat for the sooty oystercatcher, pied oystercatcher, hooded plover, and red-capped plover.

Large numbers of the crested terns and silver gulls roosting on ocean and bay beaches, in addition to small numbers of caspian terns. Ocean beaches are used by small numbers of sanderlings. Species such as Arctic jaegers and black-faced shags occur mainly at the entrances to Western Port. Other sea-birds use embayments (like the little penguin and short-tailed shearwaters), while the many in inshore ocean waters include black-browed and shy albatross, fluttering shearwater, Australasian gannet, and white-faced storm-petrel. A full list of sea-birds recorded for the study area, either as sightings or beach-washed birds, is included in Appendix V.

Significant and Notable Vertebrate Fauna

A number of vertebrate taxa have been identified as being of 'significant' or 'notable' status in the study area. The large number here relative to other LCC study areas reflects its importance for the conservation of vertebrate fauna in Victoria. Of the native species recorded, 24% of the mammals are considered significant or notable, as are 11% of the birds, 21% of the reptiles, and 18% of the amphibians.

Criteria used in assessing status

A taxon is listed as 'significant' if it conforms to either of two criteria.

- * It is considered to be threatened in Victoria and is in the IUCN categories of endangered, vulnerable, or indeterminate.
- * The study area is important for its total conservation.

Taxa are listed as 'notable' if they conform to either of the following criteria.

- * The taxon is considered to be threatened in Victoria and is in the IUCN categories of rare, indeterminate, insufficiently known, or restricted colonial breeding or roosting sites.
- * It is threatened regionally.

Species categorised as indeterminate have been allocated to significant or notable depending on the importance of the study area for the species (for example, if only old records exist, the species may warrant a notable classification).

A full list of taxa considered significant or notable in the study area is presented in Appendix VI, together with: an assessment of their distribution and abundance in Australia, in Victoria, and in the study area; their conservation status in Australia and Victoria; and the population trend since European settlement in Victoria. Appendix VI also provides definitions of the IUCN threatened-species categories.

Significant Taxa - Mammals

Tiger quoll (*Dasyurus maculatus*)

The tiger quoll is the largest marsupial carnivore surviving on the Australian mainland. It is limited to eastern Australia, and the distribution at the time of European settlement approximated the region receiving a mean annual rainfall in excess of 600 mm (Mansergh 1984). In Victoria this was concentrated on the Great Dividing Range and included 60% of the State. Since European settlement the range has contracted by about half. Changes in abundance are more difficult to assess; however, many early accounts (including that of Wheelwright) considered the species to be rare. A combination of habitat destruction, widespread trapping and poisoning, and possible competition for food with foxes and feral cats, has probably caused the decline in this species (Mansergh 1984), which is now classified as vulnerable in Victoria.

Little is known of its biology, but it makes nests in hollow logs and trees, and is an opportunistic predator on a range of terrestrial and arboreal species including

birds, arboreal mammals, and reptiles (Edgar 1983). Habitat destruction in the form of clearing, or timber-harvesting, is likely to have deleterious effects on the availability of nest sites and food.

Records of tiger quolls are scattered widely throughout the Central Highlands; however, very few are within conservation reserves. There are few records subsequent to 1970.

Leadbeaters possum (*Gymnobelideus leadbeateri*)

In 1960, Leadbeaters possum was listed as 'probably extinct'. At this time, only five specimens had been collected, all before 1910: three came from the Bass River area, one from Tynong on the edge of the Koo-Wee-Rup Swamp, and one from Mount Wills 250 km north-east of Bass River. As



Leadbeaters possum

virtually all of the forest had been cleared from the first two localities, and numerous searches in all three had failed to locate any more animals, its survival was considered unlikely.

In 1961, however, Leadbeaters possum was rediscovered at Tommy's Bend near Marysville in the Central Highlands

(Wilkinson 1961). Since then it has received considerable attention from the general public and wildlife biologists. Extensive surveys and intensive research have greatly increased our knowledge of the species. The Department of Conservation and Environment has recently prepared a draft management strategy (Macfarlane and Seebeck 1991) with the aim of ensuring its long-term conservation.

The species is now classified as endangered, and the entire range occurs within the study area. It is largely restricted to the montane ash forests of the Central Highlands, within a tract less than 100 x 100 km. Not all ash forest within this area supports suitable habitat, and the distribution of the species is patchy and disjunct (Smith and Lindenmayer 1988). The possum has recently been found at one locality outside the Central Highlands, in the Yellingbo State Nature Reserve - a lowland, swamp-gum-dominated forest along the Cockatoo Creek. This habitat differs markedly from those in the Central Highlands, but may be similar to the site where the early specimen was collected from the edge of the Koo-Wee-Rup Swamp.

Leadbeaters possum, its habitat requirements, and the draft management plan prepared for its protection are discussed in Chapter 20.

Large-footed myotis (*Myotis adversus*)

This rare bat feeds on aquatic insects and small fish taken from the surface of water. Thus, its distribution is restricted to areas containing suitable permanent water bodies, mainly relatively slow-flowing rivers and creeks at low altitudes (see Figure 2). However, its precise habitat requirements are not known, and the species has not been recorded at many apparently suitable sites. In the recent survey of the Central Highlands, the Wildlife Branch caught the large-footed myotis at only five of the 42 sites trapped specifically for this species, which comprised less than 1% of the 5000 bats trapped. The large-footed myotis was originally recorded as a cave-roosting species in Victoria; however, these caves were deserted soon after discovery, and very few roosting sites have since been located. It is now thought that this bat probably uses tree hollows, in addition to caves and tunnels. Due to its rarity and our lack of knowledge about it, the species has been classified as indeterminate in

Victoria (that is, known to be endangered, vulnerable, or rare, but with insufficient information available to decide which of these applies).

As the species is restricted to areas with permanent water, the majority of known sites in the study area are in riparian forest complex, with some in floodplain riparian woodland. The bat has been recorded on the Goulburn, O'Shannassy, Taponga, Tyers, and Yarra Rivers, and also uses smaller creeks such as Badger Creek at Healesville and Walsh Creek in the Upper Yarra catchment. Most of these sites are outside conservation reserves, although several are within Board of Works-controlled catchments. As the species depends on the aquatic environment, any practices that adversely effect this are likely to be detrimental to its conservation. However, the detailed effects of practices such as timber-harvesting and associated road-building are not known.

Eastern broad-nosed bat (*Scotorepens orion*)

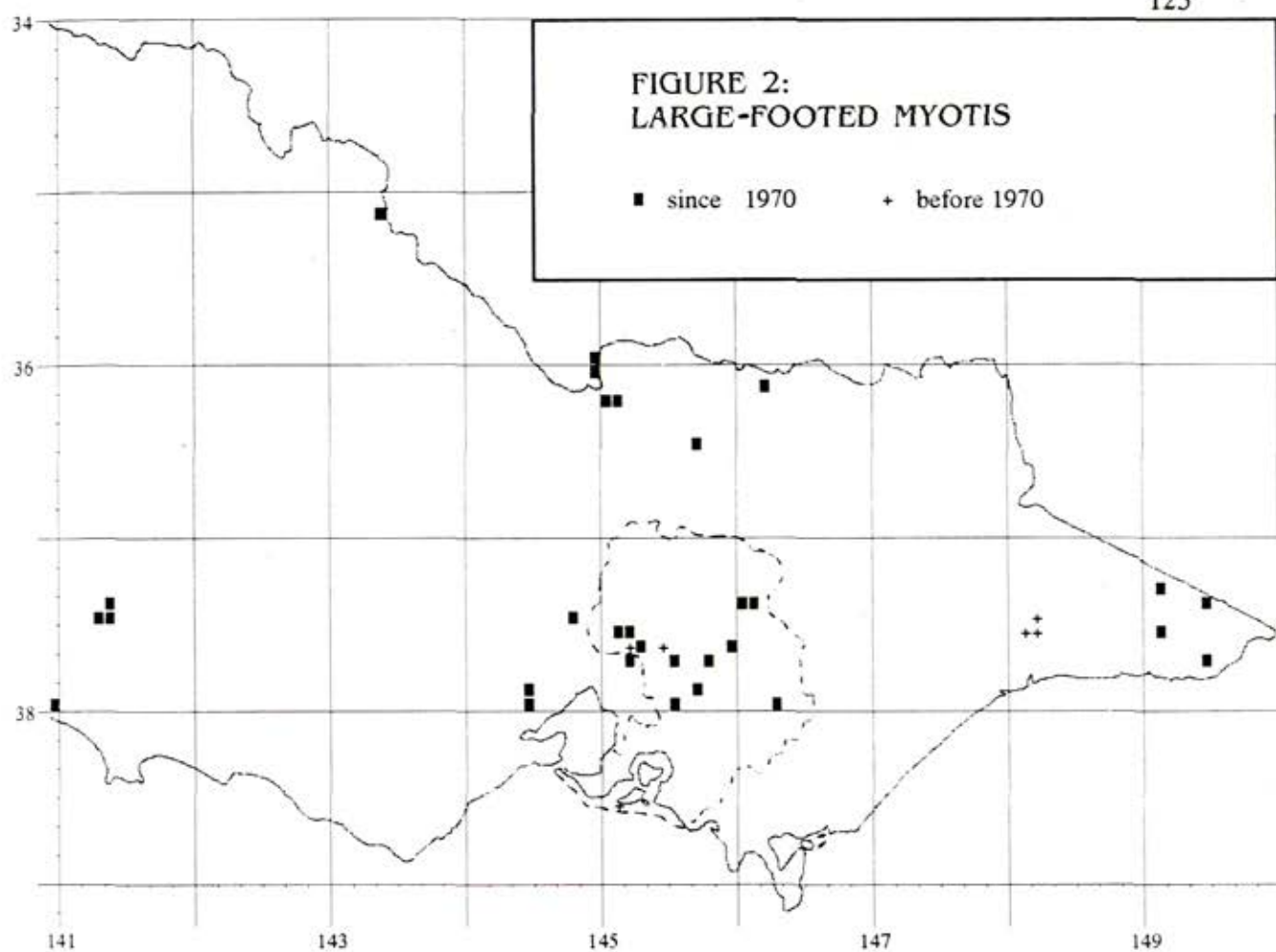
Its taxonomic status has been in a state of flux for many years, and the eastern broad-nosed bat has frequently been included with other broad-nosed bats. Recently Kitchener and Caputi (1985) have elevated it to full species status. In external appearance it is very similar to the western broad-nosed bat (*Scotorepens balstoni*) and the distribution of the two in Victoria is still being resolved. Further information is required to clarify its distribution, abundance, and ecological requirements before its conservation status can be fully ascertained, and meanwhile it has been classified as indeterminate. Records in the study area have come from the outer suburbs of Melbourne such as Eltham, Braeside, and at Healesville, in riparian and heathland vegetation.

New Holland mouse (*Pseudomys novaehollandiae*)

The first record of the New Holland mouse in Victoria occurred in 1970, on private land at Tyabb on the Mornington Peninsula. Since then it has been recorded at several other sites along the coast in coastal heaths (see Figure 3). However, its distribution remains disjunct and restricted, and it is classified as endangered in this State. Within the study area, in addition to Tyabb, the species has

**FIGURE 2:
LARGE-FOOTED MYOTIS**

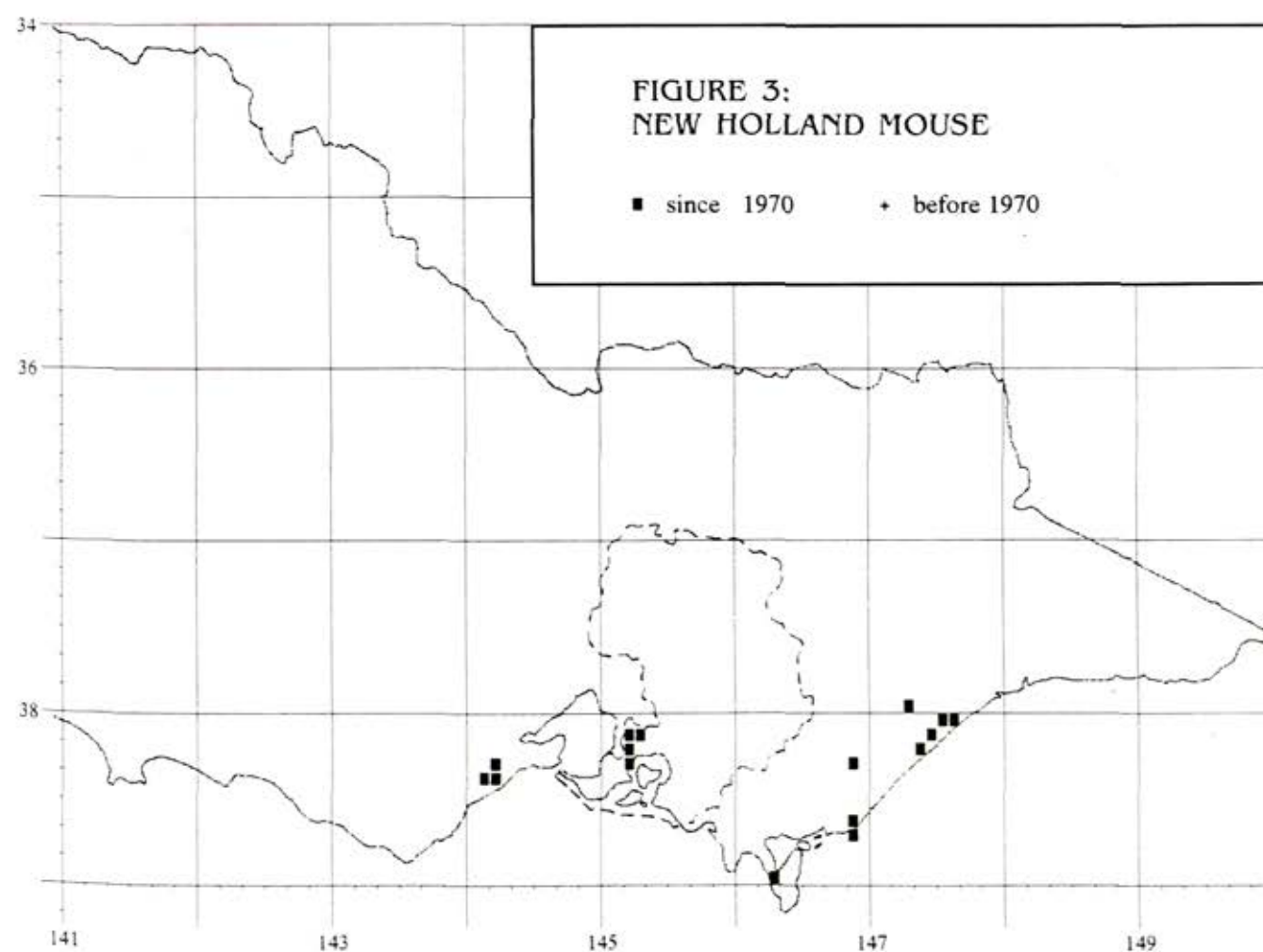
■ since 1970 + before 1970



Source: Atlas of Victorian Wildlife

**FIGURE 3:
NEW HOLLAND MOUSE**

■ since 1970 + before 1970



Source: Atlas of Victorian Wildlife

been recorded at the Cranbourne Annex of the Royal Botanic Gardens and Langwarrin Flora and Fauna Reserve. However, it was last recorded at Tyabb in 1972, at Cranbourne in 1976, and at Langwarrin in 1983. Extensive trapping at Langwarrin in recent years has failed to detect any animals (Brereton *et al.* in prep.). It is likely that the New Holland mouse is now very rare, or possibly extinct, in the study area.

The New Holland mouse has been described as a habitat specialist and a food generalist (Braithwaite and Gullan 1978). It feeds on a wide range of foods such as seeds, root material, fungi, moss sporangia, and insects (Watts and Braithwaite 1978). The introduced house mouse also has a preference for the early stages of regenerating heath, but it has been shown that the species, where they co-exist, have a strong dietary separation (Cockburn 1980). Both species are omnivorous, but the house mouse tends towards an insect diet and the New Holland mouse towards a diet of grains. Further research is required to determine the current status of this species in the study area and to ascertain appropriate management strategies.

This species has very restricted habitat requirements. All the above sites are in the sand heathland community, and the animal appears to depend on regenerating heath between 2 and 8 years after fire or clearing. At some of the known sites, especially Tyabb, the vegetation is now much older than this, and is probably no longer suitable for the species. At Langwarrin, however, in an attempt to provide suitable habitat, a program of prescriptive burning to produce a mosaic of different-aged heaths has been carried out since 1980.

Australian fur-seal (*Arctocephalus pusillus*)

This is the most common of the three species of seals resident in Australian waters. It is found throughout Bass Strait and around Tasmania, and extends along the east coast of the mainland into south-eastern New South Wales. Early last century intensive sealing in Bass Strait almost wiped out the population. Since becoming a protected species, which in Victoria occurred in 1891 (Warneke 1983), its numbers have recovered and are now stable at approximately 30 000. However, the original population was probably two to five times greater.

Australian fur-seals use traditional breeding sites, where the large males establish territories, mating occurs, and the females give birth to their young. There are only nine of these breeding colonies, of which the Victorian ones comprise half the total population. Seal Rocks State Faunal Reserve, off Phillip Island, contains the largest Victorian of these, estimated at 5600 individuals and hence the study area is important for the conservation of the species. The seals can be observed in the study area along the ocean coastline, as well as within Western Port.

Southern right whale (*Baleana glacialis australis*)

In the 1800s when whaling first began in Victoria, the slow speed of the southern right whale, and the fact that it was so rich in oil that it floated even when dead, led to its name as the 'right' whale to hunt. Throughout the summer, the southern right whale feeds in the plankton-rich sub-Antarctic waters, moving north to spend the winter along the coasts of South America, South Africa, New Zealand, and southern Australia. In order for the calves to survive they need to be born in relatively warm water, and the whales use sheltered bays close inshore for calving. This made them very vulnerable to bay-based whaling, and last century many whaling stations were set up along the Victorian coast. By 1843 the number of southern right whales wintering here was on the decline, and in the 1850s most of those companies were dissolved. Ship-based whaling then took over as the main hunting method. By the end of the 19th century, the southern right whale was on the edge of extinction. In 1935 it became the first whale to be protected by international agreement and, although it is still rare, with a total world population of only approximately 2000, its numbers show signs of a slow recovery. It is classified as endangered in Australia (CONCOM 1990) and vulnerable in Victoria.

In recent years individuals have been seen regularly along the Victorian coast, and females are returning to traditional breeding areas, such as Logans Beach near Warrnambool, to give birth to their young. In the last 10 to 20 years the number of sightings of the southern right whale off the coastline of the study area has been increasing.

Humpback whale (*Megaptera novaeangliae*)

Like the southern right whale, the humpback has been extensively hunted since the 1840s. However, exploitation of this species continued for longer, with more than 20 000 humpbacks taken by Australian shore stations between 1949 and 1962. It is now estimated that less than 2000 remain in the Southern Hemisphere (Watson 1981). The species is classified as endangered in both Australian (CONCOM 1990) and Victorian waters.

Two virtually independent populations are recognised and each spends the summer in different areas of Antarctic waters. Each population migrates north, one up the west coast of Australia and the other up the east coast, including the islands of the south-west Pacific. The western edge of the east coast migration route follows the east coast of Tasmania and New South Wales; however, some animals enter Bass Strait and several have been off the study area coastline.

Significant Taxa - Birds

Little penguin (*Eudyptula minor*)

The little penguin - the world's smallest penguin - is the only species to breed in Australia. It nests on islands and occasionally on the coast of the southern mainland and Tasmania, mainly in burrows (Emison *et al.* 1987). It feeds at sea, tending to keep within 20 km of the coast, where it catches small schooling fish and squid. In Victoria it breeds in suitable habitat along the entire coastline. The largest breeding colonies occur on Gabo Island in eastern

Victoria and on Phillip Island. In 1978 Harris and Norman (1981) estimated approximately 20 000 little penguin burrows in the State (an index of the size of the breeding population), with about 30% on Phillip Island and 30% on Gabo Island. Outside the breeding season, little penguins may forage at sea for many weeks. Those on Phillip Island appear to move mainly into Port Phillip Bay in the non-breeding season (Weavers in prep.).

The Phillip Island population has declined substantially, but now shows signs of stabilising (Dann in prep.). Substantial efforts have been made to protect breeding habitat and remove introduced predators from nesting colonies. The pilchard and anchovy fishing industry is a potential competitor for food resources, and a recent increase in the commercial harvest of whitebait in Port Phillip Bay is of concern. Parts of Port Phillip Bay and Bass Strait have primary importance as foraging areas for adult little penguins from Phillip Island. As an important step to ensure conservation of the colony on Phillip Island, these areas require special care to protect them from disturbance (for example, oil spills, dredging, overfishing).

Short-tailed shearwater (*Puffinus tenuirostris*)

The short-tailed shearwater is a sea-bird that breeds exclusively in Australia and lives at sea for extended periods of time, feeding on krill and small squid. It leaves each year in May to winter in the northern Pacific and returns in the following September to breed on islands in south-eastern Australia. In Victoria, it breeds in excavated burrows in soil under vegetation. Most nesting takes place on Gabo Island, on islands off Wilsons Promontory and off Port Fairy, and, in the study area, on Phillip Island and French Island. The largest numbers nest on the north-western and southern coastlines of Phillip Island (Andrew *et al.* 1984). The number of nesting burrows (an index of the population size) in Victoria was estimated in 1979 to be 1.45 million, or approximately 10% of the world total (Blakers *et al.* 1984). At this time, the Phillip Island population was estimated to be 540 000, or approximately 30% of the State total (Harris and Bode 1981). The majority of nesting colonies occur on public land managed by DCE. Factors such as a reduction in fish



Little penguins

availability may affect short-tailed shearwater numbers, and so the size and status of shearwater populations should be regularly assessed.

Australian pelican (*Pelicanus conspicillatus*)

This well-known, large, moderately common water-bird occurs on open wetlands, tidal bays, and estuaries in the study area. Pelicans nest in colonies, and in Victoria they breed at only four sites, one of which is within the French Island State Park, where approximately 100 pairs nest in spring and summer. Its restricted, colonial breeding strategy has resulted in the Australian Pelican being placed on the Victorian threatened



Australian pelican

species list. With a significant proportion of the State's breeding population found on French Island, the study area is important for the conservation of the species in Victoria.

Pied cormorant (*Phalacrocorax varius*)

Being large fish-eating birds, which catch their prey by underwater pursuit, pied cormorants live in large fresh-water and saline wetlands and tend to be most common in coastal embayments. They are widespread in Australia and Victoria and are relatively common throughout their range, but have a restricted breeding distribution. They build their nests in trees within lakes and mangroves. In Victoria, few permanent breeding colonies are known, the largest being at Lake Borrie west of Port Phillip

Bay, where 150 pairs nest (Emison *et al.* 1987). Pied cormorants have probably nested in Western Port for most of this century. The most recent colony was at Clump Lagoon on French Island, where 150 pairs bred in 1980. They abandoned the colony site when the nest trees collapsed and, although no new colony site has been located, are probably still nesting in Western Port. Potential breeding sites can be preserved by protecting the remaining wetlands and mangroves around Western Port from clearance and drainage. Any nesting colonies within the study area have conservation values for the species.

Square-tailed kite (*Lophoictinia isura*)

The square-tailed kite, a bird of prey, specialises in hunting among the canopy of trees, catching insects and nestlings of smaller birds (Frith 1979). In southern Australia it shows a preference for open forests and woodlands, particularly on fertile soils.

The species is uncommon to rare throughout its range (Brouwer and Garnett 1990) and is considered vulnerable in Victoria. Records are scattered throughout the State and the kites migrate here in spring to breed. Habitat destruction and alteration have probably caused a decline in the population in Victoria, now estimated to be less than 50 breeding pairs (Debus and Silveira 1989). Of the few sightings recorded in the study area, the most recent occurred in 1989, when an individual was observed in foothill forest complex in the Black Range, east of Woodbourne.

King quail (*Coturnix chinensis*)

This species, a small granivorous bird, lives in pairs or small groups and forages and nests on the ground. In Victoria it appears to favour wet treeless heaths (Emison *et al.* 1987). Elsewhere in Australia, it also occurs in very dense wet grasslands and on swamp edges. In subtropical heaths, king quail prefer 'middle-aged' heaths (2.5–7.5 years since the last fire), which have the highest vegetation density and seed production. This preference may also apply to the Victorian population.

King quail range from India and south-east Asia through to Australia. Australian records

are all broadly coastal, including northern, eastern, and south-eastern Australia, but rare in Victoria, with only six sightings reported here between 1973 and 1986 (Emison *et al.* 1987). Most of these records came from French Island, where a resident population occupies coastal heathland and has been recorded breeding there since 1986. Management of the fire regime in these heaths is likely to be important in maintaining king quail on French Island. Draining and clearance of wet heaths has eliminated the species from areas near Melbourne.

Plains-wanderer (*Pedionomus torquatus*)

The plains-wanderer is a small quail-like bird that nests and forages on the ground, feeding on insects and seeds. Its preferred habitat is open native grassland where the cover of grass is approximately 50%. Its current distribution is restricted to parts of: western Victoria, the Riverina in southern New South Wales, the Mallee, north-eastern South Australia, and south-western Queensland (Baker-Gabb *et al.* 1990). It is considered rare in Australia (Brouwer and Garnett 1990) and vulnerable in Victoria. The main causes of its decline in range and abundance are overgrazing, cultivation, and pasture improvement, leading to the extinction of local populations. In the study area, plains-wanderers have been recorded immediately east of the Hume Highway on private land, most recently in 1983. All records are from private land. Here the plains-wanderer is at the south-eastern edge of its known range and the study area probably never contained substantial areas of suitable habitat.



Plains-wanderer

Bush thick-knee (*Burhinus magnirostris*)

This species is a ground-dwelling bird whose presence is often only detected by its mournful nocturnal call. It is omnivorous and nests on the ground. In Victoria, the bush thick-knee now lives in open grassy woodlands and wooded farmland in the north and west. Its range has declined markedly since European settlement, especially in southern central Victoria (Emison *et al.* 1987). It is now considered vulnerable in Victoria. It was present around Western Port last century and was probably moderately common in grassy woodlands in the north-west of the study area. A small population of less than 20 individuals survives in the far north of the study area on land owned by the Commonwealth Department of Defence, where breeding was recorded in 1990. The decline in numbers and distribution of bush thick-knees has been attributed to clearance and fragmentation of habitat, and predation by foxes and cats. Some suitable habitat occurs in roadside reserves and small nature reserves. Conservation of this species requires the control of introduced predators, and the management of remnant vegetation in cooperation with private land-owners.

Pied oystercatcher (*Haematopus longirostris*)

The pied oystercatcher is a medium-sized shore-bird, whose red bill and legs contrast strikingly with its black and white plumage. It lives on beaches and estuaries around Australia, feeding in the littoral zone and nesting above the high-tide mark. In the study area, it inhabits muddy shores, sandbanks, and sheltered rocky or sandy beaches, especially if near mudflats. Pied oystercatchers are relatively common in Western Port and the population here appears to be increasing: it is now the second-largest breeding population in Victoria (which contains a total of only about 1200 individuals), (Lane 1987) and is important for the conservation of this species. Nesting pied oystercatchers are vulnerable to disturbance by people and dogs using beaches, and to predation by foxes.

Hooded plover (*Charadrius rubricollis*)

This small endemic wader lives on sandy ocean and bay beaches. It feeds on invertebrates caught in the intertidal zone, and nests above the high-tide mark on the

beach and in the dunes. It appears that hooded plovers have always occurred in low numbers and have always been restricted in their distribution. However, numbers are likely to have declined since European settlement and the Victorian population is now estimated at no more than 500 pairs (Schulz and Bamford 1987). It is considered to be vulnerable in Victoria.

Within the study area, the birds are found in low numbers along all ocean beaches, although uncommon in the muddier beaches within Western Port. Nesting hooded plovers are highly vulnerable to disturbance by people, dogs, and other introduced predators. On Phillip Island, the population size is stable, despite observations of very low breeding success: in 1989, the local council banned dogs from beaches where hooded plovers were nesting, and breeding success subsequently rose. Population size on other study area ocean beaches also appears stable (Murliss 1989).

Eastern curlew (*Numenius madagascariensis*)

The eastern curlew, a large wading bird, breeds in the eastern Soviet Union and spends the northern winter in Australia where it feeds in estuaries, mudflats, and sandy beaches, preferring mudflats with extensive seagrass meadows (Lane 1987). The world population of eastern curlews is thought to be less than 20 000 individuals, most of which overwinter in eastern Australia. It is a rare species in the State. Within Victoria its largest populations live on tidal mudflats in Corner Inlet (counts of 1740 birds) and in Western Port (1020 birds), which is its fourth-most important overwintering site in Australia (Lane 1987). A decline in the population size in Western Port in the 1970s appeared to be associated with an 85% reduction in the biomass of seagrass in the bay; however, eastern curlew numbers have subsequently recovered, while seagrass communities do not appear to have. Conservation of eastern curlews and many other shore-birds in the study area requires further research to understand and better manage the seagrass communities of Western Port.

Little tern (*Sterna albifrons*)

The little tern is the smallest tern in Australia. It is migratory, arriving in spring to breed in eastern and south-eastern

Australia on ocean beaches or islands, usually associated with estuaries. The birds tend to nest in colonies and, during nesting, are vulnerable to disturbance from people and introduced predators such as dogs. Their Australian population is less than 1000 pairs, of which an estimated 120 pairs live in Victoria (Hill *et al.* 1988) where they are considered an endangered species. Larger numbers of non-breeding little terns visit the Victorian coastline, from populations probably breeding in the Northern Hemisphere. They are very rare visitors to Western Port (Andrew *et al.* 1984) and no breeding has been recorded in the study area, although a small population regularly uses Port Phillip Bay in winter.

Fairy tern (*Sterna nereis nereis*)

Another of Australia's smallest terns, this is a breeding resident in coastal Victoria. It inhabits sheltered bays and estuaries where it catches small fish and crustaceans, and nests on small sandy and rocky islands and ocean beaches, generally near sheltered water (Hill *et al.* 1988). Most of the world's fairy terns live in Australia (with small populations of two other subspecies occurring in New Caledonia and New Zealand), but the bird is rare even here, with a total of about 2000 individuals (Hill *et al.* 1988). In Victoria, the fairy tern occurs primarily in Port Phillip Bay, Western Port, Corner Inlet, and the Gippsland Lakes. Up to 40 pairs nested regularly at Rams Island in Western Port from 1974 until 1987, but in 1988 this ceased, possibly because of flooding of nesting sites caused by very high tides. The Western Port population seemed to disappear and fairy terns are now rarely seen in the study area. This population is now appears to be nesting in East Gippsland. Rams Island may again become important for this species, and should continue to be managed to allow fairy terns the option of recolonising Western Port.

Swift parrot (*Lathamus discolor*)

Being nectarivorous, the swift parrot resembles the lorikeets in behaviour and ecology. It is gregarious, feeding in small parties on the blossom of eucalypts, calling noisily while feeding and flying. The swift parrot is rare throughout its range, with the total population estimated in 1989 as 1320 breeding pairs (Brown 1989). It occurs in a

range of forest types, moving semi-nomadically according to the timing of eucalypt flowering in a particular year. It breeds on the eastern coast of Tasmania, in hollows in blue gums, only where the blue gums are flowering. In March the majority of the population migrate to Victoria, while some go further north into New South Wales. Here they feed primarily on flowering eucalypts such as manna gum, grey box, red ironbark, yellow gum, white box, and swamp gum.

In the study area swift parrots favour dry forests, however they will use moist forests where suitable flowering eucalypts occur. For example, approximately 200 birds visited flowering manna gums at the Yellingbo State Nature Reserve in March 1990. The marked decline in numbers has been attributed to clearance and harvesting of blue gum in Tasmania, and extensive clearing of winter-flowering eucalypts in northern Victoria and central New South Wales. In Victoria, recommended conservation measures include reducing harvesting of box-ironbark forests in the north and planting winter-flowering eucalypts in rural areas.

Orange-bellied parrot (*Neophema chrysogaster*)

This small parrot visits Victoria each year from its breeding range in south-western Tasmania, where it nests in tree hollows in eucalypt forests intersected by sedgeland plains, and feeds on the seeds and flowers of a variety of sedge and heathland species (Brown and Wilson 1984). In autumn it migrates to south-eastern Australia, where it feeds in coastal salt-marsh and dune vegetation on the seeds of salt-marsh shrubs. The distribution and abundance of the orange-bellied parrot has declined markedly and now it is one of Australia's rarest birds, with a total population of fewer than 200 individuals, including about 50 breeding pairs (Menkhorst *et al.* 1990). Figure 4 shows its winter range - from the mouth of the Murray River in South Australia, east to Jack Smiths Lake in South Gippsland. Most of the birds use less than five overwintering sites, and at times 50-70% of the population congregates at three sites on the western side of Port Phillip Bay (Menkhorst *et al.* 1990). Some use coastal salt-marsh on French Island in March and April, when they first arrive from Tasmania.



Orange-bellied parrot

The decline of the orange-bellied parrot can be largely attributed to the clearance and degradation of coastal salt-marsh, and a lack of this overwintering habitat may be limiting the species' recovery. A recovery plan was developed in 1984, and implementation is continuing (Brown and Wilson 1984). Monitoring indicates that population numbers have remained stable over the last 10 years.

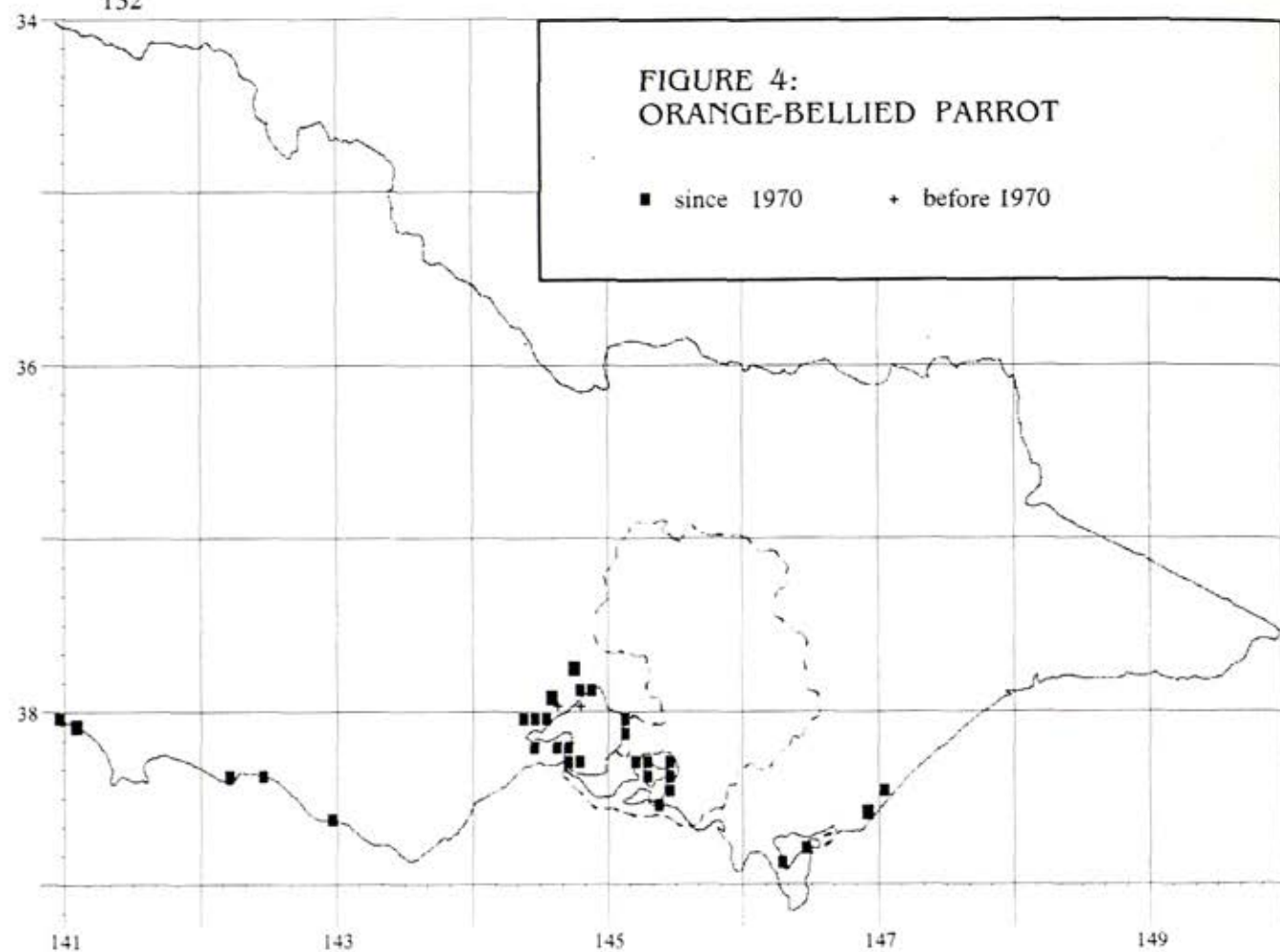
Sooty owl (*Tyto tenebricosa*)

The sooty owl is a nocturnal, forest-dwelling owl listed as rare in Victoria. It nests and roosts in hollows within large old eucalypts (more than 2 m diameter), and feeds on a variety of small to medium-sized mammals and birds as well as insects. In Victoria, it is restricted to tall eucalypt forests, often in association with cool or warm temperate rainforest. Two main populations occur, one in the Central Highlands, and the other in East Gippsland (see Figure 5).

Within the study area, sooty owls occur primarily in wet sclerophyll forest and damp sclerophyll forest dominated by mountain ash, and in riparian forest complex dominated by mountain grey gum or manna gum. They tend to occur within or near large patches of old-growth (including mixed-age) mountain ash forests in the mountain ash forests in the Central Highlands. Forests utilised for timber production (and/or affected by wildfire) may be less suitable habitat for sooty owls because they have fewer of the

FIGURE 4:
ORANGE-BELLIED PARROT

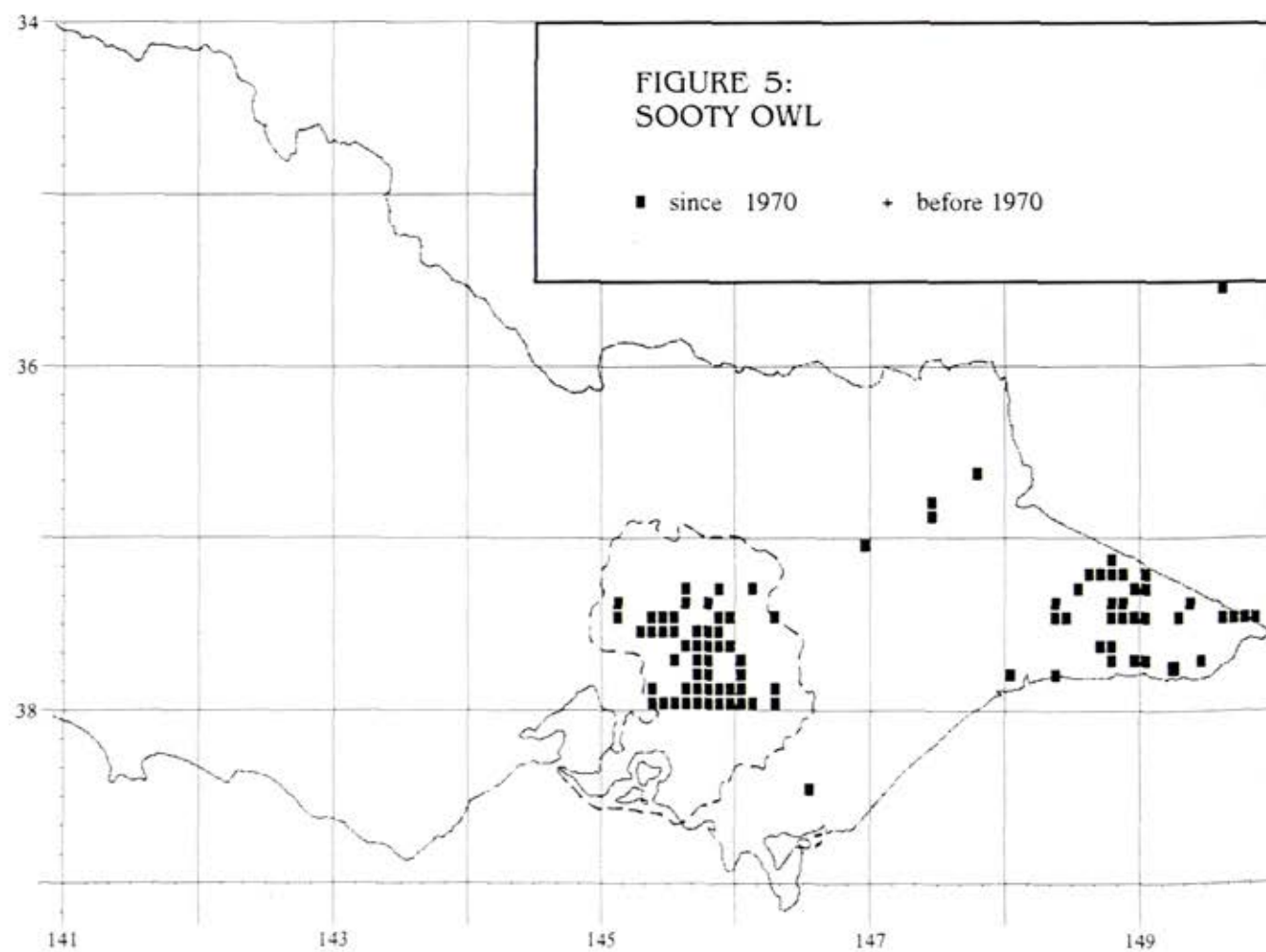
■ since 1970 + before 1970



Source: Atlas of Victorian Wildlife

FIGURE 5:
SOOTY OWL

■ since 1970 + before 1970



Source: Atlas of Victorian Wildlife

large trees required for nesting and roosting, and the density and diversity of some potential prey species may be lower. The old-growth forests of the Board of Works-controlled catchments are very important for the conservation of the owl, which has rarely been recorded within conservation reserves in the study area.

Pink robin (*Petroica rodinogaster*)

This small songbird feeds on insects and other invertebrates taken from the ground, in the air, and from foliage. It is restricted to south-eastern Australia, where it occurs predominantly in central and eastern Victoria and in Tasmania. In summer, pink robins live and breed in upland cool temperate rainforest and occasionally in wet eucalypt forest (Loyn 1985). In autumn, many birds move into drier and lower-elevation forests, and coastal scrub. The extensive moist forests in the Central Highlands are important breeding areas and hence vital for the species' conservation.

Grey-crowned babbler (*Pomatostomus temporalis*)

The grey-crowned babbler lives in small groups of related individuals, and feeds on invertebrates and small vertebrates in the ground litter layer. It nests and roosts in large-domed nests or dormitories, which are a conspicuous feature of a territory. It now inhabits dry forest and woodland remnants, generally on floodplains (Emison *et al.* 1987), (see Figure 6).

The grey-crowned babbler is considered vulnerable in Victoria because its range has contracted significantly. Although once common and widespread in south-eastern Australia, its range now appears to be slowly contracting northwards and the last population south of the Great Dividing Range, on the Mornington Peninsula, is now threatened with extinction. Since 1960, at least nine of the 19 known colonies on the Peninsula have become extinct (Schulz *in press*). Most of the rest have undergone population reductions, and now occupy remnant vegetation on roadsides and golf-courses: none are within conservation reserves. Fragmentation and modification of remaining habitat, and predation by foxes and cats, appear to be the main causes of their decline. A number of steps have been

recommended in an attempt to rescue this population; these include encouraging land-owners to retain native vegetation, replanting roadside vegetation, and controlling feral predators around known colonies.

Regent honeyeater (*Xanthomyza phrygia*)

The nomad regent honeyeater follows the flowering of eucalypts in small groups of up to 20 birds. It is restricted to south-eastern Australia, now being found mainly in a few sites in north-eastern Victoria and central-eastern New South Wales (Franklin *et al.* 1989). Regent honeyeaters were once widespread here, mainly in box-ironbark forests (Webster and Menkhurst 1990); however, their range has contracted markedly this century, and they are considered to be in danger of extinction, with possibly fewer than 1000 individuals remaining (Brouwer and Garnett 1990). The decline appears to be associated with clearance of their preferred habitat for agriculture, rural tree decline, and removal of mature trees during timber-harvesting.



Regent honeyeater

In the study area regent honeyeaters are only known to occur regularly in the Plenty Gorge, where they visit flowering red ironbark in winter. Until recently they have been regular visitors to outer north-eastern suburbs (like Eltham and Christmas Hills), Fraser National Park, and around Eildon, and

these areas may be used regularly again in the future.

Helmeted honeyeater (Lichenostomus melanops cassidix)

These subspecies of the yellow-tufted honeyeater, which is widely distributed in Victoria (Emison *et al.* 1987), live in a variety of forested habitats, in riparian vegetation (subspecies *gippslandica* and *cassidix*), and in a range of drier forests (ssp. *meltoni*).

The helmeted honeyeater is classified as endangered in Victoria. It occurs in lowland swampy riparian forest with a dense shrub understorey, but its range and population size have declined substantially in recent years. In 1963, the total population was estimated to be no more than 270 individuals, with at least 180 individuals around Yellingbo (Hyett 1964). Now, however, only one population is still extant, at Yellingbo State Nature Reserve, where 50–60 individuals survive (see Figure 7). This decline may be due to dieback in eucalypts, clearance of the slope vegetation honeyeaters use for foraging in winter, and competition with bell miners for food and space (Smales *et al.* 1990). A recovery plan for this species, currently being implemented, includes revegetation on the reserve and adjacent private land, control of bell miners, population manipulation to increase breeding success, and the establishment of a captive population.

Significant Taxa - Reptiles and Amphibians

Spotted tree frog (Litoria spenceri)

Despite much recent scientific interest, few data concerning the spotted tree frog its basic biology are available. Since 1983, only two of the previously known 13 populations have been confirmed extant in Victoria (Watson *et al.* in prep.). Figure 8 shows the distribution of these populations. One of them occurs in the study area in the Taponga River catchment and the other, in north-eastern Victoria, on the upper reaches of the Wongungarra River (Shulz *et al.* 1987). It has been recorded outside of Victoria at only one locality, Bogong Creek near Mount Kosciusko (Cogger 1986). Despite extensive searching in recent years at all known sites,

none of the other populations appear to have survived.

In addition to the Taponga, river systems within the study area where the spotted tree frog has been collected between 1960 and 1980 are the Thomson River, Big River (Eildon), and the Goulburn River (Woods Point).

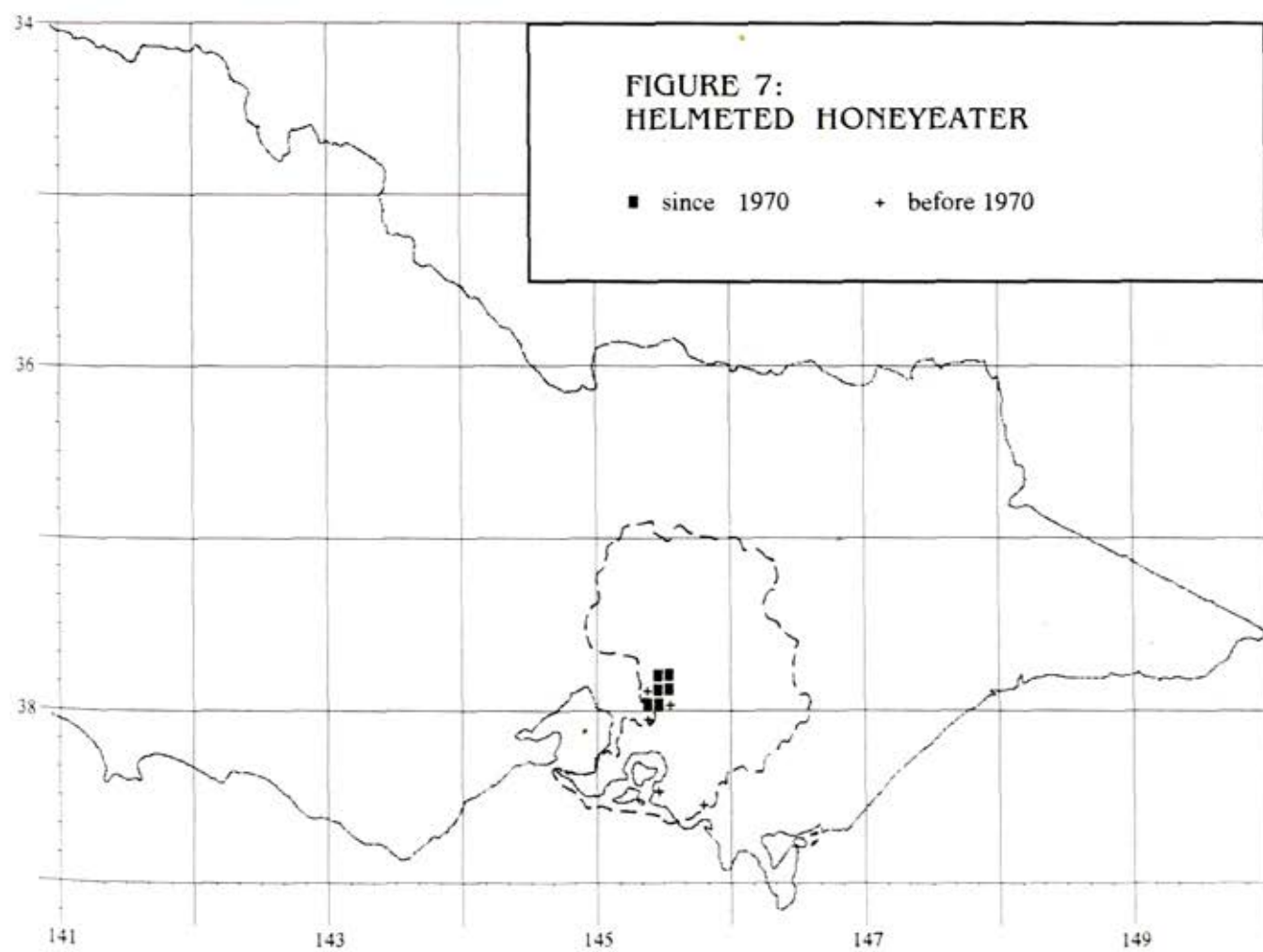
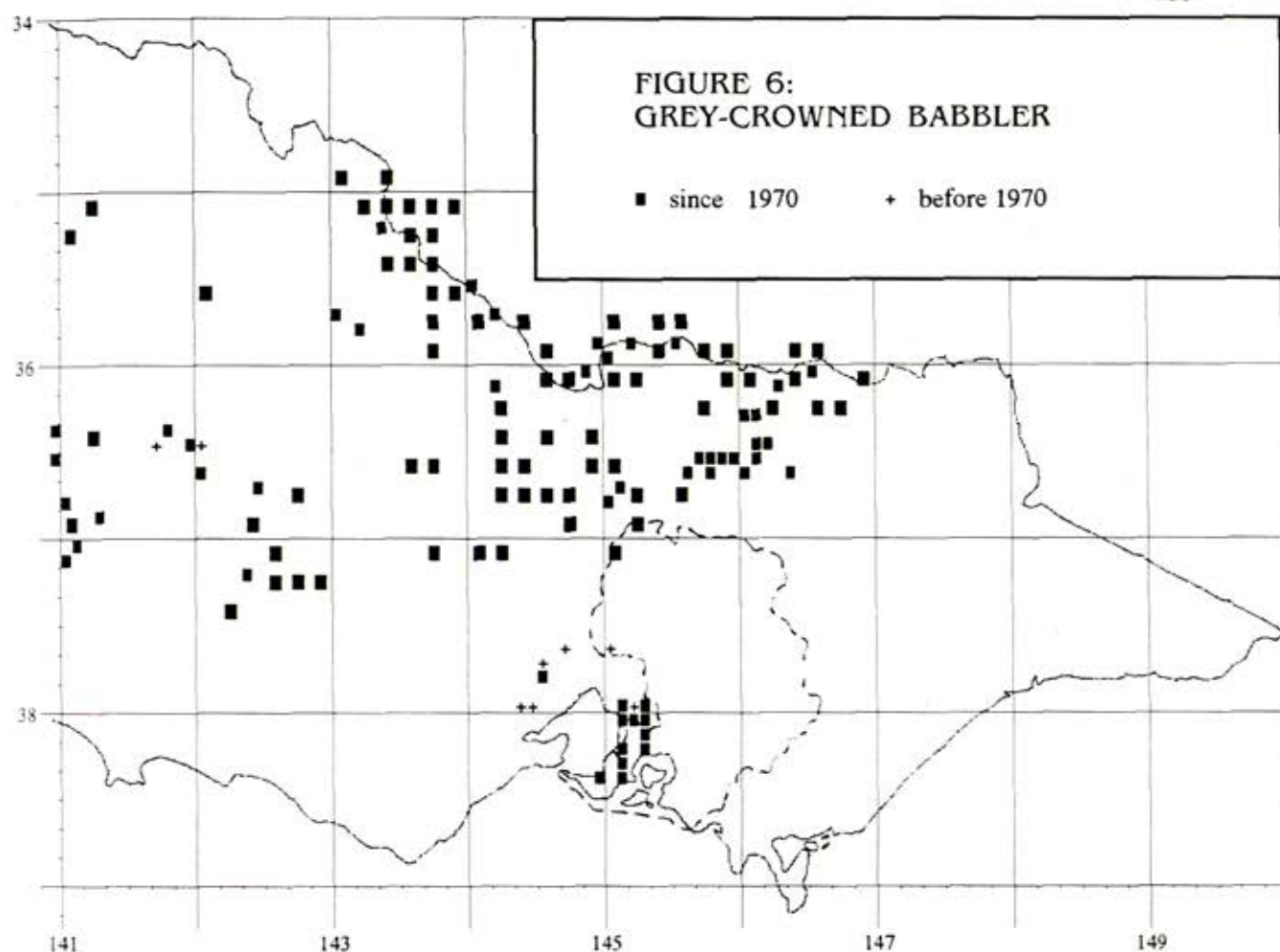
All records have been from naturally - vegetated, rocky, fast-flowing upland streams at elevations of 300–800 m (Watson *et al.* in prep). The specimens were all detected between November and April; activity patterns outside of this period are not known. Individuals often shelter under rocks on shingle banks and in rock crevices next to flowing water, retreat into dense vegetation, perch on low overhanging branches, or bask on exposed boulders and log debris during the day. All of these structural components appear to be important habitat requirements for the species.

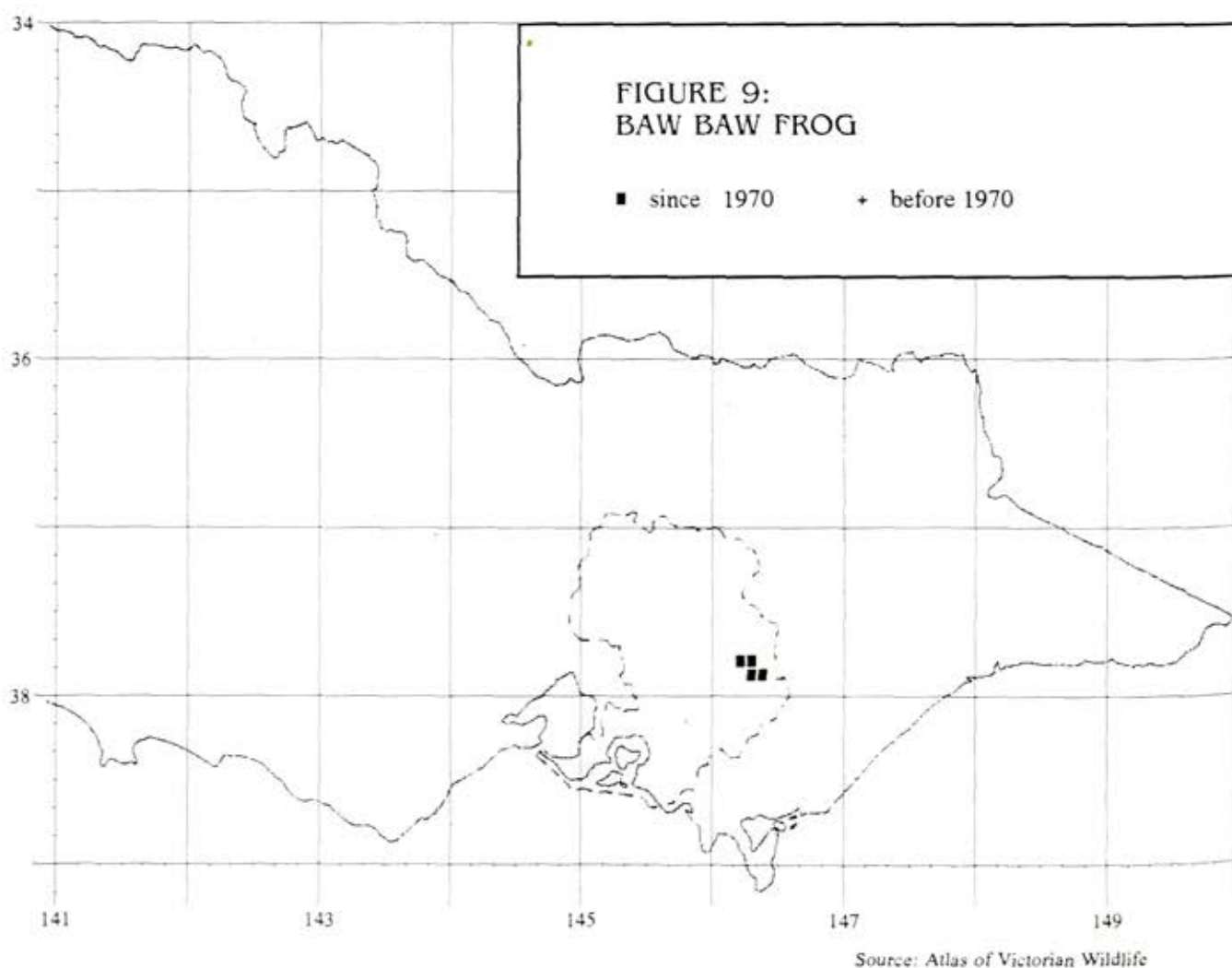
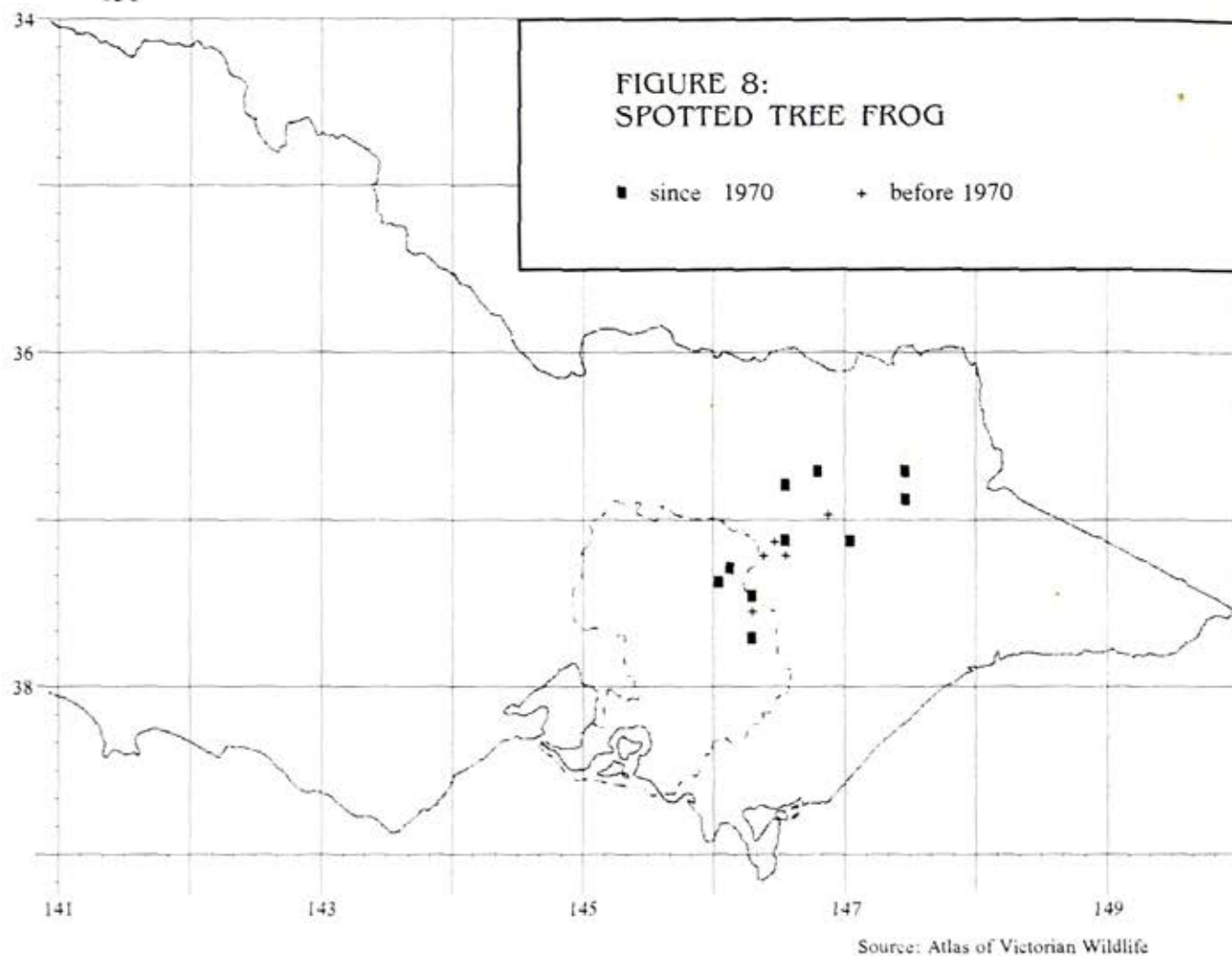


Spotted tree frog

The breeding biology of this frog is unclear. However, within a fast-flowing stream environment the quiet, shallow, riverside pools are likely breeding sites. Intensive searches around the Taponga River are revealing substantial numbers of metamorphlings, indicating successful breeding over the last 3 years. Although adult males are found regularly, the apparent absence of adult females from the stream environs remains enigmatic. The location and movements of adult females is not known.

A number of past and future threats to the continued survival of the spotted tree frog in Victoria have been suggested.





- * Dam construction and subsequent inundation of a natural river system has implications for the stream-flow regime and water temperatures; both these factors potentially influence the survival and growth of eggs and larvae. Alteration of flow regimes and inundation of suitable habitat during construction of the Thomson Dam probably caused the loss of the population from the Thomson River.
- * Eductor Dredging, although once widespread in the upper catchments of the study area, is now illegal in Victoria. More than half the localities from which the spotted tree frog has apparently disappeared have experienced either legal or illegal dredging. Such activity could have detrimental effects on all stages of the life cycle of this rare frog. Both rivers with surviving populations have been free of dredging practices.
- * Exotic fish may prey on one or more stages. To co-exist with native fish, the eggs, larvae, and adults of frogs may evolve a certain degree of unpalatability. However, introduced fish (such as brown trout), previously not exposed to them, may find them less unpalatable. Consequently, the tadpoles may now be restricted to those streams (or sections of streams) that are not accessible to exotic fish.
- * Timber harvesting and associated road-building may adversely affect potential habitat of the spotted tree frog, particularly if they affect stream conditions - temperature, sediment loads, turbidity, nutrient levels, and water yields.
- * Recreational activities such as angling and bait collecting, involving varying levels of disturbance, may affect populations of the spotted tree frog.
- * Introduced predators such as the fox and cat are often seen hunting along river edges, and the practice of basking in the open during the day may make the spotted tree frog vulnerable to predation.

The spotted tree frog faces a serious threat of extinction. It has declined rapidly over the last 30 years, and further research on its ecology is required in order to develop effective management strategies for its long-term conservation.

Giant burrowing frog (*Heleioporus australiacus*)

Little is known of the ecology of this large, burrowing frog. Prior to 1965, only a single specimen had been collected in Victoria; elsewhere it was known as a small population in and around Sydney. In February 1966, individuals were located near Walhalla and Boola Camp (Littlejohn and Martin 1967), but it has not been sighted in the study area since that time.

Recent extensive surveys have detected the giant burrowing frog in a variety of habitats throughout eastern Victoria (Gillespie 1990). While no specific habitat details are known for the study area, habitats used in eastern Victoria include low montane riparian forest, damp sclerophyll forest, dry sclerophyll forest, and montane sclerophyll woodland. Despite extensive searches, no records have come from cleared land, which suggests a dependence on forested habitats. Many of the individuals found were active after periods of heavy rainfall.



Giant burrowing frog

The frog has a distinctive external morphology, being readily identified by: its large size (body length up to 95 mm); the presence of black spines capping the warts on the back, sides, and throat; and the colourful bluish and yellow sides and underparts. Most calling, mating, and egg-laying activity occurs from within a burrow, usually

adjacent to water. Dredging of streams increases sedimentation and may have long-lasting deleterious effects on breeding sites by altering flow rates, decreasing food availability, and changing temperature regimes. Streams can also be affected by timber-harvesting and road-building in their catchments, and such disturbances may potentially affect the viability of amphibians such as the giant burrowing frog.

Due to its limited distribution, and to our lack of knowledge of both its habitat use and vulnerability to current land management practices, this frog has been assigned an indeterminate conservation status in Victoria. It is poorly represented within conservation reserves in the State. The historical localities (25 years ago) in the study area lie within State forest that is subject to timber-harvesting and occasional mining.

Baw Baw frog (*Philoria frosti*)

The entire global distribution of the Baw Baw frog is contained within the Melbourne Area, District 2, centred upon the Baw Baw Plateau above 1300 m, predominantly within the Baw Baw National Park (see Figure 9). Despite extensive searching, it has not been recorded outside this area. The species is one of the seven amphibians regarded by CONCOM (1990) as being either endangered or vulnerable within Australia, and is listed as vulnerable in Victoria. The allocation of such a high conservation status is due to several factors:

- * its highly restricted distribution
- * the constant threat of habitat attrition from recreational activities associated with the skiing industry
- * its narrow ecological requirements

The total number of adult males in the population (as extrapolated from calling males during the 1983–84 breeding seasons) was estimated as 10 000–15 000 (Malone 1985). These breeding aggregations appear to be closely associated with the 'wet alpine heath-bog ecotones and wet alpine heath communities'. The Baw Baw frog exhibits an unusual reproductive strategy. Females lay between 50 and 200 large unpigmented eggs in a foam nest usually located within a protected burrow. These eggs hatch up to 8 weeks later, producing free-swimming, non-feeding tadpoles. The tadpoles are sustained

through to metamorphosis by a yolk-store in the gut.

Potential conflict arises where the habitat of the Baw Baw frog coincides with areas managed for skiing, and environmental changes are occurring in parts of the Baw Baw Plateau (Rawlinson 1981). These include: clearing of natural vegetation in and around the Baw Baw village for the associated infrastructure, and from the downhill ski slopes, which are then planted with introduced pasture grasses; diversion of stream flow to supply the village with water; and pollution of streams with drainage from the village area. While it is not known what specific effects these disturbances have on the Baw Baw frog, it has been demonstrated that the species has greater reproductive success in undisturbed sites than in disturbed ones (Malone 1985). A management plan for the Baw Baw National Park is currently being prepared and will address these issues.

Striped legless lizard (*Delma impar*)

The striped legless lizard received a considerable degree of public attention during the late 1980s due to the apparent disappearance of populations near Melbourne, and the lack of knowledge about its general biology (Coulson 1990). It is now regarded as vulnerable in Victoria. Museum records indicate its main distribution was in western Victoria (particularly just west of Melbourne) with isolated populations in South Australia (Bool Lagoon Game Reserve) and the Australian Capital Territory. Within the study area, the striped legless lizard has only been documented at Yea and Trawool, with recent observations occurring on private land around Craigieburn.



Striped legless lizard

Recent studies in Victoria suggest that the population density is highest in dense relatively undisturbed native grassland. Most known sites are on flat or gently undulating basalt plains, with a good cover of grass and often with surface rocks; and most localities possess deeply cracking clay soil. This species has also been recorded in narrow roadside reserves with a cover of introduced grasses and surface rock or cracking soil, but long-term survival of these roadside populations is unlikely.

Our limited understanding of the diet, habitat use, home range, and the size and dynamics of populations highlights the need for further investigations. Preliminary research indicates that the lizard is highly vulnerable to human disturbance. Immediate threats to its remaining habitat of native grasslands and to include existing populations:

- * industrial and housing development
- * road-construction
- * removal of rock and vegetation cover
- * intensive agricultural use, (such as cultivation and heavy grazing)

Lined earless dragon (*Tympanocryptis lineata pinguicollis*)

This small, cryptic dragon is currently recognised as a south-eastern Australian subspecies of the earless dragon. In Victoria, it is restricted to the land surrounding Melbourne. The few museum specimens come from the study area's basalt plains and were collected prior to urban development, when the landscape was predominantly native grassland. The last confirmed specimen for the State dates from 1967, and suitable habitat has been so drastically reduced that it is now regarded as endangered.

Additional taxonomic work is required to adequately describe the morphological features of this highly variable form. However, as the name suggests, its tympanum (ear opening) is hidden below the skin, and it may have distinctive pale vertebral and dorso-lateral lines extending from head to tail.

In the study area, suitable habitat for the lined earless dragon is extremely rare due to urbanisation encroaching into native grasslands. An unconfirmed sighting was recently reported from a woodland dominated

by river red gum on private land near the Merri Creek (on the western boundary). The sighting, if confirmed, will give this locality and adjacent native grasslands very high conservation value. Further work is required to ascertain the status of the lined earless dragon here and determine appropriate conservation measures.

Swamp skink (*Egernia coventryi*)

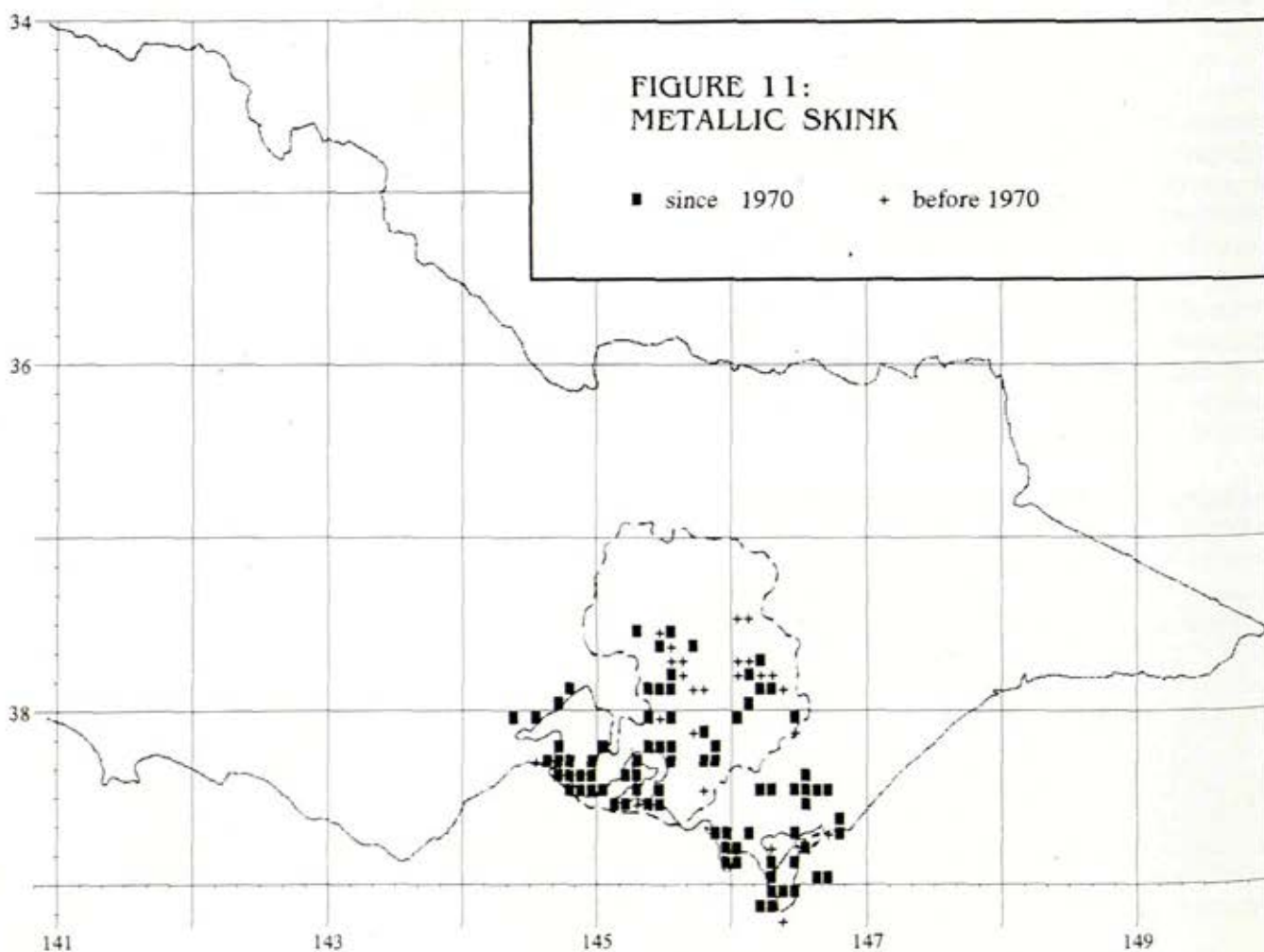
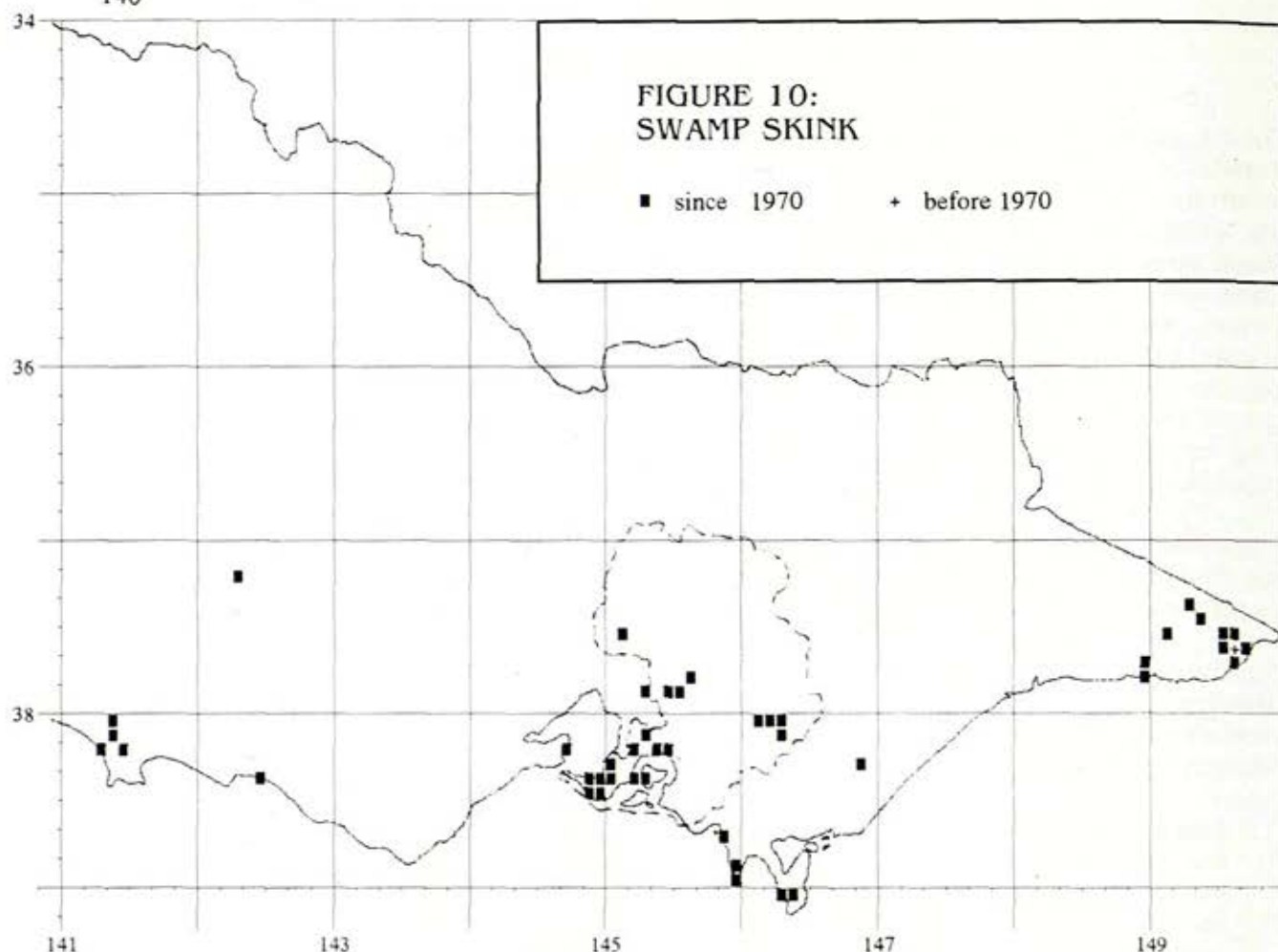
This moderately sized skink, previously referred to under the scientific name of *Egernia luctuosa* (LCC 1973), is regarded as rare in Victoria. It occurs in disjunct populations throughout southern Victoria (see Figure 10), and in south-eastern South Australia and New South Wales (Cogger 1986).



Swamp skink

Vegetation communities in which the skink has been recorded in the study area include swamp scrub of the Yellingbo State Nature Reserve, wet heathland near Hill End, and some coastal salt-marsh areas fringing Western Port. The area of suitable habitat at these sites is generally small. The population at Yellingbo may be one of the largest recorded in Victoria, as it extends throughout the 50-ha Cockatoo Swamp (Smales 1981). The swamp skink occurs in tidally influenced coastal salt-marsh areas only where there is an abundance of driftwood (Schulz 1985).

A common feature of this species' habitat is the presence of burrows, excavated either by themselves or by other species such as yabbies. The burrows may be used as prime refuge sites, and exposed logs (where available) as basking sites or for secondary shelter. It is not known how the skink survives periods of flooding (for example, during high tides).



The swamp skink has been recorded in a number of conservation reserves (for example, French Island State Park and Cranbourne Annex of the Royal Botanical Gardens), and also occurs on private land. Further alienation or drainage of swampy environments will pose serious threats to its persistence.

Metallic skink (*Leiopisma metallicum*)

The study area is very important for the conservation of this species, because it contains a large proportion (approximately 60%) of the skink's Victorian distribution (see Figure 11). This small, terrestrial skink occurs in a range of habitat types, including sub-alpine vegetation at Mount Baw Baw, dry forests in the foothills north of Tyers, heathland vegetation around Western Port, and coastal vegetation at the mouth of the Bunyip River, and is well represented in reserves. It is one of the few species that can tolerate conditions within a coastal salt-marsh environment. Outside Victoria, the metallic skink occurs on nearly all of the Bass Strait islands and is one of the most widespread skinks in Tasmania (Rawlinson 1967).



Metallic skink

Notable Species

Swamp antechinus (*Antechinus minimus*)

The swamp antechinus is classified as rare in Victoria, and is restricted to near-coastal areas west of Corner Inlet. It occurs in dense closed heath, tussock grassland, and sedgeland (Wainer and Gibson 1976) and has a patchy distribution in the State, reflecting the disjunct nature of suitable habitat. In heath, it prefers areas with relatively open

ground vegetation and dense cover one to two metres above the ground.

Like most species of antechinus, it has a single breeding season, with all males dying immediately after mating and births occurring in July and August. The swamp antechinus feeds on insects and insect larvae found in the soil (Wainer 1983).

In the study area, this species has been recorded at only a small number of localities along the coastline, such as at the mouth of the Powlett River in coastal tussock grassland and at The Gurdies in sand heathland. Isolated inland records have come from Korumburra in 1978, and from an area of wet heathland east of Gembrook, in the Bunyip State Park, in 1981.

Brush-tailed phascogale (*Phascogale tapoatafa*)

This medium-sized, predominantly insectivorous marsupial, has a striking bottle-brush tail. Although largely arboreal and nests in tree hollows. It is currently distributed in a broad band across lowland inland Victoria from Tallangatta to the southwest, it is classified as rare in the State. It formerly occurred in Gippsland, but no confirmed sightings have taken place there since the 1960s. The reason for this disappearance remains unknown, but the general reduction in numbers and distribution is probably a result of extensive modification to its preferred habitat, including widespread clearing, and the effects of goldmining, timber-cutting, and grazing (Menkhorst and Gilmore 1979). The brush-tailed phascogale is also susceptible to predation by cats.

Its preferred habitat is dry sclerophyll open forests and woodlands, especially of box and stringybark eucalypts. In the study area the species is widespread throughout the northern drier areas, predominantly in dry sclerophyll forest, and is found in some outer suburbs of Melbourne, such as Warrandyte and Christmas Hills (see Figure 12), but only rarely within conservation reserves.

Common dunnart (*Sminthopsis murina*)

Contrary to its name, the common dunnart is not common in Victoria, and is classified as rare. It is widespread, although rarely recorded, throughout western and northern

FIGURE 12:
BRUSH-TAILED PHASCOGALE

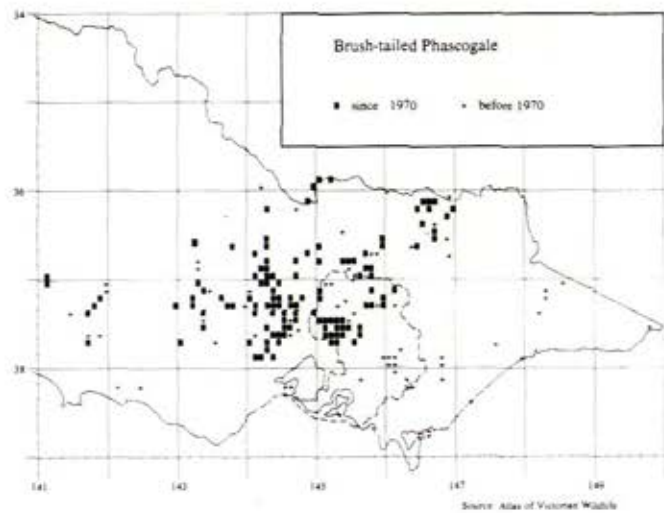


FIGURE 13:
COMMON DUNNART

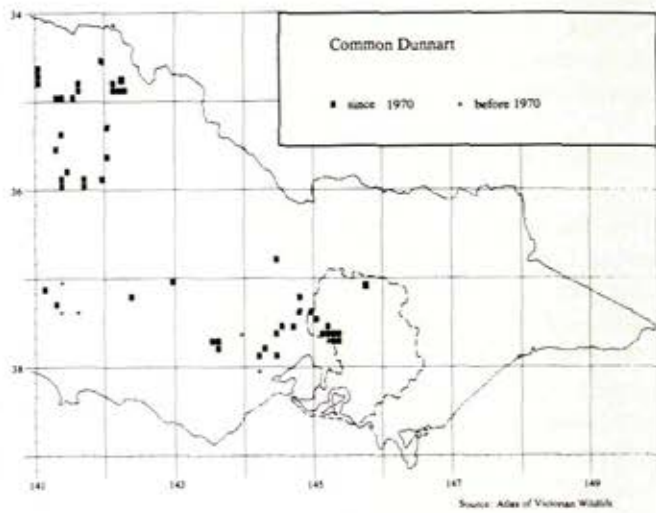


FIGURE 14:
EASTERN HORSESHOE-BAT

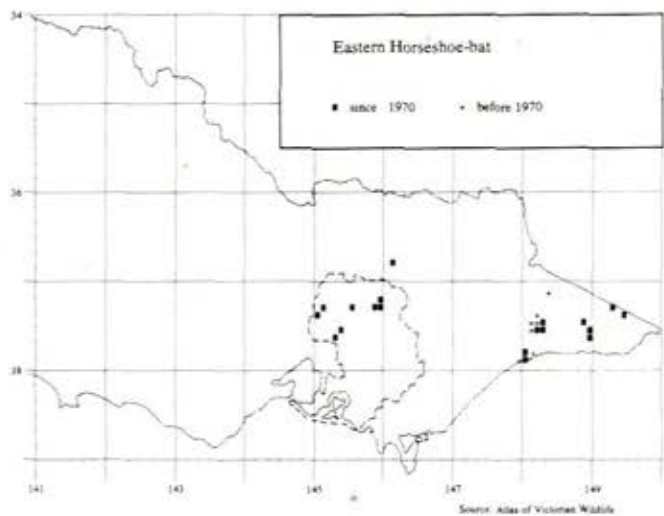
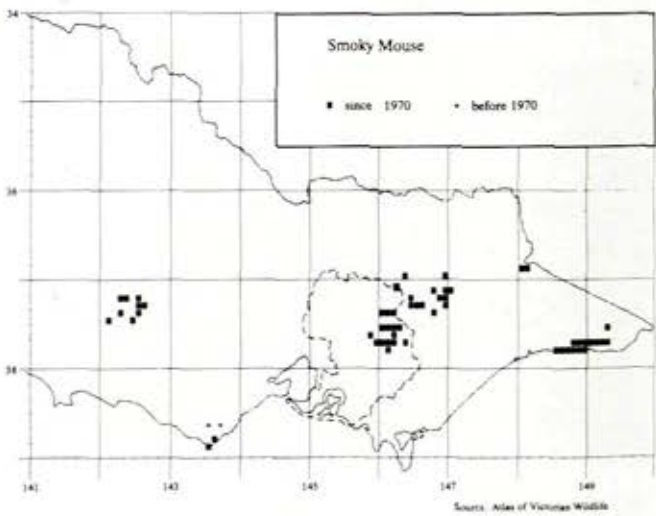


FIGURE 15:
SMOKY MOUSE



Victoria, and the study area forms the eastern limit of its distribution (see Figure 13). Habitats utilised include dry open forest, woodland, mallee, and open heath, all where the shrub and ground layer are sparse. The common dunnart feeds opportunistically on a range of invertebrate prey. As much of its preferred habitat has been cleared since European settlement, its numbers have probably been greatly reduced.

The closely related white-footed dunnart has a complementary distribution and occurs in eastern and southern Victoria. The study area is an important region for studying the relationships between these two species, as their ranges closely approach one another north-east of Melbourne (Christmas Hills--Buxton). The common dunnart prefers drier habitats to those used by the white-footed dunnart; however, both occur in the study area in dry sclerophyll forest.

Squirrel glider (*Petaurus norfolcensis*)

In Victoria the squirrel glider is restricted to dry sclerophyll forest and woodland of the northern plains. Within this range it has a patchy distribution, as the natural vegetation has been extensively cleared and the remaining areas are highly fragmented. As a result, it is classified as rare here. In some places, the loss of suitable habitat means that the squirrel glider is restricted to narrow reserves, along roads and streams, that contain mature trees. Timber-harvesting (including firewood-collecting) and grazing further threatens its conservation (Menkhorst *et al.* 1988).

The species lives in mature or mixed-aged stands, usually where more than one eucalypt species is present, or riparian open forests of river red gum (Menkhorst *et al.* 1988). The mixed-species stands usually contain gum-barked and high-nectar-producing species, including many that flower during winter. Squirrel gliders are primarily insectivorous but also take plant exudates, such as gum from silver wattles, which may provide an important source of winter food.

In the study area, the squirrel glider has been recorded around Seymour in 1966, and again in 1989. This represents the southern limit of its range in central Victoria. It was detected in an extensive roadside reserve east of Seymour that had a high diversity of eucalypts, including mature grey box, red stringybark, red box, river red gum, and red ironbark. Four other species of arboreal mammals, including the closely related sugar glider, were also recorded at this site, demonstrating the importance of such mature diverse remnants in areas that are predominantly cleared.

The use of veteran trees for firewood in the Seymour district is of concern, as this depletes the availability of essential nest sites for the squirrel glider. Residential development currently being undertaken in the vicinity of the known colony also poses a serious threat. To expand the area of suitable habitat, tree-planting, such as that being undertaken in the Whitehorse Creek catchment, should be encouraged.

Eastern horseshoe-bat (*Rhinolophus megaphyllus*)

By utilising mineshafts, the eastern horseshoe-bat appears to have expanded its range into the study area since European settlement, and this now forms the western limit of the species in Victoria (as shown in Figure 14). An extensive network of mineshafts stretches throughout the north of the study area, and the eastern horseshoe-bat has now been recorded in mines around Mount Disappointment, Kinglake, Black Range, and Eildon. Only a small proportion of the mines have been investigated and it is possible that further searching will reveal more roost sites. To date, it appears that the Central Highlands population is small; the largest congregation found comprised about 40 animals.



Squirrel glider



Eastern horseshoe-bat

This species requires high temperature and humidity at roosting sites (Hall *et al.* 1975). These conditions are extremely critical at maternity sites, of which only three have been located in Victoria - all in East Gippsland. Because a significant proportion of the population congregate at single sites during the breeding season, the species is vulnerable to disturbance and has been placed on the threatened species list for Victoria. Females have been found in an advanced state of pregnancy in the Central Highlands, suggesting the presence of a local, as-yet-unlocated, maternity site. If found, this site will be extremely important for the conservation of the species here.

Several of the occupied mines are within conservation reserves. However, many other mines, not yet investigated, are in State forest. People, including those re-working the mine for extracting minerals, may disturb a roost site, possibly causing the bats to desert it. Gates to exclude people, if used, need to be fitted in such a way that they neither impede the flight of the bats, nor alter the microclimate within the roost.

Common bent-wing bat (Miniopterus schreibersii)

The common bent-wing bat is restricted to parts of southern Victoria that contain suitable roost sites in the form of caves, mines or tunnels. In the study area its populations are centred around mineshafts and aqueduct tunnels, where colonies of up to several thousand have been located.

The bat has been placed on the list of threatened species in Victoria, because of its

reliance on only a small number of maternity sites where the females congregate to give birth to their young. Only two of these are known here, one in East Gippsland and the other in the west of the State; although Victorian bats are known to use two other maternity sites across the border. Large numbers of bats congregate at these sites, with an estimate of 60 000 individuals at the East Gippsland one (Dwyer and Hamilton-Smith 1965). During the Wildlife Branch survey of the study area, pregnant females were banded in December 1988 at a mine near Eildon. Several were recaptured a month later at the maternity site in East Gippsland, approximately 200 km away.

Although it does not contain any known maternity sites, the study area does provide important sites for non-breeding females, males, and dispersing young. These are vulnerable to human disturbance, especially in winter when the bats are in torpor. Any disturbance at this time results in the bats raising their body temperature to become active, costing them valuable energy reserves. If they cannot replenish this energy (which is difficult during winter when food supplies are low), many may die. The resurgence in re-working old mineshafts may also conflict with the conservation of this species.

Broad-toothed rat (Mastacomys fuscus)

The broad-toothed rat occurs in east and southern Victoria at altitudes from sea level to 1800 m. It occupies a range of habitats, from alpine sedgelands to tall open forests and coastal tussock grasslands. However, it appears to be restricted to areas of high annual rainfall where the vegetation includes a dense ground layer of grasses, sedges, and herbs, as it feeds mainly on the stems and leaves of such plants. These habitat and dietary requirements result in a patchy distribution with discrete populations, and consequently the species is classified as rare in Victoria. Predation from foxes, dogs, and cats, a sparseness of suitable habitat, a low reproductive rate, and competition from other native rodents may all contribute to its rarity.

In the study area, the broad-toothed rat is moderately widespread throughout forested zones of the Central Highlands, in patches of suitable habitat. Vegetation communities

utilised include riparian forest complex and damp sclerophyll forest.

Smoky mouse (*Pseudomys fumeus*)

Although classified as rare in Victoria, the smoky mouse was, until recently, thought to be endemic to the State, where it has a wide, but disjunct distribution. It occurs in the Grampians, Otways, East Gippsland, and the Central and Eastern Highlands. Its preferred habitat is ridge-top sclerophyll forest with a diverse understorey of heath, dominated by legumes (Menkhorst and Seebeck 1981). The seeds and berries from these shrubs are an important food source. Underground fungi and insects such as the Bogong moth are also important dietary items at certain times of the year. Like several others in the genus *Pseudomys*, this species is adapted to certain successional stages of post-fire regeneration (Cockburn 1983).

In the study area, the smoky mouse occurs on dry ridge-tops in the Upper Yarra Catchment east to Woods Point and Mount Terrible. It utilises several vegetation communities here, including sub-alpine woodland, montane dry forest, foothill forest complex, and heathy dry forest, all containing a heathy understorey, but has not been recorded in any of the conservation reserves (see Figure 15). Most sightings have occurred in State forest, and others in Board of Works-controlled catchments. The effect of frequent fuel-reduction burning, often undertaken in the preferred habitat of this species, is not known.



Smoky mouse

Factors Affecting Distribution and Status of the Vertebrate Fauna

Numerous factors influence the distribution, abundance, and conservation status of fauna in the study area. Some of the most prominent are discussed below.

Habitat loss and fragmentation

As discussed in previous chapters, the primary factors affecting the distribution and abundance of many species include the loss and fragmentation of habitat. Approximately half of the Melbourne Area, District 2, has been cleared for agriculture or urban development. Clearing has not occurred uniformly across all habitats, but has been concentrated mainly at low altitudes. Many vegetation communities that would have once been widespread, such as box woodland, are now reduced to small remnants. Most tracts of near-coastal and low-lying vegetation have been completely cleared, including the extensive swamps on the eastern side of Port Phillip Bay and to the north of Western Port. The Koo-Wee-Rup Swamp was the largest of these, covering approximately 40 000 ha. That clearing is directly responsible for the extinction from the study area of species such as the ground parrot that relied on such vegetation. Other species still occur here but have declined greatly in distribution and abundance as a result of the clearing. For example, Australasian bitterns - common in the swamps where Wheelwright hunted last century - are now a threatened species in Victoria and rare in the study area.

Although clearing no longer occurs to the same extent, some species are still declining as a result of habitat loss. Expanding urbanisation threatens native grasslands on the northern edge of Melbourne, affecting species such as the lined earless dragon and striped legless lizard. The grey-crowned babbler and bush thick-knee are now restricted to small populations in remnant vegetation, and further habitat loss would threaten their continued existence in the study area.

Timber-harvesting

Extensive areas of native hardwood forests within the Central Highlands are subjected to timber-harvesting for the commercial tree species mountain ash, alpine ash, shining

gum, mountain grey gum, and messmate stringybark. The net productive area suitable for these logging operations within the study area is 265 728 ha (see Chapter 15), only a relatively small portion of which is cut over in any one year. Although still heavily utilised, the less economic mixed-species forests are not as extensively harvested. Approximately 315 000 cu.m of sawlogs are extracted from the study area annually. The two major timber-harvesting techniques employed are clearfelling and selective logging, which result in a mosaic of different-aged forest following regeneration.

Modification to the forest environment at this scale and magnitude must influence the distribution and status of many forest-dependent species. Tyndale-Biscoe and Calaby (1975) categorised forest fauna into four groups: transient species, marginal species, non-dependent residents, and dependent residents, of which the last are most adversely affected by timber-harvesting. The Research Working Group of the Australian Forestry Council lists 44% of terrestrial mammals recorded in the study area as sensitive to forestry operations (see Appendix V), and a lower proportion of the bird species (mainly owls and parrots). Conversely, some species will increase in numbers following timber-harvesting - principally those that colonise early successional stages in regrowth or those adapted to more open habitats. As their conservation status is usually secure, they will not be discussed further.

The susceptible dependent residents, such as arboreal marsupials, rely on hollows in mature trees for denning and breeding sites. Most eucalypts take many decades before they begin to form hollows (for example, mountain ash takes 120 years). This exceeds the standard harvesting rotation cycle of 80 years for production forests. Some hollow-bearing trees are protected under forestry prescriptions, such as designated habitat trees and those within streamside buffers. In the study area, all of the arboreal marsupials except the koala are known to use tree hollows for nesting. Consequently, the loss of hollow-bearing trees during timber-harvesting can have a significant long-term impact on them. The greater glider, for example, is more abundant in old-growth forest than in forests regenerating after harvesting (Macfarlane 1988). Individuals of

many of these species, including the greater glider and mountain brushtail possum, do not survive clearfelling, nor do they migrate to other habitat once an area has been logged.



Arboreal marsupials, such as the sugar glider, are dependent on forest habitats

Bats too utilise tree hollows for nest sites and refuge. In Victoria, 18 of the 20 species of microchiropteran bat use them for roosting. Removal of hollow-bearing trees therefore probably adversely affects bats also.

Mature forests have a greater range of foraging substrates, utilised by arboreal fauna, than younger ones. Leadbeaters possum searches the loose bark hanging from living mature trees for arthropods, one of the essential requirements of its diet. Another foraging substrate affected by timber-harvesting occurs in specific eucalypt trees that yellow-bellied gliders incise to extract the phloem sap. Gliders will only utilise certain, usually large, trees; however, the basis of this exploitation is still poorly understood. Clearfelling of forests on a rotation cycle that does not allow trees to develop the full range of foraging substrates can be detrimental to many forest-dependent species.

Many studies have assessed the impact of timber-harvesting on the forest avifauna. These have revealed that mature eucalypt forests support the highest populations and diversity of birds. Most bird species disappear from an area that has been clearfelled but return progressively as the regeneration ages. The main species of concern are the high-order predators, such as the powerful owl and sooty owl. Both of these rely on large deep tree hollows for nesting, which take several hundred years to develop, and may be particularly vulnerable

to the removal of the large trees. The existence of large owls in an area is also related to the abundance of their prey species. It has been estimated that a pair of powerful owls consume the equivalent of 250–300 greater gliders per year (Tilley 1982). If timber-harvesting reduces the numbers of a common prey species (such as the greater glider), it will affect the suitability of the area for predators like the powerful owl.

Relatively little information has been documented concerning the effect of timber-harvesting on the distribution and status of reptiles and amphibians in Australia. Nevertheless, a knowledge of their ecological requirements suggests that the clearfelling process and subsequent regeneration burn may adversely affect many species. The opening up of the canopy and burning of the understorey alter the on-ground habitat components (shelter, breeding, and basking sites) of many reptiles (Lunney *et al.* 1991). Amphibians that breed in streams and rivers may be adversely affected by increased sediment loading derived from logging and road-building activities within the catchment area and changes in temperature as a result of clearing.

Much emphasis has been placed on the value, for wildlife conservation, of exclusion zones (that is streamside reserves, wildlife corridors, buffer zones, and steep and rocky areas) within hardwood production areas. Few data are available as to the effectiveness of these zones for the conservation of forest-dependent fauna. Although these unlogged zones may cater for some species, within they may not be sufficient for the entire habitat requirements of the more sensitive ones. Further research is required to ascertain the value of these exclusion zones in effectively sustaining viable populations.

Road construction in the Central Highlands

In 1988, the Department of Conservation, Forests and Lands (now Department of Conservation and Environment) commenced a major upgrading and extension of the road network in the Central Highlands, often referred to as 'ash roading'. The purpose of the program was to increase access to the regions' timber resources, especially the ash forests. It was planned to upgrade approximately 1200 km of existing roads and build 600 km of new ones over a period of

20 years. Apart from safety considerations, the expected high volume of traffic, and long time frame over which harvesting will occur, these 'ash roads' differ considerably from typical forest tracks. They have large clearing widths, some initially up to 100 m. Canopy connection is limited, due to the large clearings and the generally small crown size of ash trees.

Roading is an integral part of timber-harvesting and, due to its potential impact on fauna conservation, requires sensitive management. Its major impacts on fauna and are summarised below.

- * Roads form barriers to movement for many species of vertebrates and invertebrates. These can limit gene flow and may result in populations becoming isolated, and fragmentation of a species' distribution into small populations increases the likelihood of extinction. The width of the road and its easement largely determines its effect as a barrier. Even relatively narrow clearings may affect species with limited mobility. Little research has been undertaken in Australia to assess the impact of roads as barriers. However, a study of small mammals in New South Wales found that the number of road crossings by bush rats and brown antechinus decreased as the width of the road increased. Even small overgrown and disused tracks influenced the movement of small mammals (Barnett *et al.* 1978). A similar study in north Queensland also revealed a reluctance by the brown antechinus to cross roads (Burnett 1991).
- * Road construction involves the direct destruction of wildlife habitat.
- * Road construction exposes soil, making it vulnerable to erosion and weed invasion. In the Central Highlands, creek crossings are numerous. Silt production from roads tends to be highest during and immediately following construction, and following high-rainfall events. Erosion may be reduced as vegetation is re-established on verges, and proper maintenance undertaken. Increased water turbidity and siltation can affect the many species dependent on the aquatic environment,

such as platypus, water-rat, frogs, and their invertebrate prey.

- * Introduced predators, such as the fox and feral dog, preferentially use roads and tracks as movement pathways and for hunting. Fauna living close to roads are consequently exposed to higher rates of predation. Introduced carnivores may also compete for prey with native ones such as the tiger quoll, and this will be more prevalent where roads provide access.

Due to public concern over the environmental impact of these 'ash roads', the Minister for Conservation, Forests and Lands initiated a review of this process in September 1989. Since then, all proposed roads have been assessed by specialists from various fields of natural resource management, including flora and fauna. To reduce the impact of road networks on fauna, many aspects of road planning and construction have been modified; for example, clearing widths have been reduced, canopy connectance increased, habitat trees protected, wildlife corridors established, and roads re-routed.

Fire

Most of Australia's flora and fauna have evolved in the presence of fire of varying intensities and frequencies and have adapted to it. Fire affects the floristic composition and structure of the vegetation, which subsequently affects the faunal composition. A fire regime has three major components - frequency, intensity, and season of burning - all of which affect fauna in various ways. The two general types are uncontrolled wildfire and controlled fuel-reduction burning.

The study area has been subjected to a number of intense wildfires since European settlement. The most devastating, the 1939 fires, burnt 1.3 million hectares, including 79% of the montane ash forests of the Central Highlands (Macfarlane 1988) and converted extensive areas of old growth forest into even-aged regeneration, which has had a marked effect on the distribution and abundance of many species. The effects of these fires are still evident today and continue to influence the fauna, especially those species dependent on hollows for nesting or roosting. In 1983 wildfires again burnt

approximately 50 000 ha in the Warburton, Upper Beaconsfield, and Cockatoo areas (Rawson *et al.* 1983).

A preventative measure used widely throughout the dry forests of Victoria is fuel-reduction burning. Its aim is to reduce the amount of fuel on the forest floor so as to slow, or stop, the progress of wildfires. The technique involves intentional burning during periods when fuel moisture levels and weather conditions are optimal to allow a low-intensity fire with flame heights less than 2 m. It is not undertaken in all forest types - ash and other wet forests, alpine and sub-alpine areas, reference areas, and environmentally and silviculturally sensitive ones are excluded - but is concentrated in the foothill mixed-species forests.

Fuel-reduction burning differs from wildfires in all three of the basic components of a fire regime. Its frequency is much higher: every 3-5 years in Priority 1 zones; 5-8 years in Priority 2 zones; and 8-12 years in Priority 3 zones. Intensity is much lower; and the season usually differs, burns being conducted at a cooler time of the year. The vegetation and the fauna generally are not adapted to this altered fire regime, and respond differently as a result (Shaw 1984).

Different vegetation communities are adapted to differing fire regimes. Some communities, such as heathlands, are relatively flammable due to the rate of accumulation of litter and the continuity of fuel: heaths reach maturity at approximately 20-30 years old and depend on a relatively frequent fire regime for their continued existence. Others, such as cool temperate rainforest, burn relatively infrequently, due to high moisture content. Rainforest is at the climax of the wet forest successional stage and has developed in the absence of fire, and is therefore adversely affected if burnt.

Following European settlement, the increased frequency of fire is thought to have changed the composition and structure of some dry sclerophyll forests, with an increase in abundance of bracken and understorey shrubs at the expense of grasses and herbs (Chesterfield 1984). A hot fire stimulates prolific regeneration of plants, such as the native legumes, that regenerate from seeds. Large areas of Victoria's dry forests now have a simple understorey dominated by a

few leguminous shrubs as a result of over-frequent fires (ABRG 1984). Changes in vegetation structure are likely to affect the composition and abundance of the fauna using these understorey layers. Many birds are restricted to, or are most abundant in, one particular stratum of the vegetation. Species that favour an open grassy ground layer, such as the spotted quail-thrush, have been greatly affected as a result of frequent fires producing a shrubby understorey.

The response of animals to successional stages following fire have been most thoroughly studied for small mammals. They respond in a variety of ways depending on their preferred habitats and food requirements. The introduced house mouse is usually the first species to colonise a burnt area and is most abundant in the first 2 years after the fire. Some natives such as the New Holland mouse depend on early successional stages of regenerating heathland and are most common 2--8 years following a fire. Others, such as the brown and dusky antechinus and bush and swamp rats, may take 6 years or more to reach pre-fire densities (Fox 1982).

The intensity of a fire influences direct mortality rates. A low-intensity fire results in fairly low mortality rates and mainly affects the ground and understorey fauna. Many species of mammal and reptile can take refuge in burrows or under rocks. Large mammals and many birds may be able to escape. A high-intensity fire is likely to kill large numbers of animals and affect species at all levels of the forest strata. Far more significant, however, is the high rate of mortality in the weeks following the fire due to starvation and predation. Predators may alter their diet after a high-intensity wildfire, in response to prey availability. For example, in a study in south-eastern New South Wales, small mammals constituted a large proportion of dingo diet prior to the fires, but the fire severely reduced their numbers. The dingoes then changed their diet to large macropods (such as swamp wallaby), which slowed the rate of recovery in macropod numbers (Newsome *et al.* 1975).

Fuel-reduction burns that occur in spring have the potential to affect breeding populations of small mammals. Species of *Antechinus* are particularly vulnerable at this time, when the population comprises only

lactating females (Suckling and Macfarlane 1984). They also have the potential to disrupt reproduction in birds.



Brown antechinus

Mining activities

Mining activities last century and early this century have resulted in an extensive network of mines in parts of the study area. Some of these now provide suitable roosting sites for cave-dwelling bats, expanding the distribution of the eastern horseshoe-bat and common bent-wing bat. However, the recent resurgence of interest in re-working these old mines can disturb the bats and cause them to desert these sites. The suspected eastern horseshoe-bat maternity site described above, if located, has very great significance.

Eductor dredging, now banned, was conducted on many watercourses in the Central Highlands. Disturbance caused by this activity may have affected a range of species that depend on the streams, including water-rat, platypus, large-footed myotis, and a number of frogs, particularly, the endangered spotted tree frog. The timing of the disappearance of the spotted tree frog from many rivers coincides with these widespread operations and Watson *et al.* (1990) consider that they could have been critical in the recent local extinctions of this species.

Introduced animals

Thirteen species of introduced mammal and 12 species of introduced birds have established feral populations in the study area. Most are widespread throughout the

extensively cleared areas. Some (such as dog, fox, cat, European rabbit, and blackbird), are also found throughout the large regions of native vegetation, while many of the bird species (including house sparrow, European goldfinch, common mynah, common starling, feral pigeon, and spotted turtledove) only utilise the edges of the extensive blocks of vegetation. Species with limited distributions here include feral pig, goat, fallow deer, mallard, and song thrush. Sambar deer are widespread in the Central Highlands and also occur on French Island. The introduced black rat and house mouse, although widespread, are more abundant close to human habitation.

Some non-indigenous native species have been introduced as a result of the escape of pets. These include scaly-breasted lorikeet, pale-headed rosella, Port Lincoln ringneck, and chestnut-breasted mannikin.

Cats and dogs - both free-ranging domestic pets and feral animals - affect native wildlife, and dumping of unwanted pets into the bush contributes to the already established feral populations. The status of wild dogs in the study area is unclear. In the Eastern Highlands of Victoria, Jones (1990) considered that most of the population could be regarded as dingo-like wild canids, displaying more variability than pure dingoes.

Introduced species interact with native wildlife in two main ways: predation and competition.

The carnivores prey on a wide range of native species. In general the dog, fox, and cat are all opportunistic carnivores, preying and scavenging on animals that are readily available in the area. The variation in the diet of these three species within south-eastern Australia reflects the differential availability of prey species. Mammals usually account for a high proportion of the diet of all three predators. In general, dogs tend to take large to medium-sized prey such as wallabies, wombats, and possums, while foxes and cats tend to take medium to small prey like possums and rats. Cats also consume a greater proportion of birds and reptiles. Large prey taken by foxes is usually scavenged. Rabbits, where abundant, usually comprise a large proportion of the diet of both fox and cat; however, where they are

sparse or absent, native species form the major prey items.

Several studies indicate that foxes play a significant role in the decline of native animals. In Western Australia, population levels of rock wallabies increased by up to 223% after a 4-year fox-control program (Kinnear *et al.* 1988). In a study on the Murray River tortoise (Thompson 1983), foxes destroyed 93% of nests, in comparison with 3% destroyed by natural predators. The tortoise population consisted predominantly of old individuals with very little recruitment of juveniles. Predation accounted for at least 79% of nesting mortality of superb lyrebirds at Sherbrooke and in the Maroondah Catchment (within the study area). Indirect evidence suggested that the large introduced carnivores were responsible for a large proportion of nest failures (Lill 1980).

In areas of native vegetation close to human habitation, uncontrolled domestic cats and dogs are a further problem. Unlike feral predators, whose population levels are controlled by the abundance of their prey species, domestic animals do not depend on wild prey for their food and often kill just from instinct. Especially in small isolated patches surrounded by human habitation, freeranging domestic animals could result in the local extinction of native species.



Superb lyrebirds have been subject to severe predation by introduced species in the Dandenong Ranges

Probably because of competition, the native marsupial carnivores once found in the area are now either in very low numbers (tiger quoll) or extinct (eastern quoll). Although little is known of the diet of the tiger quoll, both foxes and cats may compete for similar

food resources. Tasmania, where the tiger quoll and eastern quoll are most common, has no foxes.

Hollow-nesting birds, such as the common starling compete with parrots, treecreepers and other native species for nesting sites in old trees, especially in areas of remnant vegetation.

Possibly the introduced honey bee may affect the native fauna by a reduction in available nectar supply, which may lead to a decline in numbers of native pollinators; increased hybridisation of native plants; inefficient pollination and consequently seed production in native plants; and competition for tree hollows with hollow-dependent fauna.

Urbanisation

The study area incorporates most of the outer northern, eastern, and southern suburbs of Melbourne. As the population of Melbourne grows and extends the outer urban limits, land is converted from rural or native vegetation into housing estates. The study area contains sections of two current major growth corridors - the Plenty Valley and the Berwick/Pakenham Corridors.

Increased urbanisation can affect wildlife in a number of ways, including the following.

- * The removal of native vegetation to make way for houses and associated infrastructure decreases the amount of available faunal habitat. Grassland species that occur on the outskirts of Melbourne, such as the striped legless lizard and lined earless dragon, are especially vulnerable.
- * Increased fragmentation of remaining natural areas can result in populations becoming isolated and less viable, and hence more susceptible to catastrophic events such as wildfire.
- * Degradation of native vegetation in the vicinity of urban areas can result from factors such as increased recreational use and the gathering of firewood, which results in the removal of nest and shelter sites.
- * Predation by free-ranging domestic cats and dogs from urban areas can have a

marked effect on populations of native animals, especially when these populations are already small due to habitat fragmentation. Remnants of native vegetation within urban areas are often used as dumping grounds for unwanted pets, which further exacerbates this problem.

- * Native vegetation surrounded by altered areas suffer from weed infestation and this can change the natural habitat of faunal species.
- * Pollution of stream environments can affect a number of species, such as frogs.

While some species - such as common ringtail possum, grey butcherbird, white-plumed honeyeater, and garden skink - have adapted to altered environments and can survive in urban areas, most are adversely affected and have declined in abundance or become extinct there.

Climatic changes

Currently, 'greenhouse effect', which may result from human-induced changes to the earth's atmosphere, forms the focus of considerable scientific debate. It is the global warming predicted to occur as a result of an increase in atmospheric concentrations of carbon dioxide and other 'greenhouse' gases. This warming would change weather patterns at a rate unprecedented in the last 160 000 years (Pearman 1988). As climate is a fundamental environmental variable that determines the geographic distribution of species, such changes have the capacity to dramatically alter the distribution of individual species and the floral and faunal composition of ecosystems. The predicted resultant climatic changes and general implications for Nature conservation were discussed in Chapter 5.

Wildlife species most at risk from the predicted 'greenhouse effect' include those with one or more of the following ecological attributes (with examples):

- * genetically impoverished and/or localised populations (helmeted honeyeater)
- * specialised habitat requirements (Leadbeaters possum)



New Holland mouse

- * peripheral or disjunct populations (New Holland mouse)
- * coastal species (orange-bellied parrot)
- * alpine species (Baw Baw frog)

The Wildlife Branch of DCE is currently examining the potential 'greenhouse effects' on the distribution of fauna within Victoria. This project uses BIOCLIM, a bioclimate analysis and prediction model, to establish the 'climatic profile' of selected faunal species occurring in the State, from distributional data stored in the Atlas of Victorian Wildlife. One of its aims is to assess the effectiveness of Victoria's reserve system in coping with future climate change and the consequent effects on the distribution of flora and fauna.

Bioclimatic and predictive modelling have been undertaken for Leadbeaters possum (Lindenmayer *et al.* 1990), which is restricted to a narrow range of climatic conditions confined to the Victorian Central Highlands. All the 'greenhouse' scenarios analysed substantially reduced its predicted distribution. Bioclimatic analyses can be used to help identify areas with the greatest conservation value for a species, both in the immediate and long-term future. For example, all the scenarios examined predicted that the Snobs Creek Reserve, at the northern limit of this possum's distribution, is unlikely to remain climatically suitable. Thus, any areas reserved specifically for the conservation of Leadbeaters possum will need

to be concentrated in those areas predicted as most likely to contain suitable habitat in the future.

The orange-bellied parrot is similarly clearly vulnerable to potential 'greenhouse' effects (Mansergh and Bennett 1989). It has a total breeding population of fewer than 200 individuals and depends on winter feeding areas in Victorian coastal salt-marshes. The predicted rise in sea levels would eliminate much of its existing habitat, and increased storms and wind speeds would effect the bi-annual migration across Bass Strait.

Other species that are currently more widespread would also be affected. The smoky mouse currently has a patchy and disjunct distribution across Victoria. If the temperature rose by 3°C, its distribution would probably contract to the Eastern Highlands, with the areas occupied by the outlying populations becoming climatically unsuitable.

Various strategies have been suggested to counter the effects of 'greenhouse' on wildlife (Mansergh and Bennett 1989).

- * Increase the resilience of the reserve system to ensure that reserves are as healthy as possible, to retain the potential to adapt to climate change. To achieve this, land uses that degrade the environment should be phased out; reserves should be made larger and accommodate adjacent climatic zones; the reserve system should be flexible; and conservation practices on private property should be encouraged.
- * Prevent fragmentation and/or elimination of all remaining native vegetation and faunal communities.
- * Implement a State-wide regional corridor system to link major conservation reserves.
- * Support reafforestation of cleared land with local indigenous trees and shrubs.

Under the 'greenhouse effect' scenario examined, the resulting climate change would have major effects on the fauna of the study area, with many species becoming locally extinct and the distributions of many others drastically altered.

Influences on Fish Conservation

European settlement greatly altered catchment and in-stream conditions, and many of these changes are described in other parts of this report. Most of them resulted in the loss of fish habitat and greatly affected the conservation status of native fish by reducing the range and population sizes of particular species. Listed below are the major factors influencing this status (after Koehn and O'Connor 1990).



Macquarie perch



Murray cod

Habitat removal

A wide range of activities remove or alter fish habitat. De-slagging of watercourses, channelising, river straightening, wetland drainage, and sand and gravel extraction have all contributed to the loss or reduction of fish species. These activities cause loss of shelter, which fish use as protection from water velocity, predators, competitors, and sunlight.

Removal of in-stream habitat causes loss of spawning sites and food supply sources. Flood mitigation or control can reduce available offstream habitat in wetlands that are replenished by flood events.

Riparian conditions

Riparian vegetation forms much fish habitat and greatly influences in-stream conditions. It acts as filter for run-off, assists in maintaining natural water quality and bank stability, and provides organic matter and habitat for invertebrates that are major sources of energy and food. Its woody debris furnishes fish habitat and spawning sites, and it gives shade that influences the temperature regime. Clearing, grazing, and introduced vegetation species (such as willows) alter such habitat conditions.

Sedimentation

Rapid erosion of exposed soils in the catchment, and within the watercourse and riparian zone, accelerates the input of sediment into the watercourse. Sources of eroded sediment include catchment run-off from agricultural and urban areas, construction works (such as water storages, bridges, and roads), and timber-harvesting, mining, and in-stream gravel extraction.

Sedimentation causes loss of in-stream habitat by changing not only bed and bank conditions (perhaps destroying bed spawning sites), but also in-stream vegetation and possibly the biological functions of fish - such as respiration, feeding, and spawning.

Reduced water quality

Pollutants may emanate from diffuse sources (such as the run-off of chemicals from agricultural lands or salt from salinised areas) or from point-sources (like effluents from sewerage works, industry, or stormwater drains). Water storages can also alter water quality chemically, physically, and biologically.

Loss of water quality produces lethal and sub-lethal effects on fish. Sub-lethal effects include loss of suitable habitat, reduction of growth rates, reduced feeding, and physiological and behavioural changes. Indirect effects of pollution can include loss or changes to riparian and in-stream vegetation.

Changed stream flow and barriers to fish passage

Water storages and diversions can alter stream flow and yield. Irrigation releases can alter the seasonality of peak flows. Storages alter the natural patterns of flow, typically reducing the incidence of small and moderate floods. The total yield of a watercourse can be substantially altered through the operation of a storage or the direct diversion of stream flows. Storages, weirs, and other smaller barriers (such as erosion-control structures, culverts, and drains) can block the movement of fish, which can disrupt the life cycles of some species.

Changes in stream flow affect available habitat through reduced inundation of wetlands and other areas, and may disrupt spawning and thus the life cycles of those species dependent on the natural timing of flows. Habitat loss can occur through changes in the flooding regime and reductions in water yield. Environmental flow allocations are designed to address some of the effects of changes within managed water supply systems, and these are described in Chapter 12.

Introduced species

Introduced fish compete with native species for food and habitat; for example, trout and redfin have similar diets to many native fish. Predation can pose a threat to the smaller species. For example, brown galaxias is particularly prone to predation by trout and at least two populations have disappeared following trout introduction. Introduced species may carry foreign fish diseases, with potential for great loss of native fish. Introduced species are artificially stocked and released in the study area.

Stocking

The Department of Conservation and Environment maintains a program for stocking native and fresh-water species, for recreational and conservation purposes. Three native species, two of which are considered vulnerable and occur naturally here (Macquarie perch and Murray cod), are stocked in watercourses in the study area. Introduced trout are stocked in several watercourses and water bodies for recreational purposes, as described in Chapter 13.

Areas of High Conservation Value for the Vertebrate Fauna

Representation of fauna within the current reserve system

Assessment of how well the fauna of the study area are represented within the current reserve system can use either of two main criteria: the faunal habitat, in terms of representation of the vegetation communities, or the distributions of individual species.

Some species have very specific habitat requirements and may only occur in one or two vegetation communities (for example, New Holland mouse, helmeted honeyeater, and Baw Baw frog). If those communities are not well represented in the reserve system then these species may not be adequately protected. Other species that are more widespread and utilise a wide range of communities are more likely to have at least some of their preferred habitat reserved. Some fauna, while widespread for most of the year, have very precise habitat requirements in the breeding season. For example, the pink robin has been recorded in a range of communities in moist forests, dry forests, and heathland vegetation. However, it breeds almost exclusively in cool temperate rainforest, and to ensure adequate reservation status, this community needs to be targeted.

Chapter 7 discussed the conservation status of the vegetation communities. Although individual ones probably have varied extent within the broad vegetation categories, it is useful to consider the extent of those categories.

Sub-alpine vegetation is limited in extent in the study area, but occurs in a number of conservation reserves such as Baw Baw National Park and the unreserved Lake Mountain State Park. Non-reserved areas, particularly of sub-alpine woodland, include Mounts Terrible, Matlock, Torbreck, and Bullfight.

Montane vegetation and moist forests are both very poorly represented within conservation reserves, except for small areas in the two parks above. The Board of Works-controlled catchments contain significant areas but the bulk lies within State forest. The lack of representation of these vegetation categories is illustrated by species

that are restricted to them; Leadbeaters possum, for example, has less than 5% of its distribution within reserves.

Dry forests are more adequately represented, being found in Eildon State Park, Cathedral Ranges National Park, Fraser National Park, Bunyip State Park, and Moondarra State Park. Nevertheless, although relatively widespread they do not adequately cover all species contained within them. For example, the smoky mouse is restricted to dry forests, sub-alpine vegetation, and montane vegetation, the first two being relatively well reserved. However, no records of the smoky mouse within the study area have come from conservation reserves.

Plains vegetation is poorly represented on the public land. Most of it has been cleared for agriculture and the balance often comprises small remnants or linear strips. Very little native grassland remains on public land, and even less is reserved. This severely limits the areas of suitable habitat for the threatened grassland species, the striped legless lizard and lined earless dragon.

Heathland vegetation is relatively well represented. Bunyip and Moondarra State Parks contain areas of heathy woodland and wet heathland, and coastal heathland is well represented in French Island State Park. Other coastal vegetation is also relatively well represented, being included in French Island State Park, and Point Nepean National Park, and on Phillip Island.

At the level of vegetation category it is apparent that those types most poorly represented in conservation reserves are the montane and moist forests.

The second way to assess the adequacy of fauna representation in the current reserve system is to consider individual species. Significant and notable species are usually rare, have a limited distribution, or have specific habitat requirements. If these species are adequately catered for in the reserve system, then the more common and widespread ones should also be accommodated. Many of the accounts of significant and notable species given above, have discussed representation in the current reserve system.

Their level of representation varies greatly. For some, such as the Baw Baw frog and

helmeted honeyeater, despite an extremely limited distribution, most of the population are within the reserve system. In contrast, other species have been recorded in few if any reserves. Significant or notable ones poorly represented include the tiger quoll, Leadbeaters possum, large-footed myotis, brush-tailed phascogale, squirrel glider, smoky mouse, bush thick-knee, sooty owl, powerful owl, grey-crowned babbler, painted honeyeater, mountain dragon, spotted tree frog, and giant burrowing frog. None of these species are well-represented State-wide, as most have little current representation, although a few have a moderate level outside the study area.

Old-growth forest

Management of viable old-growth forest ecosystems is one of the most crucial issues facing forest managers in Australia. The study area supports some of the most important old-growth forests in the State, which are perceived as being uncommon and diminishing, but a detailed inventory has not yet been undertaken. The Department of Conservation and Environment is currently developing a working definition for old-growth forest, and a discussion paper (Humphries 1990) has suggested the following basis.

'Old growth is forest characterized by the presence of standing living trees ... that are both large and old, and have low growth rates ... and in which senescence is facilitating the development of hollows suitable for the denning needs of a range of hollow-dependent vertebrate fauna.'

These forests may contain trees of predominantly one age class (even-aged forest) or more than one (multi-aged forest).

Old-growth forests are important for the conservation of a range of fauna, especially hollow-dependent species. Most arboreal mammals and bats within the study area require hollows for nesting or roosting, as do many birds, including owls, parrots, and treecreepers. For some species, like the sooty owl, old-growth ash forest is the principal habitat within the study area. Others such as the greater glider, while also occurring in regeneration, are most abundant here.

The 1939 bushfires resulted in predominantly even-aged regeneration, with many of the fire-killed old trees remaining as stags. As these stags collapse over the next 50 years, the 1939 regeneration will become largely devoid of hollow-bearing trees. The remaining old-growth forest will then provide the main habitat for those species dependent on hollows. Even species currently more abundant in 1939 regeneration than in old-growth forests (for example, Leadbeaters possum), depend on the latter for their long-term conservation.

Multi-aged forest contains a high structural diversity that provides a wide range of foraging substrates. The uneven canopy layer contains a variety of habitats suitable for invertebrates, which are required by canopy-feeding insectivorous birds such as the satin flycatcher and black-faced monarch. Multi-aged forests also provide a variety of hollow sizes, necessary to support a range of species.

Large logs on the forest floor are another characteristic of old-growth forests, providing habitats for ground-dwelling fauna. These may be important in recycling nutrients, particularly nitrogen and carbon, as well as providing habitats for ground-dwelling fauna. Fallen logs provide valuable basking and foraging substrates for some reptiles, like the southern water skink (CTF), movement pathways for small and medium-sized mammals, shelter for ground-nesting birds, and a rich source of invertebrates for insectivorous species.

A significant proportion of the old-growth ash forests of the study area occur in Board of Works-controlled catchments. The O'Shannassy Catchment and the State forest surrounding its northern boundary are particularly important as they form the largest and most intact continuous tract of old-growth forest in the study area. Elsewhere, the patches are smaller and more fragmented (for example, south of Baw Baw National Park, Royston River south of Rubicon, and New Turkey Spur north-east of Powelltown).

While most discussions on old-growth forest have focused on ash species, mixed-species old-growth forests are also very important for fauna conservation. The powerful owls, for example, probably require these for its

survival, and arboreal mammals are more abundant here than in younger forests. The eucalypts in them often survive wildfires, which results in multi-aged forests (compared with the even-aged regeneration forest, most often produced when an ash forest is burnt). Therefore, multi-aged mixed-species forests are relatively more common than multi-aged ash forests. The figures provided in Chapter 15 for mature/over mature forest, while this is not identical to old-growth forest, give some indication of the extent. Approximately 85% of mixed-species forest in the study area is classified, in forestry terminology, as mature/over mature, compared with 20% of mountain ash, 10% of alpine ash, and 8% of shining gum.



Powerful owl

In addition to protecting old-growth forests, particularly ash species, consideration must be given to the continued development of this age class. Existing areas of old-growth forest can be further reduced through timber harvesting or if another extensive wildfire occurred. To ensure the continued survival of species dependent on old-growth forest, strategies to ensure the maintenance and protection of current ecological processes must be investigated.

The location, mapping, and identification of 'ecologically mature forest' (a term often used interchangeably with old-growth forest), and the protection of representative and ecologically viable samples of this forest type, are commitments made in the 1987 State Conservation Strategy (Victoria 1987). Although some of these forests are still being logged at present, the inception of a comprehensive strategy will better cater for the management of old-growth forests in timber-production areas in the future.

Board of Works-controlled water supply catchments

The Board of Works' protected water catchments of the study area (Wallaby Creek, Maroondah, O'Shannassy, and Upper Yarra) have a high faunal conservation value. Their use is carefully controlled and the level of human disturbance is low. Logging is normally excluded (although some salvage logging following the major November 1982 fire has been undertaken in the Wallaby Creek catchment), and so they have not suffered the generally deleterious effects fauna associated with this activity. Due to the requirement for high water quality, roads are maintained in good condition, which minimises sediment run-off into streams and maintains stream quality.

The O'Shannassy, Maroondah, and Wallaby Creek Catchments contain large areas of old-growth ash forest (up to 300 years old) that are very important for the long-term conservation of hollow-dependent fauna. Being naturally very wet, they have less probability of being burnt by wildfire, and are therefore more likely to retain and develop old-growth forest over a long period. If a wildfire did burn these forests, the resulting highly dense stags would still provide short-term suitable habitat for hollow-dependent fauna. However, salvage logging, if undertaken after the fire, would decrease the number of trees remaining as stags and hence the value to fauna.

The combination of the above factors makes these catchments extremely important for fauna conservation in the Central Highlands. To maintain this value, an appropriate management regime for them would need to be maintained.

Western Port

The extensive intertidal mudflats of Western Port are important for the conservation of a wide range of bird species. In 1983, its international significance was formally recognised by its listing on the Ramsar Convention (the 'Convention on Wetlands of International Importance especially as Waterfowl Habitat' convened at Ramsar, Iran). Many of the birds that use Western Port are also listed on two other international agreements. The Japan-Australia Migratory Birds Agreement (JAMBA) recognises that

certain species migrate between Australia and Japan and that some of these are endangered in one or other country, and includes a commitment to conserve their habitats of these species. There is a similar agreement with China (CAMBA).

The most numerous of the birds using Western Port are the migratory waders, which predominantly breed in the Northern Hemisphere and migrate south each year to spend the northern winter in Australia. Many of these are included in the international agreements. There have been counts of up to 16 000 waders from Western Port, making it one of the most important areas for waders in Victoria. Western Port supports the second-largest aggregation of the rare eastern curlew in Victoria, and it is the fourth-largest overwintering site for the species in the world (Lane 1987). Significant proportions of the Victorian populations of whimbrel, grey-tailed tattler, greenshank, and terek sandpiper also occur here.

Other species of water-birds present in large numbers include the black swan (recent counts of 12 000), sacred ibis (2000), and white-faced heron (1100).

Birds that feed on mudflats frequently congregate, sometimes in their thousands, at high-tide roosts awaiting the next ebbing tide. The waders utilise roost sites on small islands, promontories, or banks of sand or stone. Some of the more important ones include Rams Island, Tortoise Head, Barallier Island, and Yallock Creek/Bunyip River mouth (Loyn 1975). Many of the larger



Royal spoonbill

water-birds, such as the white-faced heron, sacred ibis, and royal spoonbill, roost in mangroves and so have a wide choice of roosting sites available to them in Western Port.

A number of human activities have the potential to affect the conservation status of birds using Western Port.

- * Habitat destruction and alteration such as that resulting from reclamation of mudflats for industrial development. The most important mudflats are those that stay exposed at high tide, thus providing extended feeding opportunities. If these areas are removed (and being closest to the shore they are often the ones most



Australian pelicans and black swans

vulnerable) some species would be unable to feed for a sufficient period of time during each tide cycle to ensure their continued use of the bay. Mangroves provide secure roost sites for many of the larger water-birds, and removal of mangroves could result in a decline in their numbers (Loyn 1975).

- * Human disturbance to shore-birds which require undisturbed feeding and high-tide roosting sites, can cause birds to take flight and use valuable energy reserves, by either flying around until the disturbance is past or moving to an alternative roost which may be several kilometres away (Loyn 1975). Disturbance to breeding sites of species

such as the pied oystercatcher can reduce breeding success.

- * Pollution can affect birds by altering their invertebrate food supply. Sometimes organic pollution can increase the amount of food available and benefit some species; however, it may be to the detriment of others (Lane 1987). The effects of other types of pollutants such as petrochemicals, synthetic chemicals, and heavy metals are not precisely known, but are likely to be detrimental.

In 1977, the LCC recommended that a large proportion of Western Port become a wildlife management co-operative area. It recognised

that the region was very important for wildlife, but that the waters of the bay also served a number of other functions. This recommendation has not been implemented due, in part, to the difficulty and complexity of coastal management.

Of the few large embayments that occur on the Victorian coast, some, such as Port Phillip Bay, have already been extensively developed for urban and industrial use. Western Port, however, has remained largely rural and the bay is comparatively unpolluted (by world standards), which makes it extremely important, especially for the migratory waders whose survival depends equally on the protection of the breeding areas in the Northern Hemisphere and on that of the overwintering sites in Australia. There is a commitment under the international agreements to protect the wetland habitat in Western Port. It is therefore very important that Western Port be maintained as an area of suitable habitat for these species.

Remnant vegetation

Although much of the study area incorporates large areas of intact native forests, some communities such as box woodland have been extensively cleared for agricultural development. The native vegetation in these areas is now restricted to small remnants surrounded by farmland.

The value of remnant vegetation for the conservation of wildlife in fragmented areas cannot be over-emphasised (Bennett 1990). In less than 200 years, broad-scale clearing has drastically reduced the available wildlife habitat here to fragmented blocks or linear strips such as roadsides, disused laneways, creeks, and fencelines. These linear reserves often contain old-growth elements and, if large enough, can support viable populations of species. Their value is further increased if they adjoin larger forested blocks and, by functioning as corridors, they allow for the movement of wildlife. Their structure, age, and degree of disturbance influence the composition and diversity of fauna persisting in the area.

Roadside reserves with very old trees can support a large number of individuals. For example, arboreal marsupials such as the common ringtail possum and the common

brush-tail possum can reach high densities within them. They often provide tree hollows and foraging substrates for birds and mammals, and shelter-sites for ground-dwelling reptiles and mammals. Patches of remnant vegetation also provide some cover, against predation by raptors, for birds moving through cleared landscapes.

Wildlife utilising remnant vegetation can have positive benefits for the surrounding rural environment. For example, insectivorous bats, roosting in remnant patches and foraging over farmland, consume large quantities of pest insects.

A number of roadside reserves within the study area have been identified as crucial for the survival of some significant species. For example, the only known population of the squirrel glider here, is along a minor road in the Seymour district, where the overstorey vegetation is predominantly mature grey box. The value of this reserve is enhanced as it is continuous with more extensive river red gum forests along the Goulburn River. Furthermore, the connecting vegetation contains a high eucalypt species diversity, including important nectar-producers such as yellow box, red box, and red ironbark. The survival of some rare bird species in the study area depends upon remnant patches. The only known population of the grey-crowned babbler south of the Divide occurs within remnant woodland on the Mornington Peninsula. The bush thick-knee survives within a small patch in the north of the study area.

An alarming number of trees within these already fragmented reserves are suffering from ill health; the precise causes of this problem remain unknown. However, the long-term viability of these remnants may be affected by minor-produce activities (such as firewood-gathering), grazing, rural tree decline (dieback), insect attack, salting, aerial spraying of herbicides, and roadworks. The effects of all of these processes need to be investigated so that remnant areas can be managed to provide valuable wildlife habitat within these rural environments.

Invertebrates

Invertebrates - animals without backbones - are the most numerous and diverse group

of multi-cellular organisms on earth. Australia supports about 6000 vertebrates, but about 100 000 described invertebrate species and possibly another 200 000 undescribed ones.

It would be extremely useful if all the invertebrate species that occur in the study area could be listed as we have done above, with few exceptions, for the vertebrate fauna. It would also be worth while to describe their ecology, distribution, and conservation status. We could then state what species were rare and where each was located. Sites of significance for them could then be identified and taken into account in the land-use planning processes. However, with a limited number of exceptions, this is not possible.

Because invertebrates are so diverse and complexly distributed, and because insufficient research has been conducted on them, our knowledge of invertebrate fauna is poor.

A broad-scale survey of invertebrates in the Mallee was conducted for the Land Conservation Council's Mallee Area Review but this has not been done for the Melbourne Area, District 2. The following assessment therefore, provides a generalised view of the composition, distribution, and ecology of the invertebrate fauna, with an indication of species known to be at risk, and identifies some threatening processes.

Ecological importance

Invertebrates comprise the largest portion of animal biomass in both terrestrial and aquatic environments. They range from microscopic organisms to earthworms, crustaceans, molluscs, scorpions, spiders, and insects. Invertebrates perform a wide range of functions, including maintaining the energy flow through the ecosystem, recycling nutrients, aerating and fertilising soil, maintaining water quality, pollinating and dispersing the seed of flowering plants, regulating the growth of individual plants and of plant communities, regulating the population size and distribution of plants and animals, and providing food for animals and plants.

A very small proportion of invertebrates are detrimental from a human perspective. Some

may be the agents or vectors of disease of human beings, their stock, or crops. Others attack forest trees, timber, clothing, food, and other materials.

Apart from their essential roles in natural ecosystems, invertebrates are also of direct benefit to humanity. They may provide food - not only the shellfish etc, but products such as honey from bees. In combination with other factors, they assist in maintaining natural water quality. A vast array of insects pollinate crops and garden flowers. Many predatory and parasitic species provide biological control over pest species, decreasing the need for the application of dangerous pesticides. Many of the larger and more brightly coloured ones have considerable aesthetic appeal. All species are of great scientific interest, providing invaluable information on the organisation and functioning of natural ecosystems, evolution, and biogeography. Many are useful as indicators of environmental health. All form a genetic resource with unforeseen benefits for humanity.

The fauna

Invertebrates are found in all terrestrial and aquatic habitats within the Melbourne, District 2 study area, from the sea and rocky and sandy shores to the rivers, swamps, grasslands, woodlands, and forests. Very specialised species are found in caves, are associated with particular host plants, or are confined to climatic refuge areas such as mountain tops.

A partial review of the existing literature by Vaughan in 1989 provided a preliminary listing of species recorded in the Department of Conservation and Environment's Melbourne region, but the lack of comprehensive information on the study area's invertebrate fauna, remains. Apart from a few well-studied taxa, it is not possible to identify significant species here, and therefore their protection depends upon protection of remaining natural habitat and upon the widespread amelioration of the threatening processes identified below.

Significance of the invertebrate fauna

In the virtual absence of species inventories arising from recent surveys of the fauna, the following discussion deals with species that

are sufficiently well known to be identified as significant and at risk. Most of them appear to be rare and could be considered for listing under the *Flora and Fauna Guarantee Act* 1988.

Eltham copper butterfly (*Paralucia pyrodiscus lucida*)

The Eltham copper butterfly utilises a dwarf form of the sweet bursaria (*Bursaria spinosa*), and is attended by species of the plant genus *Notoncus*. Rural and urban expansion have destroyed much of the habitat of the butterfly, which was generally thought extinct until its rediscovery in early 1987 on a planned subdivision in Eltham. Additional colonies were subsequently found near Eltham, at Castlemaine, and at Kiata in the Wimmera. Extensive searching of other potentially suitable habitat was unsuccessful, and established that the sub-species is rare and patchy in occurrence.

The developers took positive action by delaying work on the subdivision. A public appeal raised funds for acquisition of part of the subdivision, which were supplemented by additional funds from the Eltham Council and the then Department of Conservation, Forests and Lands. The land has now been bought, a management plan has been produced, and three areas have been set aside for conservation of the species, but it still faces considerable threat from the surrounding residential development.

Mount Donna Buang wingless stonefly (*Riekoperla darlingtoni*)

This rare stonefly is one of the two Victorian species listed by the International Union for the Conservation of Nature (IUCN). It is confined to small temporary streams close to the summit of Mount Donna Buang, and is already subject to the pressure of visitors and the encroachment of car parks. As with other species that are found in mountain refugia, it may face the loss of its habitat through changes to climate arising from the enhanced greenhouse effect.

Dandenong freshwater amphipod (*Austrogammarus australis* Sayce)

The species has been found only in the foothills of the Dandenong Ranges, including the Dandenong Creek near Bayswater, a

tributary of the Monbulk Creek, and in a 'gully half way to Sassafras'. It has not been collected since 1911, and is either rare or extinct. The Dandenong Creek locality has been heavily modified and now functions as a stormwater drain. Many other creeks in the vicinity have been degraded as a result of urban development.

An action statement has been prepared for the amphipod as required under the *Flora and Fauna Guarantee Act* 1988. Intended management actions include a survey of the headwater creeks of the Dandenong Ranges to determine whether the species still exists there and, if found, the collection of data on the characteristics of its habitat and the implementation of safeguards to protect it.

Giant Gippsland earthworm (*Megascolides australis*)

One of the largest earthworms in the world, the giant Gippsland earthworm, is endemic to a small area in South Gippsland. It is listed as vulnerable by the IUCN and studies on its ecology and population dynamics are currently being undertaken. The species appears to be locally common but declining within an area of some 100 000 ha centred on Loch, Korumburra, and Warragul, in the hills of the western Strzelecki Ranges. It has been found mostly on private land, apart from a small population discovered in the Mt Worth State Park in 1988. Most worms are presently found on stream-banks or hills too steep to plough.

Factors that may influence the worm's numbers are altered drainage patterns, land disturbance (ploughing), altered land use (crops instead of dairying), addition of chemicals (herbicides, insecticides), and the collection of the worm by biological supply houses for sale to collectors, educational institutions, and museums.

Long-term research on its ecology and biology is required. Members of the local farming community are quite proud of their giant worm, and are keen to ensure its long-term survival here. It would be opportune, given this attitude, to develop stream and river management plans and incentive schemes to persuade farmers to manage their land in ways to assist the conservation of the worm.

Copepods

The following species of copepod appear to be restricted to one or two localities and may be rare.

- * *Canthocamptus dedeckeri* (Hamond) is only known to occur on Mt Baw Baw and in the Lake Mountain Alpine Resort, where it has been found among soil and plant remains or in sphagnum.
- * *Canthocamptus mammillifurca* (Hamond) occurs near Lake Mountain, in a small, slowly trickling, ankle-deep, and rather muddy stream full of leaf litter that flows into the Snowy Creek, which is a tributary of the Acheron River.
- * *Canthocemptus sublaevis* (Hamond) is found at Mt Baw Baw, among sphagnum at high altitude.

All these species are restricted to highland country, which may render them susceptible to temperature changes associated with the greenhouse effect, particularly if highland areas become warmer. It is important to establish their distributional and conservation status and, if they are regarded as rare, to establish their temperature tolerance regimes.

Warragul burrowing crayfish (*Engaeus sternalis*)

Only known in the Labertouche Creek, near Warragul, this burrowing crayfish has been recorded as vulnerable because of the potential threats posed to the population by agricultural activity. Cattle have access to the creek and could damage the population by trampling banks and causing erosion. Parts of the floodplain of the creek are in process of being drained.

Narracan burrowing crayfish (*Engaeus phyllocercus*)

This species is found only over a 30-km section of the highland region of the western Strzelecki Ranges in South Gippsland, and was first collected from near Narracan around the turn of the century. There is a need to document its life history and breeding biology. Any activity that may lead to an alteration in the nature of the stream-side watertable should be discouraged. In the

case of development, forestry activity, or mining activity, the habitat of the species requires protection by providing buffer strips that include the stream or gully banks and the floodplains of the creeks.

Gippsland crayfish (*Euastacus kershawi*)

The Gippsland crayfish has also suffered range reduction, which may be due to heavy amateur fishing and land development. Research on *Euastacus* has suggested that crayfish may survive in developed areas, if the riparian vegetation is retained.

Nemertine worm (*Argonemertes australiensis*)

One of three Australian terrestrial nemertine worms listed as rare in the IUCN Red Data Book, it is found in Gippsland and at other sites. It is vulnerable to deforestation, as the forest where it occurs has been rapidly logged. Several of its other sites of occurrence in Victoria have been lost by the expansion of Melbourne. Australia is the only continent with endemic terrestrial Nemertina and the group therefore has international significance.

Sites of significance for invertebrates

Any habitat that is critical to the survival of the species listed above should be regarded as sites of significance.

In addition, vegetation communities and subcommunities that are restricted in distribution are likely to be of significance. However, because many invertebrates are distributed in a patchy and often unpredictable manner within a given vegetation type, making their conservation a complex issue. Therefore all areas of indigenous vegetation are potential sites of significance for invertebrates, and establishment of priorities should be based on the best available information.

A great many species have been described for the first time from locations within the study area. These type localities are often the only site where a species has been recorded (although this may arise because of insufficient sampling elsewhere). They are also important for subsequent scientific research, giving them significance on two counts.

Other significant sites are scientific reference areas subject to ongoing research and monitoring. These include the upper reaches of the Acheron River, the Taggerty and Stevenson Rivers and Cement Creek, where scientists from the Museum of Victoria and Monash University have conducted research on aquatic invertebrate communities for many years. An important site on the Acheron river was recently disturbed by the building of a dam across the river for water extraction.

Threatening processes

Invertebrates, like plants and vertebrate animals, are subject to direct loss of their habitat due to the expansion of urbanisation, industry, forestry, mining, agriculture, and the damming and diversion of waterways. Apart from the direct removal of habitat, native vegetation adjacent to developed areas may be subject to altered drainage patterns, weed invasion, pollution, and the increased incursion of humans and their domestic stock.

Contamination of terrestrial and aquatic habitats by biocides, herbicides, and fertilisers also threatens invertebrates.

Of particular concern is the excessive removal of logs and fallen wood, either for firewood or through their destruction along with the leaf litter and upper soil habitat as a result of fuel-reduction burning. This removes the habitat of a great many invertebrates and much greater care should be taken to develop a program of mosaic burning, with areas burnt at different time intervals and other areas not burnt at all. Later successional species will be driven to local if not total extinction if all their habitat is burnt at short intervals. The increased fragmentation and isolation of natural habitat remnants aggravates the situation.

Certain species are under threat from over-collection. This applies particularly to rare and highly prized species, especially butterflies such as the Eltham copper butterfly. It also applies to the edible shellfish of our rocky shores, which have been subject to heavy illegal collection over recent years.

Considerable debate has concerned the impact of the introduced honey bee (*Apis mellifera*) on native invertebrates and other wildlife.

Research on the topic continues, but results to date have been inconclusive and often contradictory. There is, however, consensus on the need to eliminate feral populations of the honey bee. Also, nobody can dispute that the introduction of an animal in large numbers has an impact on natural ecosystems.

Other introduced invertebrates of concern are the European wasp (*Vespula germanica*), snails and slugs, and a host of pests of agricultural crops that may also affect on native communities.

Any potential alterations to climate arising from the enhanced greenhouse effect will affect invertebrates, whether through alteration to the habitat on which they depend or through the creation of conditions to which they are not physiologically adapted. Of most concern are coastal habitats, which may suffer inundation, and other habitats of restricted distribution such as mountain refugia, which may disappear completely with climatic change.

References

- Andrew, D.L., Lumsden, L.F., and Dixon, J.M. (1984). Sites of zoological significance in the Western Port region. *Ministry for Conservation Environmental Studies Program* No. 327.
- Australian Biological Research Group (1984). The impacts of timber production and harvesting on native flora and fauna. Appendix C. Report of the Board of Inquiry into the Timber Industry in Victoria. (Victorian Government Printer Office: Melbourne.)
- Baker-Gabb, D.J. (1990). List of threatened fauna in Victoria in 1990. Unpublished report. Department of Conservation and Environment, Victoria.
- Baker-Gabb, D.J., Benshemesh, J.S., and Maher, P.N. (1990). A revision of the distribution, status and management of the Plains-wanderer *Pedionomus torquatus*. *Emu* 90: 161-8.
- Barnett, J.L., How, R.A., and Humphreys, W.F. (1978). The use of habitat components by small mammals in eastern Australia. *Australian Journal of Ecology* 3: 277-85.

- Bennett, A.F. (1990). Habitat corridors, their role in wildlife management and conservation. Department of Conservation and Environment, Victoria.
- Blakers, M., Davies, S.J.J.F., and Reilly, P.N. (1984). 'The Atlas of Australian Birds.' Royal Australasian Ornithologists Union. (Melbourne University Press: Carlton.)
- Blandowski, W. (1855a). Excursion to Frankston, Balcomb's Creek, Mount Martha, Port Phillip Heads, and Cape Schanck. *Transactions of the Philosophic Institute of Victoria* 1: 24-37.
- Blandowski, W. (1855b). Excursion from Kings Station to Bass River, Phillip and French Islands. *Transactions of the Philosophic Institute of Victoria* 1: 50-67.
- Braby, M.F. (1989). Reptiles of the northern section of Kinglake National Park. *Victorian Naturalist* 106: 79-85.
- Braithwaite, R.W., and Gullan, P.K. (1978). Habitat selection by small mammals in a Victorian heathland. *Australian Journal of Ecology* 3: 109-27.
- Brereton, R., Schulz, M., Beardsell, C., Mansergh, I., Sandiford, K., and Bennett, S. (in prep.). Sites of zoological significance of south-east Melbourne and the Mornington Peninsula. *Arthur Rylah Institute for Environmental Research Technical Report Series No. 92*.
- Brouwer, J., and Garnett, S. (Eds.). (1990). Threatened birds of Australia. An annotated list. *Royal Australian Ornithological Union Report No. 68*.
- Brown, G.W., Earl, G.E., Griffiths, R.C., Horrocks, G.F.B., and Williams, L.M. (1989). Flora and fauna of the Acheron forest block, Central Highlands, Victoria. Department of Conservation, Forests and Lands. *Ecological Survey Report No. 30*.
- Brown, P.B. (1989). The Swift Parrot *Lathamus discolor*. A report on its ecology, distribution and status including management considerations. (Department of Lands, Parks and Wildlife: Tasmania.)
- Brown, P.B. and Wilson, R.I. (1984). The Orange-bellied Parrot recovery plan. (Department of Lands, Parks and Wildlife: Tasmania.)
- Burnett, S. (1991). The effects of a rainforest road on the movements of small mammals. *Abstract 37th Scientific Meeting of the Australian Mammal Society*. University of New England, Armidale.
- Chesterfield, E.A. (1984). Effects of fire on the flora of dry sclerophyll forests. In 'Fighting Fire... With Fire: A Symposium on Fuel Reduction Burning in Forests.' (Ed. E.H.M. Ealey.) pp.129-45. (Monash University: Melbourne.)
- Cockburn, A. (1980). The diet of the New Holland Mouse (*Pseudomys novaehollandiae*) and the House Mouse (*Mus musculus*) in a Victorian coastal heathland. *Australian Mammalogy* 3: 31-4.
- Cockburn, A. (1983). Smoky Mouse *Pseudomys fumeus*. In 'The Australian Museum Complete Book of Australian Mammals.' (Ed. R. Strahan.) p.413. (Angus and Robertson: Melbourne.)
- Cogger, H.G. (1986). 'Reptiles and Amphibians of Australia.' (rev. edn.) (Reed Books: Frenchs Forest, NEW SOUTH WALES.)
- CONCOM (1990). Draft list of Australian endangered vertebrate fauna. CONCOM Adhoc Working group on Endangered Fauna.
- Coulson, G. (1990). Conservation biology of the Striped Legless Lizard (*Delma impar*). An initial investigation. *Arthur Rylah Institute for Environmental Research Technical Report Series No. 106*.
- Dann, P. (in prep.). Distribution, population trends and factors influencing the population size of Little Penguins *Eudyptula minor* on Phillip Island, Victoria.
- Debus, S.J.S. and Silveira, C.E. (1989). The Square-tailed Kite *Lophoictinia isura* in Victoria. *Australian Bird Watcher* 13: 118-23.
- Department of Conservation, Forests and Lands (1988b). A permanent road network for the ash and associated mixed species forests of the Central Highlands of Eastern Strzeleckis. Internal technical report,

Department of Conservation, Forests and Lands, Victoria.

Department of Conservation, Forests and Lands (1989). Code of forest practices for timber production. Revision No. 1. Department of Conservation, Forests and Lands, Victoria.

Department of Water Resources (1989). Water Victoria: An Environmental Handbook. (Victorian Government Printing Office: Melbourne).

Dwyer, P.D. and Hamilton-Smith, E. (1965). Breeding caves and maternity colonies of the Bent-winged Bat in south-eastern Australia. *Helictite* 4: 3-21.

Edgar, R. (1983). Spotted-tailed Quoll *Dasyurus maculatus*. In 'The Australian Museum Complete Book of Australian Mammals.' (Ed. R. Strahan.) pp.18-19. (Angus and Robertson: Melbourne.)

Emison, W.B., Beardsell, C.M., Norman, F.I., Loyn, R.H., and Bennett, S. (1987). 'Atlas of Victorian Birds.' (Department of Conservation, Forests and Lands, and Royal Australian Ornithologists Union: Melbourne.)

Fleming, M.R., Temby, I.D. and Thomson, R.L. (1979). Sites of zoological significance in the Upper Yarra region. *Ministry for Conservation, Environmental Studies Program Report* No. 247.

Fox, B.J. (1982). Fire and mammalian secondary succession in an Australian coastal heath. *Ecology* 63: 1332-41.

Franklin, D.C., Menkhorst, P.W., and Robinson, J.L. (1989). Ecology of the Regent Honeyeater *Xanthomyza phrygia*. *Emu* 89: 140-54.

Frith, H.J. (Ed.) (1979). 'The Readers Digest Complete Book of Australian Birds.' (Readers Digest Service: Sydney.)

Gillespie, G.R. (1990). Distribution, habitat and conservation status of the Giant Burrowing Frog, *Heleioporus australiacus* (Myobatrachidae), in Victoria. *Victorian Naturalist* 107: 144-53.

Gruen, F., Leslie, A., and Smith, A.P. (1989). Inquiry into the proposed trial of the

value adding utilisation system in the Central and East Gippsland Forest Management areas, under the Environmental Assessment Act. Ministry for Planning and Environment, Melbourne.

Hall, L.S., Young, R.A., and Spate, A.P. (1975). Roost selection of the Eastern Horseshoe Bat *Rhinolophus megaphyllus*. *Proceedings 10th Biennial Conference Australian Speleological Federation*, pp.47-56.

Harris, M.P. and Bode, K.C. (1981). Population of Short-tailed Shearwaters and Little Penguins and other seabirds on Phillip Island. *Emu* 81: 20-8.

Harris, M.P. and Norman, F.I. (1981). Distribution and status of coastal colonies of seabirds in Victoria. *Memoirs of the National Museum of Victoria* 42: 89-106.

Heyer, W.R. and Liem, D.S. (1976). Analysis of the intergeneric relationships of the Australian frog family Myobatrachidae. *Smithsonian Contributions to Zoology* 233: 1-29.

Hill, R., Bamford, M., Rounsevell, D., and Vincent, J. (1988). Little Terns and Fairy Terns in Australia - an RAOU Conservation Statement. *Royal Australian Ornithological Union Report* No. 53.

Humphries, R. (1990). A review of criteria on which old growth forests in Victoria may be based. Unpublished report, Department of Conservation and Environment, Victoria.

Hutchinson, M.N. (1979). The reptiles of Kinglake National Park. *Victorian Naturalist* 96: 124-34.

Hyett, J. (1964). The present status of the Helmeted Honeyeater (*Lichenostomus cassidix*). *VORG Notes* 12: 14-32.

Jones, E. (1990). Physical characteristics and taxonomic status of wild canids, *Canis familiaris*, from the eastern highlands of Victoria. *Australian Wildlife Research* 17: 69-81.

Kinnear, J.E., Onus, M.L. and Bromilow, R. N. (1988). Fox control and rock-wallaby population dynamics. *Australian Wildlife Research* 15: 435-50.

- Kitchener, D.J. and Caputi, N. (1985). Systematic revision of Australian *Scoteanax* and *Scotorepens* (Chiroptera: Vespertilionidae), with remarks on relationships to other Nycticeini. *Records of West Australian Museum* 12: 85--146.
- Koehn, J.D., and O'Connor, W.G. (1990b). Threats to Victorian native freshwater fish. *Victorian Naturalist* 107(1): 5--11.
- Land Conservation Council (1973). 'Report on the Melbourne Study Area.' (Victorian Government Printing Office: Melbourne.)
- Land Conservation Council (1977). 'Final Recommendations, Melbourne Study Area.' (Victorian Government Printing Office: Melbourne.)
- Land Conservation Council (1985). 'Melbourne Area, District 1. Review.' (Victorian Government Printing Office: Melbourne.)
- Lane, B.A. (1987). 'Shorebirds in Australia.' (Nelson Publishers: Melbourne.)
- Lewis, F. (1954). The rehabilitation of the Koala in Victoria. *Victorian Naturalist* 70: 196--200.
- Lill, A. (1980). Reproductive success and nest predation in the superb lyrebird, *Menura superba*. *Australian Wildlife Research* 7: 271--80.
- Lindenmayer, D.B. (1989). The ecology, and habitat requirements of Leadbeaters possum. Ph.D. Thesis. Australian National University, Canberra.
- Lindenmayer, D.B., Nix, H.A., McMahon, J.P., and Hutchinson, M.F. (1990e). Bioclimatic modelling and wildlife conservation and management - a case study on Leadbeaters possum, *Gymnobelideus leadbeateri*. In 'Management and Conservation of Small Populations.' (Eds. T.W. Clark and J.H. Seebeck.) pp.253--73. (Chicago Zoological Society: Brookfield, Illinois.)
- Littlejohn, M.J. (1963). Frogs of the Melbourne area. *Victorian Naturalist* 79: 296--304.
- Littlejohn, M.J. and Martin, A.A. (1967). The rediscovery of *Heleioporus australiacus* (Shaw) (Anura: Leptodactylidae) in eastern Victoria. *Proceedings of the Royal Society of Victoria* 80: 31--6.
- Loyn, R. (1975). Report on the avifauna of Westernport Bay. *Ministry for Conservation, Environmental Studies Program, Project Report No. 448.*
- Loyn, R.H. (1978). A survey of birds of Western Port Bay, Victoria, 1973-74. *Emu* 78: 11--19.
- Loyn, R.H. (1985). A bird population in successional forests of Mountain Ash *Eucalyptus regnans* in central Victoria. *Emu* 85: 213--30.
- Loyn, R.H., Macfarlane, M.A., Chesterfield, E.A. and Harris, J.A. (1980). Forest utilisation and the flora and fauna in Boola Boola State Forest in south-east Victoria. *Forests Commission Victoria Bulletin* No. 28.
- Lunney, D., Eby, P. and O'Connell, M. (1991). Effects of logging, fire and drought on three species of lizards in Mumbulla State Forest on the south coast of New South Wales. *Australian Journal of Ecology* 16: 33--46.
- McCoy, F. (1867). On a new genus of Phalanger. *Ann. Mag. Nat. Hist.* 20: 287--8.
- Macfarlane, M.A. (1988). Mammal populations in Mountain Ash (*Eucalyptus regnans*) forests of various ages in the Central Highlands of Victoria. *Australian Forestry* 51: 14--27.
- Macfarlane, M.A. and Seebeck, J.H. (1991). Draft management strategies for the conservation of Leadbeaters possum *Gymnobelideus leadbeateri*, in Victoria. *Arthur Rylah Institute for Environmental Research Technical Report Series* No. 111.
- Malone, B.S. (1985). Status, distribution and ecology of the Baw Baw Frog (*Philoria frosti*). *Arthur Rylah Institute for Environmental Research Technical Report Series* No. 36.
- Mansergh, I. (1984). The status, distribution and abundance of *Dasyurus maculatus* (Tiger Quoll) in Australia, with particular reference to Victoria. *Australian Zoology* 21: 109--22.

- Mansergh, I., Beardsell, C., Bennett, S., O'Connor, W., Sandiford, K., and Schulz, M. (1989). Report on the sites of zoological significance in the Upper Yarra Valley (western sections) and Dandenong Ranges. *Upper Yarra Valley and Dandenong Ranges Authority Technical Report Series* No. 25.
- Mansergh, I. and Bennett, S. (1989). Greenhouse and wildlife management in Victoria. *Victorian Naturalist* 106: 243-52.
- Mansergh, I.M. and Norris, K.C. (1982). Sites of zoological significance in Central Gippsland. *Ministry for Conservation, Environmental Studies Program* No. 359.
- Martin, A.A. (1965). Tadpoles of the Melbourne area. *Victorian Naturalist* 82: 139-49.
- Martin, A.A., Littlejohn, M.J. and Rawlinson, P.A. (1966). A key to the anuran eggs of the Melbourne area, and an addition to the anuran fauna. *Victorian Naturalist* 83: 312-15.
- Menkhorst, P.W. (1987). Working list of Victorian mammals. Second edition. *Arthur Rylah Institute for Environmental Research Technical Report Series* No. 50.
- Menkhorst, P.W. and Gilmore, A.M. (1979). Mammals and reptiles of north central Victoria. *Memoirs of the National Museum of Victoria* 40: 1-34.
- Menkhorst, P.W., Loyn, R.H., and Brown, P.B. (1990). Management of the Orange-bellied Parrot. In 'Management and Conservation of Small Populations.' (Eds. T.W. Clark and J.H. Seebeck.) pp.239-52. (Chicago Zoological Society: Brookfield, Illinois.)
- Menkhorst, P.W. and Seebeck, J.H. (1981). The distribution, habitat and status of *Pseudomys fumeus* Brazenor (Rodentia: Muridae). *Australian Wildlife Research* 8: 87-96.
- Menkhorst, P.W., Weavers, B.W., and Alexander, J.S.A. (1988). Distribution, habitat and conservation status of the Squirrel Glider *Petaurus norfolcensis* (Petauridae: Marsupialia) in Victoria. *Australian Wildlife Research* 15: 590-71.
- Murliss, M. (1989). Hooded Plover and Pied Oystercatcher survey - Victoria 1988. *Stilt* 14: 31-3.
- Newsome, A.E., McIlroy, J. and Catling, P. (1975). The effects of an extensive wildfire on populations of twenty ground vertebrates in south east Australia. *Proceedings of the Ecological Society of Australia* 9:107-23.
- Norris, K.C., Mansergh, I.M., Ahern, L.D., Belcher, C.A., Temby, I.D., and Walsh, N.G. (1983). Vertebrate fauna of the Gippsland Lakes catchment, Victoria. *Fisheries and Wildlife Victoria Occasional Paper Series* No. 1.
- Pearman, G.I. (Ed.) (1988). 'Greenhouse: Planning for Climate Change.' (CSIRO: Melbourne.)
- Rawlinson, P. (1965). Snakes of the Melbourne area. *Victorian Naturalist* 81: 245-54.
- Rawlinson, P.A. (1967). The vertebrate fauna of the Bass Strait Islands: 2. The reptilia of Flinders and King Islands. *Proceedings of the Royal Society of Victoria* 80: 211-24.
- Rawlinson, P.A. (1971). The reptiles of West Gippsland. *Proceedings of the Royal Society of Victoria* 84: 37-51.
- Rawlinson, P.A. (1974). Revision of the endemic southeastern Australian lizard genus *Pseudomoia* (Scincidae: Lygosominae). *Memoirs of the National Museum of Victoria* 35: 87-96.
- Rawlinson, P.A. (1981). Conservation of Australian amphibian and reptile communities. In 'Proceedings of the Melbourne Herpetological Symposium.' (Eds. C.B. Banks and A.A. Martin.) pp.127-38. (Zoological Board of Victoria: Melbourne.)
- Rawson, R.P., Billing, P.R. and Duncan, S.F. (1983). The 1982-83 forest fires in Victoria. *Australian Forestry* 46: 163-72.
- Schulz, M. (1985). The occurrence of the Mourning Skink, *Egernia coventryi*, in saltmarsh in Westernport Bay, Victoria. *Victorian Naturalist* 102: 148-52.

- Schulz, M. (in press.). The Grey-crowned Babbler *Pomatostomus temporalis* - a cause for concern in southern Victoria. *Australian Bird Watcher*.
- Schulz, M. and Bamford, M. (1987). The Hooded Plover - an RAOU Conservation Statement. *Royal Australian Ornithological Union Report No. 35*.
- Schulz, M., Macfarlane, M.A., Parkes, D.M., Traill, B.J., Triggs, B., and Menkhorst, K.A. (1987). Flora and fauna of the Mount Murray Forest Block, north-eastern Victoria. *Department of Conservation, Forests and Lands, Ecological Survey Report No. 14*.
- Scotts, D.J. (in press). Old-growth forests: their ecological characteristics and value to forest-dependent vertebrate fauna of south-east Australia. In 'Conservation of Australia's Forest Fauna.' (Ed. D. Lunney.) (Royal Zoological Society New South Wales: Mosman.)
- Shaw, S. (1984). Fire protection by the Forests Commission; planning operations. In 'Fighting Fire ... With Fire: A Symposium on Fuel Reduction Burning in Forests.' (Ed. E.H.M. Ealey.) pp.78--84. (Monash University: Melbourne.)
- Shepherd, G.E. (1903). Western Port notes. *Emu* 2: 219--20.
- Smales, I. (1981). The herpetofauna of Yellingbo State Faunal Reserve. *Victorian Naturalist* 98: 234--46.
- Smales, I.J., Craig, S.A., Williams, G.A., and Dunn, R.W. (1990). The Helmeted Honeyeater: decline, conservation and recent initiatives for recovery. In 'Management and Conservation of Small Populations.' (Eds. T.W. Clark and J.H. Seebeck.) pp.225--38. (Chicago Zoological Society: Brookfield, Illinois.)
- Smith, A.P. (1980). The diet and ecology of Leadbeaters possum and the Sugar Glider. Ph.D. Thesis. Monash University, Melbourne.
- Smith, A.P. and Lindenmayer, D. (1988). Tree hollow requirements of Leadbeaters possum and other possums and gliders in timber production ash forests of the Victorian Central Highlands. *Australian Wildlife Research* 15: 347--62.
- Spencer, B. (1921). The necessity for an immediate and co-ordinated investigation into the land and freshwater fauna of Australia and Tasmania. *Victorian Naturalist* 37: 120--2.
- Suckling, G.C. and Macfarlane, M.A. (1984). The effects of fire on fauna - review. In 'Fighting Fire ... With Fire: A Symposium on Fuel Reduction Burning in Forests.' (Ed. E.H.M. Ealey.) pp.107--28. (Monash University: Melbourne.)
- Thompson, M.B. (1983). Populations of the Murray River Tortoise *Emydura* (Chelodina): the effect of egg predation by the red fox *Vulpes vulpes*. *Australian Wildlife Research* 10: 363--71.
- Tilley, S. (1982). The diet of the Powerful Owl *Ninox strenua* in Victoria. *Australian Wildlife Research* 9: 157--75.
- Tyndale-Biscoe, C.H. and Calaby, J.H. (1975). Eucalypt forests as refuge for wildlife. *Australian Forestry* 38: 117--33.
- Wainer, J.W. (1983). Swamp Antechinus *Antechinus minimus*. In 'The Australian Museum Complete Book of Australian Mammals.' (Ed. R. Strahan.) pp.48--9. (Angus and Robertson: Melbourne.)
- Victoria, Government of (1987). Conservation Strategy for Victoria: Protecting the Environment. (Victorian Government Printing Office: Melbourne.)
- Wainer, J.W. and Gibson, R.J. (1976). Habitat of the Swamp Antechinus in Victoria. Distribution and habitat requirements of the mainland Swamp Antechinus *Antechinus minimus maritimus* (Finlayson) (Marsupialia: Dasyuridae). *Victorian Naturalist* 93: 253--5.
- Warneke, R.M. (1983). Australian Fur-seal *Arctocephalus pusillus*. In 'The Australian Museum Complete Book of Australian Mammals.' (Ed. R. Strahan.) pp.462--3. (Angus and Robertson: Melbourne.)
- Watson, G.F. and Littlejohn, M.J. (1985). Patterns of distribution, speciation and vicariance biogeography of south-eastern

Australian amphibians. In 'Biology of Australasian Frogs and Reptiles.' (Eds. G. Grigg, R. Shine and H. Ehmann.) pp.91--7. (Surrey Beatty and Sons: Chipping Norton, New South Wales.)

Watson, G.F., Littlejohn, M.L., Hero, J.M., and Robertson, P. (in prep.). Conservation status, ecology and management requirements of the Spotted Tree Frog, *Litoria spenceri*. Final report - September 1990.

Watson, L. (1981). 'Sea Guide to Whales of the World.' (Hutchinson: London.)

Watts, C.H.S. and Braithwaite, R.W. (1978). The diet of *Rattus lutreolus* and five other rodents in southern Victoria. *Australian Wildlife Research* 5: 47--57.

Weavers, B. (in prep.). Seasonal foraging ranges and movements at sea of Little

Penguins *Eudyptula minor*, determined by radiotracking.

Webster, R. and Menkhorst, P. (1990). The Regent Honeyeater (*Xanthomyza phrygia*): population status and ecology in Victoria and New South Wales. Unpublished report to Australian National Parks and Wildlife Service.

Wheelwright, H.W. ('An Old Bushman'). (1862). 'Bush Wanderings of a Naturalist'. (Routledge, Warne and Routledge: London.)

Wilkinson, H.E. (1961). The rediscovery of Leadbeaters possum, *Gymnobelideus leadbeateri* McCoy. *Victorian Naturalist* 78:97--102.

Wilson, S.K. and Knowles, D.G. (1988). 'Australia's Reptiles: A Photographic Reference to the Terrestrial Reptiles of Australia.' (Collins: Sydney.)

9. MARINE AND COASTAL ENVIRONMENT

The marine and coastal environment comprises the coastal areas, waters, and seabed of Western Port and the ocean coasts from Point Nepean to Cape Paterson and 5.5 km seaward. Although Port Phillip Bay lies within the Land Conservation Council's Melbourne Area, District 1, District 2 includes the coastal lands above low-water mark of the Mornington Peninsula.

This chapter provides basic descriptions of marine and coastal physical and biological resources, but it does not attempt a comprehensive or detailed coverage of the subject. Chapter 8 gives details on the mammals, birds, reptiles, and amphibians of the study area, including the marine and coastal zones, and describes the high conservation values of Western Port for vertebrate fauna. Some aspects of flora are described below, with further information provided in the flora chapter.

Marine and coastal environments are valued for a range of uses, notably conservation, recreation, industrial, transport, and utility development. Within the study area, sites of floral, faunal, geological, and geomorphological significance have been identified, some of which have State, national, or international significance; a number of parks and reserves have been created; and international agreements apply to fauna and habitat areas.

Resource use and environmental degradation were well advanced last century, with wetland drainage, catchment clearance, and removal of coastal vegetation. Although much modified, extensive remnants - notably on French Island, sections of the coastal reserve in Western Port, and stretches of the open coast - remain.

Some marine areas have been given protection under Council's recommendations and other State and local government policies serve to protect a range of recognised values. However, some conservation values are threatened, and issues arise over the appropriate use of coastal and marine areas and their resources, and protection of existing values.

Western Port

Physical

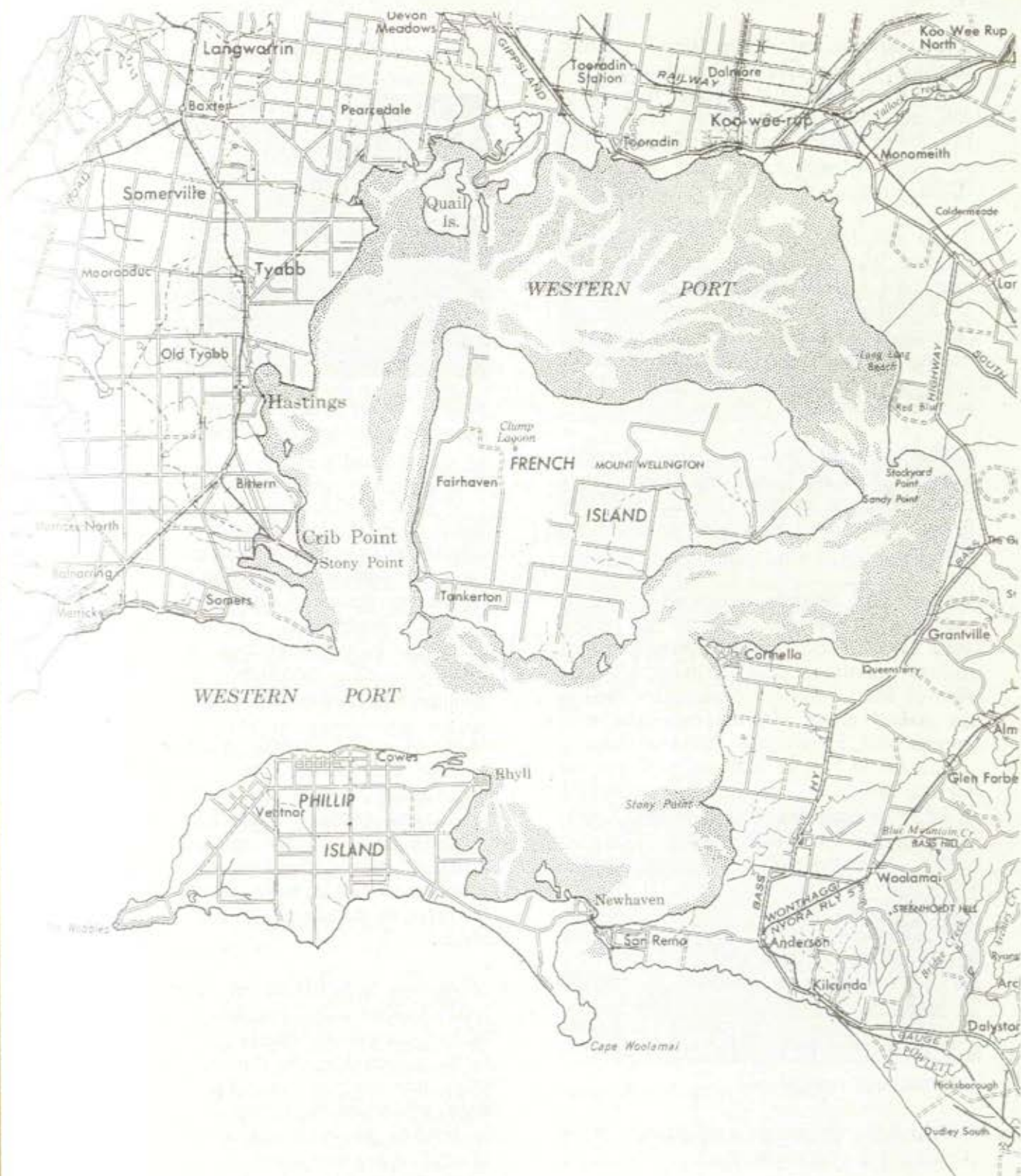
Western Port is a tidal embayment covering some 680 sq.km, of which 270 sq.km are intertidal flats (see Map 8). It contains two large islands, Phillip Island and French Island, and a number of much smaller ones. It has a catchment area of 3100 sq. km. Most of the fresh-water watercourses flow into the north of Western Port, but these inputs are relatively minor (about 400 000 ML per annum) in comparison with the volume in the bay. Bass and Lang Lang Rivers, Yallock and Toomuc Creeks, and Main Drain/Bunyip River are the principal watercourses.

Ocean swells penetrate Western Port, but only to a limited extent. The outer coastline, along the south of Phillip Island, is exposed to ocean swell prevailing from the south-west. These swells are weakened by refraction in the southern portion of Western Port. In the bay's north, the sheltered shores have a low topography featuring sandy beaches, low cliffs, cusps, spits, salt-marsh, and mangrove fringes.

A number of distinct morphological units comprise the marine and coastal environments of Western Port; beaches, rock platforms, rocky reefs, salt-marshes, mangrove zone, inshore marginal sandy zones, intertidal flats and banks, off-shore banks and shoals, embayment plains, and tidal channels. Two tidal flows dominate the channel system, North Arm and East Arm. North Arm, a shipping channel, contains a dredged section from Western Entrance (where most tidal waters enter) through to the Port of Hastings. Most sediment within the bay is transported by tidal energy.

Water temperatures vary from approximately 10°C in winter to approximately 22°C in summer. Tidal range increases with distance northwards: at Flinders the range is 1.6 m, but it reaches 2.2 m at Tooradin. Water movement follows complex patterns, as shown by the distribution of bottom sediments, with a net circulation clockwise

WESTERN PORT



LEGEND

INTERTIDAL FLATS



1 : 250 000

0 5 10 15 20

Kilometres



Land Conservation Council
Victoria

around French and Phillip Islands. Broad stretches of inter-tidal flats, exposed at low tide, are crossed by a complex network of ebb and flow channels. In the north of the bay, the ebb divides on either side of the tidal watershed between Lang Lang and French Island, a feature of international significance.

Sandy shorelines are generally receding in Western Port, as they are across Victoria, except for a small number of localised sites of accretion. Longshore sand drifts are building up spits on Sandy Point, Stockyard Point, and Observation Point, while an active dune spilling from the Woolamai isthmus supplies the shores of Cleeland Bight.

Cliffed sections are in retreat between Yallock Creek and Lang Lang River. Sandy beach sectors at Somers, Cowes, and Phillip Island's north coast are subject to continuing erosion.

Western Port contains significant geological and geomorphological sites in its coastal area; Table 15 lists those of international and national significance. In addition, some 42 sites of State significance were identified in the coastal area. Of the two sites with international significance, Pioneer Bay is within the Pt Nepean National park and the Western Port tidal watershed is within the Wildlife management Co-operative Area recommended by Council in 1977.

Table 15

**COASTAL GEOLOGICAL AND
GEOMORPHOLOGICAL SITES OF
INTERNATIONAL AND NATIONAL
SIGNIFICANCE - WESTERN PORT**

International significance

Pioneer Bay - Quaternary stratigraphy
Western Port - tidal watershed

National significance

Bass River delta and floodplain
Cape Woolamai - tombolo
Lyall Inlet to Bunyip River - coastline
Native Dog Creek to Thorny Beach
Woolamai Beach and tie bar
Yallock Creek - swamp sediments

Source: Rosengren (1984)



Erosion of the beach and primary dunes at Somers is causing vegetation loss

Vegetation

Much of the Western Port coastal vegetation consists of salt-marsh and swamp vegetation types along the sheltered intertidal areas. A zonation of species is apparent and is related to tidal submergence, possibly indicating a succession of vegetation types accompanying extension of marshland terrace and accumulation of salt-marsh peats.

Most of the intertidal mudflats carried seagrass beds (*Zostera muelleri*, *Heterozostera tasmanica*, *Amphibolis antarctica*) until recent and extensive dieback. Above the mid-tide level, many mudflats have a mangrove-fringed shoreline, with a mangrove zone up to 100 m wide, usually extending landward to the mean high-water spring-tide level.

Mangroves line 108 km of Western Port's total shoreline of 263 km, with the remainder mainly comprising beaches and rock platforms. One species, the white mangrove (*Avicennia marina*), comprises the mangrove zone, behind which a community dominated by shrubby glasswort may occur. Landward of the mangroves and within the area inundated by the maximum tidal reach is the salt-marsh. This contains a small number of species - Barson and Calder (1981) listed 49 (including introduced species) in Western Port. Swamp paperbark (*Melaleuca ericifolia*) frequently occurs on the landward side of the salt-marsh, above the level of maximum high tide.

Changes in the mangrove fringe have been determined by comparing current conditions

with a survey conducted in 1842. Mangrove dieback and disappearance have considerably reduced the once-almost-continuous fringe in northern Western Port, parts of the east coastline, and on Phillip and French Islands. The numerous reasons blamed for the losses include destruction for landings, jetties, and harbours, installation of drainage outlets (especially for the draining of Koo-Wee-Rup Swamp), wood-harvesting, and drifting sand. Toxic pollutants and smothering by accumulations of washed up seagrass are other possible causes. Following mangrove losses, coastal erosion produces foreshore instability, with possible subsequent loss of salt-marsh areas.

There has been a significant loss of seagrass in Western Port. Primary production by mangroves and seagrass probably plays a major role in the bay's ecosystem, through nutrient cycling, productivity, and their effects on the patterns of sedimentation there. Seagrasses have an important ecological role; one seagrass community (*Zostera sp.*) was shown to have provided the food supply for 19 fish species. Chapter 20 discusses the decline of the seagrass beds, in the section on nature conservation in marine and coastal areas.

Both commercial and recreational fisheries depend on fishes and other marine life that feed on seagrass and seagrass detritus. Birds and other marine fauna also depend on the seagrass.

Marine invertebrates

Western Port has a numerous and highly diverse invertebrate fauna. Some 1350 species have been recorded, representing an estimated 50–60% of the total number of species in all invertebrate groups. Because of its habitat diversity - tidal channels, fast tidal currents, rock platforms, beaches, tidal flats, mangroves, and salt-marshes - Western Port supports a wide range of species. Each habitat contains a unique assemblage of flora and fauna, as the hydrological conditions, substratum available for settling and colonisation, and the degree of aerial exposure, together determine the species' distribution.

A rich and diverse fauna of sessile, filter-feeders - sponges, ascidians, hydroids, bryozoans, bivalves, and brachiopods - is the feature of the bay that distinguishes it from

virtually all others on the Australian coastline. Shapiro (1975) stated that Western Port is virtually unique in species' composition and faunal invertebrate diversity.

Two species are identified as being of particular importance. A bivalve mollusc, *Neotrigonia margaritacea*, belongs to a family widely represented around the world as fossils, but rare as living members. This species of 'living fossil' is far more abundant here than anywhere else in Australia. A brachiopod species, *Magellonia flavesceus*, occurs in large populations in Western Port, one of the few places where this archaic and unusual species occurs.

Benthic macrofauna have a distribution closely related to sediment distribution. They comprise two main faunal assemblages: one lives in the deeper portions of the North and East Arms where little or no mud occurs in the substrate; the other occupies the muddy substrate at the shallow edges of the channels and on the intertidal flats. Shapiro (1975) found a high species' diversity at most sampling stations, but unexpectedly low diversity in the North Arm.



Inter-tidal areas at San Remo

Investigations associated with the proposed marina at San Remo resulted in the discovery of several new species and subsequent proposed nomination of the San Remo Marine Community to schedule 2 of the *Flora and Fauna Guarantee Act* (1988) by the Flora and Fauna Guarantee Scientific Advisory Committee.

Fish

Shapiro (1975) also sampled fish during his study: trawling collected 68 species and

beach seining collected 33 species, nine of which differed from those gathered by trawling. Results differed between sampling stations: the Entrance sampling area with its heavy surf and shifting substratum yielded fewer species, lower biomass and fewer individuals than more sheltered areas. Low diversity also occurred in the industrialised North Arm, possibly due to the effects of effluent discharges and of dredging. Diversity indices from the macro-invertebrate surveys were lowest in the industrialised section of North Arm, a similar finding to the fish study.

Development

The development along the Western Port coast reflects the industrial, port, fishing, recreation, and military values of the area.

Settlement to date has been characterised by a relatively high density of small coastal towns. After Cowes (2251) and Hastings (5186) (ABS 1990), the next 20 largest settlements have populations under 1000 people.

Industrial development is concentrated at Hastings and at nearby Long Island. An oil refinery, gas-processing plant, steel mill, and associated structures occupy extensive tracts in the coastal zone. Several of the industrial sites abut sensitive public foreshore and coastal areas. Many associated works - roads, piers, and easements - occupy public foreshore lands. Environmental protective measures employed in contemporary planning were not developed at the time of establishment of many of these industrial facilities. It follows, therefore, that many structures are not ideally sited and a loss of environmental values has taken place in this section of the coast. However, some exceptional circumstances exist, such as at Long Island Point, where restricted access has assisted in protecting some important bird habitat.

Recreation has a widespread impact across Western Port; many facilities associated with recreation involve public lands. There are 18 yacht and boat clubs around Western Port and Phillip Island. Westhaven Marina, a large facility at Hastings, entailed considerable coast and foreshore works. A smaller marina, operating at Yaringa, involves a lengthy artificial inlet cut through the mangrove fringe. Mooring points have

been established at several locations in northern Western Port, providing berths for several hundred craft.

A proposal for a marina at San Remo proceeded to the environmental effects statement, after which it was not approved. Investigations may proceed into alternative sites for a similar development.



Commercial and recreational craft at Hastings pier

Port facilities at Hastings include jetties at the steel mill and at Long Island for the Esso/BHP fractionation plant. Further to the south, at Crib Point, a jetty has been constructed to convey liquid hydrocarbons ashore.

Dredging occurs in the main shipping channel within the North Arm, to maintain the required depth in this zone of active sediment movement. Routine dredging is also undertaken at numerous jetties and boat ramps.

The Royal Australian Navy occupies two large sites. Flinders base, HMAS 'Cerberus' at Crib Point township, which incorporates Hanns Inlet. High conservation values have been recognised for the Sandy Point area of the Crib Point base, notably for bird habitat, and for koala and small mammal populations. The second area of Commonwealth land - the RAN gunnery range - occupies West Head at Flinders.

Koo-Wee-Rup Swamp

Drainage of Koo-Wee-Rup Swamp, clearance of its wetland vegetation, and replacement of those species with introduced pastures and row crops produced a range of environmental



Bunyip River/Main Drain close to the river mouth

effects on the adjacent coastline and marine environment. Clearance of this very large fresh-water wetland (of about 40 000 ha), caused permanent loss of large areas of habitat. Artificial channels, channelised watercourses, and natural watercourses all underwent high rates of bed and bank erosion as the drainage works greatly increased the rate of drainage and frequency of flooding. Prior to alteration, the swamp was largely drained by a series of meandering creeks, opening onto a mangrove-fringed shore, backed by fresh-water swamps. Koo-Wee-Rup Swamp's conversion to agricultural lands changed the drainage network and morphology of northern Western Port. The Standing Consultative Committee on River Improvement (1984) estimated that six million cubic metres of sand and gravel were carried into the previously muddy tidal flats and channels of northern Western Port. Channel erosion was greatest in the Lang Lang River, Bunyip River/Main Drain, and Toomuc and Cardinia Creeks. Bird and Barson (1975) identified beaches of these sediments, smothering some salt-marsh areas. Some authors have attributed the draining of the swamp and subsequent sediment deposition to the seagrass decline, but this association has yet to be proved.

Port Phillip Bay Coast

Physical

From south of Canadian Bay to Schnapper Point, Mornington, the coastline comprises sandy beaches backed by cliffs of sandstone and granite. South of Mornington to Martha Point it forms a succession of cliffs and

promontories with small embayments. Between Martha Point and The Sisters, near Sorrento, is a 23 km long sandy beach formerly backed by dunes but now much disturbed and altered. Cliffs and shore platforms with sections of narrow beach lie beyond The Sisters to Point Nepean. Beaches between Canadian Bay and Balcombe Bay have quartose sands, some with gravel; those between Dromana and Portsea carry predominantly calcareous

Table 16

COASTAL GEOLOGICAL AND GEOMORPHOLOGICAL SITES OF NATIONAL AND STATE SIGNIFICANCE - PORT PHILLIP BAY

National significance

Fossil Beach

State significance

Half Moon Bay (Mt Eliza)
Manyung Rocks
Sunnyside Beach
Manmangur Creek
Red Bluff (Mornington)
Harmon Rocks
Mount Martha
Balcombe Point (Martha Cliffs)
Martha Point East
Point McArthur

Source: Ministry for Planning and Environment (1988-90)

sands. Shallow off-shore sand-bars between Dromana and Sorrento are a feature of this coast; the innermost bar may be exposed at low tide.

Several sites of geological and geomorphological significance have been identified along the coastline; Table 16 lists those of national and State significance.

Vegetation

Much of the natural coastal vegetation has been removed, and introduced species and land-use activities have significantly affected the remainder.

Prior to European settlement the coastal fringe supported banksia and casuarina open forest, while melaleuca scrub, eucalypt open

forest and woodland grew further landward. Lime-burning in the 1850s consumed large quantities of coastal timber. Drooping she-oak stands between McCrae and Rosebud were cleared to fuel the lime kilns; wattles replaced the drooping she-oak, but had their bark stripped for use by tanneries and were replaced by coast tea-tree and coast banksia. Coast tea-tree also colonised the areas between Mount Martha and Mornington, after drooping she-oak and manna gum were cleared. Boneseed and myrtle leaf milkwort are two introduced species considered to have had a considerable impact on native species.

However, the narrow band of remnant native vegetation within the foreshore reserve, although often in poor condition, is the only such vegetation along much of the coast. Camping areas, car-parking, and formed and unformed beach-access paths have contributed to the degradation of vegetation in the reserve, especially adjacent to popular beaches. Remnant native vegetation at Point Nepean (within the Pt Nepean National park and Commonwealth land) has been identified in several studies as having high botanical value.

Ocean Coasts

Physical

From Point Nepean to Selwyn Fault, west of Cape Schanck, cliffs of dune limestone are indented with numerous embayments and beaches of siliceous sand. Gunnamatta and Rye ocean beaches have considerable length.

Dune systems are prominent along this coast. The remnants of ancient dune systems are preserved by the development of dune limestone or calcarenite. Clified outcrops of calcarenite are clearly exposed at Point Nepean, Portsea, and Sorrento ocean beaches. Younger and unlithified calcareous dunes become mobile if not bound by vegetation.

East of Selwyn Fault (at the eastern end of Gunnamatta Beach) to West Head at Flinders rise tall basalt cliffs, reaching more than 100 m near Cape Schanck (Keble 1957). A few small embayments with shingle beaches lie above the intertidal platforms; an exception is Bushrangers Bay, a large embayment with a sandy beach.

Shore platforms, sea stacks, arches, blow holes, and caves are common features along this section of coast.

Basalt cliffs and headlands extend from the Nobbies on Phillip Island to the vicinity of Sunderland Bluff. There are many small embayments, some of which have beaches. Woolamai Beach, backed by an extensive dune system forms an isthmus to Cape Woolamai, a tall, clified granite outcrop.

Along the coast from San Remo to Kilcunda, shore platforms front a clified coastline of Mesozoic siltstones and mudstones. At Kilcunda, sandy beaches are backed by parallel dunes extending to Coal Point, near Wonthaggi. From Coal Point to Cape Paterson are sandy beaches and shore platforms, backed by a dune system. At Cape Paterson, sandy beaches have some bedrock exposure.



The clified coast between San Remo and Kilcunda is of high scenic value

Vegetation

Calder (1986) surveyed the vegetation here. On the foredunes, the earliest colonisers are grasses such as hairy spinifex and the introduced marram grass. Salt spray has a major influence on dune vegetation; successive landward dunes suffer less from salt and develop a deeper soil profile, producing a horizontal zonation.

As the dune ages, sallow wattle and coast tea-tree replace the grasses; further landward the coast banksia is often dominant and grading into manna gum woodland.

Erosion has attacked many foredunes and new dunes rarely form; restorative works have been undertaken at many locations.

The basalt and calcareous cliffs have skeletal and alkaline soils, and the plants they carry are exposed to strong winds and salt spray. Widespread shrubs on the cliffed coasts include seaberry saltbush, white correa, coast beardheath, sea-box, boobialla, coast daisy-bush, and cushionbush, with kankalla, bower spinach, and New Zealand spinach prominent among the creepers. Exposed cliffs carry only infrequent trees, but some coast banksia and coast tea-tree. Communities occur on the calcareous cliffs that are absent from other cliffs; species include moonah, wirilda, thyme rice-flower, and daisy-bush.



Calcareous cliffs in Point Nepean National Park

Public land use

Land tenure along the coast is complex, as are the management arrangements, which involve a wide range of groups and authorities. Table 17 summarises the major public land areas; some may differ from Council's 1977 final recommendations, as explained in Chapter 11.

Council recommended that particular care should be taken in the coastal reserves to protect a number of sites with geological, floral, faunal, and other values. Sections of coast from Point Nepean to West Head, Flinders, and San Remo to Kilcunda were identified as having scenic value.

Land use for utilities and survey was recommended in the coastal reserves around Point Cribb--Hastings and Tyabb. A power station site was recommended on the south-east of French Island, but this has not been developed.

Issues

This discussion covers a number of issues - water quality, catchment management, the specific effects of urban and industrial development, recreation, and the implications of the greenhouse effect. Chapter 20, Issues, specifically describes Nature conservation in marine and coastal areas.

Table 17

COASTS: MAJOR AREAS OF CURRENT PUBLIC LAND USE

Classification	Area (ha)
Point Nepean National Park	2 450
French Island State Park	8 300
Arthurs Seat State Park	350
Greens Bush Reserve	390
Phillip Island Penguin Reserve	300
Western Port Wildlife Reserve	1 650
Rhyll Swamp Wildlife Reserve	250
Phillip Island Wildlife Reserve	450
Newhaven Swamp Wildlife Reserve	45
Reef Island-Bass River Wildlife Reserve	150
Western Port Wildlife Management Co-op. Area	28 400
Rhyll-Newhaven Wildlife Management Co-op. Area	2 500
Reef-Island-Bass River Mouth Wildlife Management Co-op. Area	700
Coastal Reserves	2 920

Knowledge of the marine and coastal environment is deficient in several fields, and the limited understanding often hampers assessment of proposed developments.

Greater details on the issues described below may be obtained from the Department of Conservation and Environment, the Marine Science Laboratories, the Environment Protection Authority, and the Westernport Regional Planning and Co-ordination Committee.

Catchment management

Coastal and marine areas have been greatly influenced by catchment modifications, as broadly described above. Those changes resulting in the increased stream flows and sediment delivery into Western Port and the removal of extensive areas of wetland habitat, have had particular importance.

Activities associated with the phases of rural settlement, closer settlement, modern agriculture, and the expansion of urban development and secondary industry in the catchment of Western Port have had a serious impact on the marine and coastal ecosystems. They included: clearing of native forests, woodlands, and wetlands; extensive wetland drainage; channel modifications (including straightening, deepening, and levee-building) and extensive drain construction; establishment of agriculture; waste discharge; and the expansion of urban areas. Environmental consequences of these activities included: increases in catchment run-off, erosion of catchments, erosion of stream-bed and banks, and flooding frequency; a substantial loss of flora and fauna; a loss of riverine water quality; and the discharge of large volumes of sediment into Western Port.

Management practices to tackle this issue focus on controlling erosion within the catchment, undertaking appropriate river management activities such as control of stream bank and headward erosion, and ensuring the protection of river frontages. A works program by the Western Port Catchment Authority is under way. These measures address the issues of water quality and sedimentation, but protection of the remaining wetland areas and remnant coastal vegetation is also important.

Water quality

European settlement and subsequent land uses have caused a decline in marine water quality in several locations. Physical changes that have altered the movement of waters and sediments have contributed. Of concern are those changes to water quality that are most likely partly responsible for the extensive depletion of the seagrass beds in Western Port (described in Chapter 20). Agricultural run-off is a potential source of additional nutrients reaching the marine environment.

Drainage from urban areas is another source of nutrient and other materials input. It causes disquiet that currently only three coastal towns in Western Port are sewered, and that seepage from septic tanks may enter the waters of the bay. Given the likely population increases predicted for the region the problem may intensify. Dredging within the Western Arm, minor works at launching ramps and similar sites, and the resultant need for spoil disposal gives rise to concern, as inappropriate marine or land disposal can result in the loss of environmental values.

The relatively few large point-source discharges in the study area, all have EPA licences. Effluent from the Board of Work's South East Purification Plant, which services the sewers of south-eastern Melbourne and most of the Mornington Peninsula, discharges at Boags Rocks on Gunnamatta Beach. Average daily discharges are 330 ML, and the effluent is treated to secondary level. A few industrial discharges (from the Esso refinery and Lysaght steel mills), enter the waters of Western Port at Hastings. Minor point-source discharges to the marine environment do not have EPA licences and these include stormwater drains, which may carry comparatively high pollutant levels following storms.

Water quality may fall through the increase of various materials that are discharged to the marine environment, or occur as an indirect consequence of current or earlier human activities. Loss of water quality can result in degradation of the environment, but also in a loss of the values derived from use of these waters, such as for commercial or recreational fishing, and a wide range of recreational activities.

The EPA undertakes regular monitoring of water quality in Western Port. Some biological monitoring of species indicative of water quality has also been conducted. Longer-term studies will be necessary to examine the water-quality issues of persistent contaminants and changes in marine communities, and to assess the effects of various discharges over time. Under the State Environment Protection Policy - Waters of Victoria, disposal of sewage to land is preferred to water disposal.

Recreation

Recreational use of coastal areas is exceptionally high, although much of it is focused in specific areas. It involves a wide range of activities, and of greatest interest are those with land use and environmental implications. Issues relating to coastal recreation include: access to the coast; the effects of structures (such as roads, buildings, car parks, picnic grounds, and boat ramps); damage to dune, salt-marsh, and mangrove vegetation; recreational boating; marina development; 'consumptive' activities (for example, fishing, and legal shell-collecting);

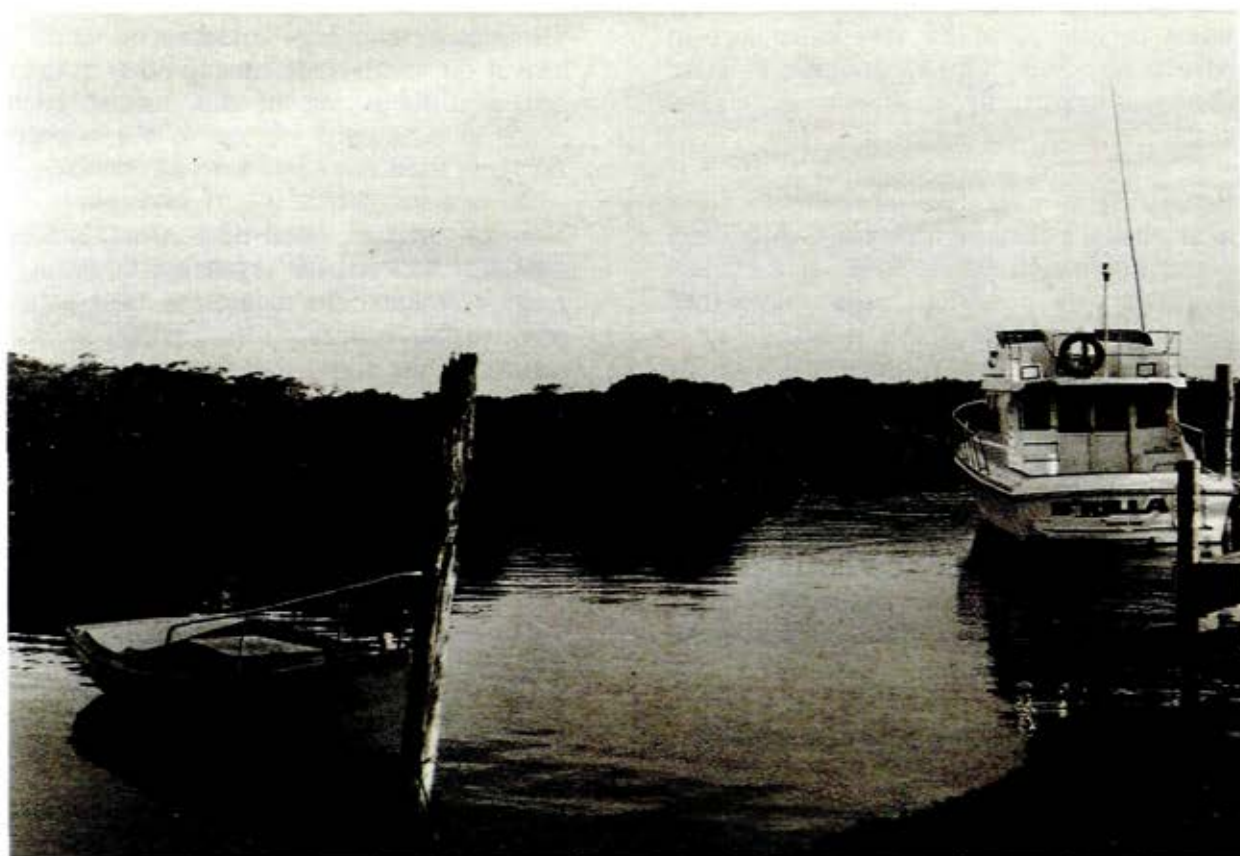
walking on reef flats or inter-tidal areas; and disturbance to bird habitat.

Melbourne's growth, particularly along the south-eastern corridor, will increase recreation demand here. Popular sites are likely to receive even more visitors. Areas within Western Port are expected to experience growth in coastal recreation, notably boating and beach activities.

Boats (and other water craft) pose particular problems. Demand for boat ramps will probably increase in future. Upgrading of existing ramps and installation of new facilities may threaten the environmental values of particular sites.

Boating activity may also lower environmental values. Disturbance - by water-craft, their passengers, and pets - of bird habitat in wetland and inter-tidal areas is of particular concern, and is described in greater detail in Chapter 20.

Uncontrolled vehicle access in coastal areas can damage coastal vegetation. Similarly, walking tracks can often destroy dune



Mangroves have been removed to provide moorings, such as here at Warneet, and for a variety of other purposes in Western Port



Woolamai Beach car park is currently sited adjacent to the beach

vegetation and other coastal environments, and controls undertaken have included closing extraneous tracks and revegetating damaged areas.

Exploitative recreational pursuits, like fishing, and shellfish- and bait-collection may threaten environmental values. Conflicts can arise between the need for protection of some species and their exploitation for recreation. Collection of plants, animals, shells, and other material in the inter-tidal and shallow water is considered by several authors to pose a significant long-term threat to these ecosystems, particularly close to population centres.

Harvesting of inter-tidal invertebrates (such as seashells, marine worms, and urchins) may cause diminution of selected species and alteration of marine and inter-tidal communities. Although this is recognised as an issue in policy documents and by management authorities, little research is available. Collection activities can involve physical disturbance of reef and inter-tidal habitat. Some species are protected under the Shellfish Protection Regulations (1983), but others not included are also believed to be in need of protection and a review of the regulations is required under the 'Making the most of the Bay' policy.

Coastal erosion and the greenhouse effect

Erosion and deposition are natural processes of coastal environments; however, accelerated erosion may cause land management and environmental problems. Some authors have suggested that coastline erosion is in a phase

of acceleration, with erosion losses exceeding deposition in the majority of places.

At a number of sites in the study area, the effects of coastal erosion on the environmental and recreational values can be observed. At Somers Beach, for example, high tides inundate the beach and are eroding the coastal dunes and causing the tea tree and other dune vegetation to fall into the sea. On the same beach the Somers Yacht Club, occupies an area of coastal dunes, and faces similar problems from encroaching sea water. Cowes beach and the remainder of the Phillip Island north coast is under active erosion.

Sea-level rises caused by the greenhouse effect have the potential to increase coastal erosion, and pose a threat to the environmental and other values of the coastal zone. With much remnant habitat confined to the often relatively narrow coastal reserves, permanent or regular inundation could result in the loss of these areas and the values they currently present.

Low-lying areas are at greatest risk, with the inter-tidal areas and coastal wetlands of Western Port being particularly vulnerable. These areas have high conservation value as habitat for water-birds, among other species, and any diminution of this habitat could result in substantial change to the Western Port ecosystems.

Loss of beaches, inter-tidal areas, coastal wetlands, and coastal vegetation threatens a range of values. In addition to their nature conservation values, these areas support recreation, the port and industry, and utilities and survey.



Somers Yacht Club

Further research is required into the influence of the greenhouse effect on coastal areas. Preliminary mapping has already identified areas along the Port Phillip Bay coast at risk from a sea-level rise induced this way.

Port and industrial development

Development of the industry-port complex in Western Port involved extensive modification to the coastal vegetation and landforms. Activities with environmental impacts included dredging, land reclamation, erection of sea walls, changes to patterns of erosion and deposition, and vegetation clearance. Future port development here will require careful planning and management, to avoid further loss of environmental values. Plans for possible port development at Hastings or Tyabb North are being considered by the Port of Melbourne Authority. Current boundaries for the Port of Hastings include areas of high conservation value for birds. Alternative locations are also being sought for the marina formerly proposed at San Remo.

Increased shipping activity carries a risk of contamination of the environment resulting from accidental spillages. Oil spills pose a high environmental risk, as Western Port has a heavy traffic in oil shipping as well as an environment susceptible to oil spills, including its inter-tidal and seagrass areas, mangroves, and sea-bed sediments. A major oil spill could result in the death of large numbers of water-birds if the mudflats become oil-covered. The environmental impacts of the detergents and other dispersants used to break up oil slicks could add to those of hydrocarbons; the result oil-dispersant mix could harm seagrass beds. No large spills have occurred to date, although a small land spill occurred at Hastings in late 1990, as well as minor ones earlier. Increased oil importation with a resultant rise in shipping traffic would increase the risk of major spills.

Waste disposal, the sewage system, and stormwater discharges from industrial areas have the potential to degrade the aquatic environment. Further development of the Port of Hastings will necessitate consideration of waste-discharge issues. Chapter 18 gives a description of the Port of Hastings.

Losses of mangroves and salt-marshes in Western Port have been incremental since

European settlement. Clearance, coastal engineering, wood-harvesting, and sedimentation are among the causes of destruction. Mangroves have an important ecological role in stabilising shorelines, as a food source, and as fish nursery areas. Reclamation, urban and recreational developments, stock-grazing, and vehicle access have contributed to the losses of salt-marsh.

Increasing population will increase the number of development proposals in marine and coastal areas. Careful planning is necessary to prevent the loss of significant environmental values through developments.

References

- Australian Bureau of Statistics (1990). *Victorian Year Book*.
- Barson, M.M., and Calder, D.M. (1981). Vegetation of the Victorian coast. *Proceedings of the Royal Society of Victoria* 92(1): 55-65.
- Bird, E.C.F. (1987). 'The Problem of Beach Erosion on the North Coast of Phillip Island.' (Phillip Island Conservation Society: Melbourne.)
- Bird, E.C.F. (1980) Historical changes on sandy shorelines in Victoria. *Proceedings of the Royal Society of Victoria* 91(1):17-32.
- Bird, E.C.F., and Barson, M.M. (1975). Shoreline changes in Westernport Bay. *Proceedings of the Royal Society of Victoria* 87(1,2):15-26.
- Calder, W. (1986). 'Peninsula Perspectives: Vegetation on the Mornington Peninsula.' 2nd ed. (Jimangle Publications: Melbourne.)
- Connell, D.W. (1975) A strategy for studies of the marine environment of Westernport Bay. *Proceedings of the Royal Society of Victoria* 87(1,2):95-105.
- Holmes, N. (1988). A preliminary ecological assessment of some Victorian coastal discharges. *Environment Protection Authority: Scientific Series* SRS 87/008.
- Keble, R.A. (1957). The Mornington Peninsula. *Geological Survey of Victoria, Memoir* No. 17.

Marsden, M.A.H., and Mallet, C.W. (1975). Quaternary evolution, morphology, and sediment distribution, Westernport Bay, Victoria. *Proceedings of the Royal Society of Victoria* 87(1,2):107--38.

Miles, I.W. (1976). The tidal watershed in Westernport Bay. *Victoria's Resources* 18(3):7--9.

Ministry for Conservation (1982). Recommendations and guidelines for the protection of seagrass communities in Western Port, Victoria. *Environmental Studies Project* No. 387.

Ministry for Planning and Environment (1988--90). *Technical Report Series: Making the Most of the Bay*.

Port Phillip Authority (1977). 'Port Phillip Coastal Study' (Victorian Government Printing Office: Melbourne.)

Rosengren, N. (1984). Sites of geological and geomorphological significance in the Westernport Bay catchment. *Environmental Studies Project* No. 401.

Shapiro, M.A. (1975). 'Westernport Bay Environmental Study 1973--1974: a Preliminary Report. (Ministry for Conservation: Melbourne.)

Smith, B.J., Coleman, N., and Watson, J.E. (1975). The invertebrate fauna of Westernport Bay. *Proceedings of the Royal Society of Victoria* 87(1,2):149--55.

Standing Consultative Committee on River Improvement (1984). 'The State of the Rivers.' (Victorian Government Printing Office: Melbourne.)

Victoria, Government of (1988). 'A Coastal Policy for Victoria.' (Victorian Government Printing Office: Melbourne.)

10. LAND SYSTEMS

Land systems provide a method of describing the characteristic pattern of a number of environmental factors across the landscape. The interactions of climate, lithology, and landform largely determine the natural distributions of indigenous vegetation and soils. Land systems map units express the co-existence of landform, lithology, climate, soils, and vegetation as a synthesis. In this form, environmental information can be readily used for land-use planning and management decisions. Such information has been used by the Land Conservation Council and other planning organisations for public land-use planning and management.

At the time of the earlier investigation of the study area (LCC 1973), no complete coverage of land systems information was available. Council's State-wide assessment (LCC 1988) incorporated a State-wide map at 1:250 000 scale - produced by compiling all available and relevant data from studies of individual areas (both published and unpublished materials) and remapping at a single scale in consistent mapping units. Map 9 reproduces that information.

The system divides the broad geomorphology of Victoria into six categories with a further subdivision into geomorphic units, of which 13 occur in the study area. Landform, lithology, and climate are determined for each geomorphic unit. To these independent variables can be added the dependent variables of soils and vegetation.

Within this land classification system, there is a hierarchy of mapping units, in which the smallest unit is the land component. Each land system comprises an aggregation of land components and in turn forms part of a geomorphic unit in this hierarchy. It follows that each land system represents a range of conditions, and examination at a more detailed level will uncover differences in the homogeneity of a land system.

Climate includes mean annual rainfall categories, broadly indicative of soil moisture availability. Temperature differences, especially in the high-rainfall, mountainous areas, are used to differentiate the temperate, montane, and subalpine areas. Landform is

categorised on the recognition of easily identifiable units. Lithology categories range from broad rock to unconsolidated materials, which have different effects on soil formation.

Data sources

Each of the data sources used in compiling the land systems map is listed below in Table 18, while Map 10 shows the areas covered by the different studies below. These data sources include the published reports of the Soil Conservation Authority and Land Protection Division of the Department of Conservation and Environment, maps and descriptions in Land Conservation Council descriptive reports, internal Soil Conservation Authority reports, and additional mapping from unpublished land system data. As a result, some differences in reliability could be expected in the land systems map.

Mapping units

Table 19 gives the categories for each land system component. Each land system is identified by a code representing, in sequence, landform, lithology and climate (see Table 20). Instances where landform or lithology are represented by more than one letter indicate a mixture of categories, with the order of letters indicating descending importance of the categories within the land system. A numerical subscript distinguishes between land systems differing in soils and vegetation.

Table 18

DATA SOURCES FOR LAND SYSTEMS MAP

E	Eildon (Rundle 1977)
Gn	Goulburn (White <i>et al.</i> in prep)
GL	Gippsland Lakes (Aldrick <i>et al.</i> in press)
Mb	Melbourne (Jeffery 1981)
U	Unpublished data
WB	Western Port (Sargeant 1975)
Y	Yarra (Van de Graaff and Howe 1976)

Source: Rowan (1990)

Table 19

KEY TO GEOMORPHIC CATEGORIES

	Category	Description
Central Victorian Uplands		
East Victorian Uplands	1.1	Dissected uplands
	1.2	Dissected plateaux
	1.3	High Plains
South Victorian Uplands	3.1	Dissected fault blocks
	3.3	Moderately dissected ridge
	3.4	Dissected fault blocks
West Victorian Volcanic Plains	7.1	Undulating plains
	7.2	Stony undulating plains
South Victorian Coastal Plains	8.1	Ridges and flats
	8.4	Fans and terraces
	8.5	Barrier complexes
South Victorian Riverine Plains	9.1	Present floodplains
	9.2	High terraces and fans

Additional information

Key letters giving information on landform, lithology, and climate are listed in Table 20. The variety in descriptive terms used for soils, results from the range of soil types and the descriptive systems used in different studies. Most descriptions refer to colour, texture or structure; they relate to the great soil groups of Stace *et al.* (1969) and use descriptive terms from Northcote (1979). Vegetation is described by structural category, as developed by Specht (1970), together with a listing of the dominant species. Soil process limitations are those deterioration processes to which the lands of each particular land system are susceptible.

In addition, the symbols used in the earlier published studies for each land system are provided, allowing the reader to obtain greater detail from the referenced studies.

Table 20

KEY TO LAND SYSTEM SYMBOLS

Landform

- C Coastal dune
- E East-west dune
- F Present floodplain
- G Gentle to moderate hill
- I Irregular dune
- L Lunette
- P Plain above flood level
- R Stranded beach ridge, usually tending NNW-SSE
- S Steep mountains and hill
- W Weakly elongated dune
- Y Gypseous dune

Lithology

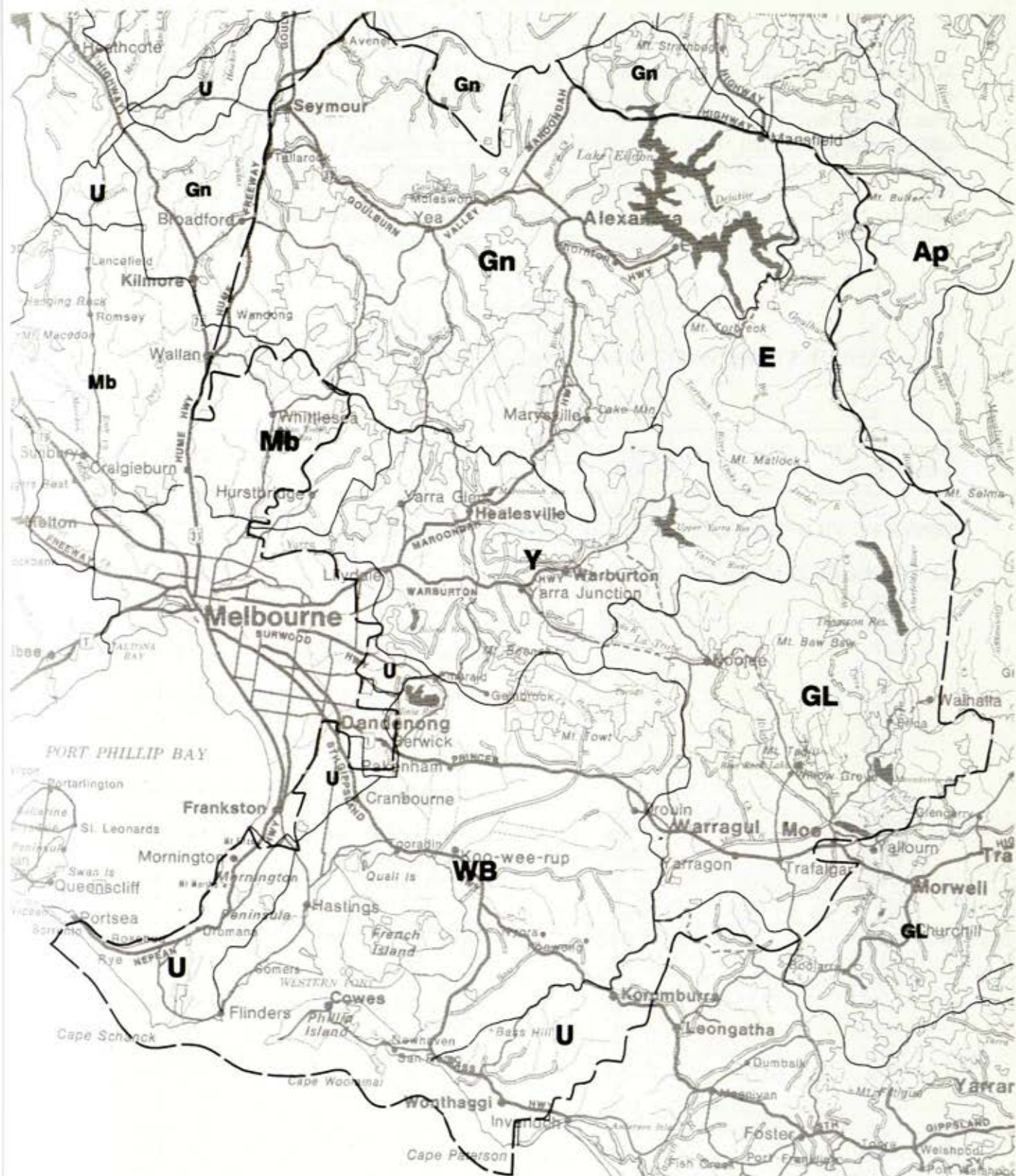
- c Coarsely textured unconsolidated deposits
- f Finely textured unconsolidated deposits
- g Granites and gneisses
- l Limestone
- s Sedimentary rocks
- v Volcanic rocks
- z Saline, finely textured deposits

Climate (mean annual rainfall)

- 2 200-300 mm
- 3 300-400 mm
- 4 400-500 mm
- 5 500-600 mm
- 6 600-700 mm
- 7 > 700 mm temperate
- 8 > 700 mm montane
- 9 > 700 mm subalpine

Representation within reserves

Areas recommended by Council for inclusion in several major land-use categories (national and State parks, reference areas, and education areas) have been selected partly on the basis of the land systems they represent. Council's policy as set out in its 'State-wide Assessment of Public Land Use' (LCC 1988) is to represent the more extensive land systems on suitable areas of public land, as well as those smaller land systems having important land or landform characteristics.

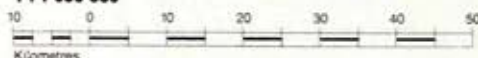


LEGEND

- Ap - Rowe 1977, Alpine,
- E - Rundle 1977, Eildon
- GL - Aldrick et al (in press), Gippsland Lakes Catchments
- Gn - White et al (in preparation), Goulburn
- Mb - Jeffrey 1981, Melbourne
- U - Unpublished data, mainly interpretation by J. N. Rowan
- WB - Sargeant 1975, Westernport Bay
- Y - Van de Graaff and Howe 1976, Yarra

- BOUNDARY OF STUDY AREA
- BOUNDARY OF LAND SYSTEMS

1 : 1 000 000



Land Conservation Council
Victoria

Cartography by Thematic Mapping Unit
Division of Survey and Mapping

MAP 10

Adequate representation was assumed to be a minimum of 10%, although other assessment criteria were involved (LCC 1988). Those land systems within the study area currently without adequate representation are shown in Table 21. Where only small areas of a particular land system remain on public land, there are few opportunities for incorporation

into a reserve. Readers will note that most land systems without adequate representation are those small in area and found predominantly or entirely on private land. Information provided in Table 21 was compiled from 1:500 000 scale maps; land systems too small to be shown at this scale were not listed.

Table 21

LAND SYSTEMS WITHOUT ADEQUATE STATE-WIDE REPRESENTATION IN RESERVES

Geomorphic units and land systems	Land system extent ¹	Conservation reserves ²	Freehold ³ (%)
CENTRAL VICTORIAN UPLANDS - EAST VICTORIAN UPLANDS			
1.1 DISSECTED UPLANDS			
Ss6 ₁	S	-	-
Sg6 ₁	S-M	-	97
Ss7 ₃	M-E	A6, B8-9, H6-7	25
Ss7 ₁₁	VE	-	3
Ss8 ₁	S	H12	83
Sg8 ₂	VS	-	-
Gs5 ₁	VE	-	80
Sg8 ₁₈	S	A1	10
Sf8	VS	-	100
Gs6 ₁	E	-	99
Gs7 ₁	S	-	92
Gs7 ₂	VS	-	100
Gs7 ₃	M-E	A6, B10, C13	90
Gs7 ₄	E	A6-7, A9, H6-7	94
Gs7 ₈	S	-	95
Gg6	M	-	94
Gg7 ₁	S-M	A11	65
Gg8 ₂	E	-	90
Gg8 ₈	S-M	B16	-
Gv7 ₄	S-M	-	95
Gfc8	S	B20	10
Pf7 ₁	S	-	97
Pf7 ₂	VS	-	100
Pf7 ₃	S	-	98
Pv7	VS	-	100
Ffc6	S	-	100
Ffc7 ₁	M	C11	97
1.2 DISSECTED PLATEAU (WELLINGTON UPLANDS)			
Ss7 ₁	VS	-	75
Sv7 ₁	VS	-	100
Gs7 ₁	M-E	-	99
CENTRAL VICTORIAN UPLANDS - WEST VICTORIAN UPLANDS			
2.1 DISSECTED UPLANDS			
Gg7 ₆	VS	-	100

Table 21 (continued)

Geomorphic units and land systems	Land system extent ¹	Conservation reserves ²	Freehold ³ (%)
SOUTH VICTORIAN UPLANDS			
3.3 MODERATELY DISSECTED RIDGE (MORNINGTON PENINSULA)			
Sg7	VS-S	-	85
Gs7	S	-	95
Gvf7	S	-	97
Pvf7	S	C16, C18, H15	97
Pf7 ₁	S-M	-	99
Pf7 ₂	VS	C18, C28, H17	98
Pf7 ₃	VS	C14	77
Pf7 ₄	VS	-	100
PCc7	S	C14, H18	94
3.4 DISSECTED FAULT BLOCKS (SOUTH GIPPSLAND RANGES)			
Ss7 ₁	E	-	100
Ss8 ₁	VE	A2, A10, B5	65
Ss8 ₂	S-M	-	80
Ss8 ₃	S	-	85
Sf8	VS	-	90
Gf7	M-E	-	98
Pf7	M	-	100
WEST VICTORIAN VOLCANIC PLAINS			
7.2 STONY UNDULATING PLAIN			
Pv6 ₃	M	-	-
Ss6 ₂	VS	-	100
SOUTH VICTORIAN COASTAL PLAINS			
8.4 FANS AND TERRACES (WESTERN PORT)			
Pf7 ₁	VS	-	100
Pf7 ₃	S	-	100
8.5 BARRIER COMPLEXES (DISCOVERY BAY/GIPPSLAND LAKES)			
Pc7	VS	-	100
SOUTH VICTORIAN RIVERINE PLAINS			
9.1 PRESENT FLOODPLAINS (GIPPSLAND)			
Ff7 ₁	S-M	-	100
Ff7 ₂	S-M	-	100
Ff7 ₃	M	C14	97
Ff7 ₄	S	-	100
Ff7 ₅	VS	-	100
Ff7 ₇	S-M	-	98
9.3 HIGH TERRACES AND FANS (GIPPSLAND)			
Gf7 ₂	M	-	-

Notes:

- Extent of land system State-wide
E Extensive (60 000–225 000 ha) S Small (5000–20 000 ha) VS Very small (less than 5000 ha)
M Moderate (20 000–60 000 ha) VE Very extensive (> 225 000 ha)
- Conservation reserves indicated by the recommendation numbers for national, State and coastal parks, reference areas, and wildlife reserves, wildlife management co-operative areas, flora reserves, and flora and fauna reserves.
- Percentage estimates of each land system occurring on freehold land State-wide.
- Land systems 1.1 Gs7₁, 2.1 Gg7₆, 7.2 Pv6₃ and Ss6₂ lie only within the City of Whittlesea in the study area, while 1.1 Ss7₃, Gs7₃, Pp7₁, lie partly within the City of Whittlesea and in the study area.

Source: LCC (1988)

References

- Aldrick, J.M., Hook, R.A., Van de Graaff, R.H.M., Nicholson, B.M., O'Beirne, D.A., and Schoknecht, N.R. (Vol. 1 1988, Vol. 2 in press). A study of the land in the catchments of the Gippsland Lakes. *Land Protection Division, Department of Conservation, Forests and Lands Technical Communication No. 17.*
- Jeffery, P.J. (1981). 'A Study of the Land in the Catchments to the North of Melbourne.' (Soil Conservation Authority: Melbourne.)
- Land Conservation Council (1973). 'Report on the Melbourne Area'. (Victorian Government Printing Office: Melbourne.)
- Land Conservation Council (1988). 'Statewide Assessment of Public Land Use'. (Victorian Government Printing Office: Melbourne.)
- Northcote, K.H. (1979). 'A Factual Key for the Recognition of Australian Soils.' 4th ed. (Rellim Technical Publications/CSIRO: Adelaide.)
- Rowan, J.N. (1990). 'Land Systems of Victoria.' (Land Conservation Council and Department of Conservation, Forests and Lands: Melbourne.)
- Rundle, A.S. (1977). A study of the land in the catchment of Lake Eildon. *Technical Communication No 11.* Soil Conservation Authority, Victoria.
- Sargeant, I.J. (1975). Soil survey. In 'Westernport Bay Environmental Study 1973-74,' ed. M.A. Shapiro, (Ministry of Conservation: Melbourne.)
- Specht, R.L. (1970). Vegetation. In 'The Australian Environment,' ed. G.W. Leeper, 4th ed. (Melbourne University Press: Melbourne.)
- Stace, H.T.C., Hubble, G.D., Brewer, R., Northcote, K.H., Sleeman, J.R., Mulcahy, M.J., and Hallsworth, E.G. (1968). 'A Handbook of Australian Soils.' (Rellim Technical Publications: Adelaide.)
- Van der Graaff, R.H.M., and Howe D.F. (1976). A study of the land in the Yarra Valley catchment. Soil Conservation Authority, Victoria; unpublished report.

PART III
CURRENT RESOURCE USE

11. PUBLIC LAND USE

This chapter provides a general view of public land use in the study area, the current resource aspects of which are described in the following chapters. More specifically, it reviews those changes to the public land estate since Council's original Melbourne area investigation. Of particular interest is the current status of various public land areas, the implementation of Council's recommendations, and subsequent special investigations by Council within or involving the study area.

Land Conservation Council final recommendations - Melbourne area

Each of the categories of public land use in the Melbourne Area Final Recommendations (LCC 1977) is shown in Table 22. The areas listed are only those within Melbourne Area, District 2. Readers seeking details on the remainder are referred to Council's Melbourne Area, District 1, Review Final Recommendations (LCC 1987).

Since Council's earlier investigation the City of Whittlesea is now excluded from the study area. However, Council's approved recommendations for the City of Whittlesea remain current. A significant addition to the study area is the Borough of Wonthaggi, which contains approximately 900 ha of public land over which Council will be making recommendations in this review.

Current public land use is shown on Map 11.

Several major differences exist between the Council's recommendations and current public land use. These have resulted from several factors (described below): changes to the public land estate; changes of status of some areas; public land additions and deletions; those recommendations not accepted by government; and subsequent special investigations by Council.

Changes to public land-use categorisation

As could be expected, there has been an evolution in the categories developed for public land use since Council's earlier investigations in the 1970s. New categories have been developed, while some of the

original ones have been absorbed into new or existing categories and are no longer in use. Most significant of these is the category of State forest. Hardwood production, uncommitted land, and forest areas (used primarily as a buffer to softwood plantations) have been classified as 'State forest' in more recent Council recommendations. Additional classifications have been used in subsequent Land Conservation Council investigations and reviews. Some may be applied in the recommendations phase of this review, but the original categories in the Melbourne investigation remain current until a government decision on final recommendations arising from this review.

Changes of status

Some of Council's recommendations are varied by Government or Parliament. Such changes account for the major differences between the Council's recommendations and current public land use, and usually relate to parks, as shown in Table 23. A summary of Council's parks recommendations and current park status, as shown in that table, reveals that government has retained the pre-existing status of several parks recommended for a different status by Council, and that two national parks (Dandenong Ranges and Point Nepean) are the outcome of specific government decisions and actions.

The new Dandenong Ranges National Park is the product of combining the former Ferntree Gully National Park (recommended by Council in 1977 to become a regional park), Sherbrooke Forest park, and Doongalla forest reserve and covers 1920 ha. Council's recommendations covering the Cape Schanck --Arthurs Seat area was for a regional park of 2300 ha. This area was substantially implemented as the Cape Schanck Coastal Park (which was pre-existing) and the Nepean State Park which have, more recently, become the Point Nepean National Park and Arthurs Seat State Park. Point Nepean consists of the ocean coast areas, the Greens Bush area (including recently acquired land) and the newly added former Commonwealth land at Point Nepean (2450 ha in total, with an additional 230 ha still to

Table 22

PUBLIC LAND USE: LCC FINAL RECOMMENDATIONS (1977)

Category	Recommended area (ha) 1977	Number of recommendations 1977	Current area (ha) 1991 ³	Current no. of reserves 1991 ³
Parks				
national ¹	13 300	1	33 080	5
State	75 500	7	58 223	8
regional	14 640	11	5 720	5
multi-purpose	113 000	1	33 500	0
Reference areas	7 270	16	7 270	16
Wildlife	34 697	14	34 718	14
Water production ²	NA	69	NA	71
Hardwood production	296 100	13	297 000	13
Softwood production	35 940	12	35 940	12
Forest area	4 300	1	4 300	1
Flora reserves and flora & fauna reserves	2 461	17	2 209	15
Bushland reserves	9	71	9	72
Coasts	2 532	5	2 920	5
Rivers & streams	57	15	49	12
Roadside conservation and highway parks	8	1		
Education areas and school plantations	1 996	9	1 996	9
Historical areas	2 500	1	2 500	1
Recreation	681	22	727	24
Scenic reserves	215	3	211	2
Agriculture	592	5		5
Mineral and stone production	496	14	494	13
Utilities and survey	131	6	131	6
Township land	377	3	377	3
Uncommitted land	10 800	4	10 800	4
Total:	617 602	321	5532 182	317

Notes:

1. Point Nepean National Park: the portion outside the study area is included in this total.
2. Water production: recommended areas usually not specified.
3. Current area and current reserves refer to areas that are implemented.
4. Current area and current reserves include the City of Whittlesea.
5. Several reference areas are within parks, and are included in the totals for park and reference areas (4050 ha in total).

Table 23

PARK RECOMMENDATIONS AND CURRENT STATUS (1977)

LCC recommendations	Area (ha)	Current status ¹	Area (ha)
Baw Baw National Park	13 300	National Park	13 300
Bunyip State Park	13 500	State Park	13 900
Cathedral Ranges State Park	3 600	State Park	3 577
Eildon State Park	29 500	State Park	24 000
Kinglake State Park	10 300	National Park	11 430 ²
French Island State Park	7 700	State Park	8 300 ³
Lake Mountain State Park	2 400	not implemented	⁴
Moondarra State Park	8 500	State Park	6 470
Crossover Regional Park	340	Regional Park	340
Fraser Regional Park	3 900	National Park	3 750
Gembrook Regional Park	2 300	Regional Park	2 650
Mt Worth Regional Park	200	State Park	1 040
Tyers Regional Park	1 200	Regional Park	1 810
Wandong Regional Park	700	Regional Park	700
Warrandyte Regional Park	100	State Park	586
Yea River Regional Park	200	Regional Park	220
Ferntree Gully Regional Park	400	Dandenong Ranges National Park	1 920
Dandenongs Regional Park	3 000	(Silvan Reservoir & Dandenong National Park)	
Cape Schanck--Arthurs Seat Regional Park	2 300	Arthurs Seat State Park	350
Yarra Valley Multi-purpose Park	113 000	Point Nepean National Park	2 680
		not implemented	33 500

Notes:

1. Total park areas are taken from the schedules of the *National Parks Act 1975* (although not all areas are proclaimed). Portions of several parks extend beyond the study area: Kinglake National Park (1600 ha); Point Nepean National Park (215 ha); Tyers State Park (730 ha); and Warrandyte State Park (282 ha), but are included in the totals given here.
2. As a portion of the park now lies in the City of Whittlesea, it is outside the study area.
3. Further areas have been acquired, but have yet to be added to the *National Parks Act 1975*.
4. The recommended State park has not been implemented. However, 590 ha has been gazetted as the Lake Mountain Alpine Resort, including part of the State park.
5. Those reference areas within parks (Baw Baw National Park, Bunyip State Park, and French Island State Park) are included in the parks as totals.

be proclaimed). Arthurs Seat State Park covers the 350 ha of public land at Arthurs Seat.

Significant additions to public land

A significant addition to the Victorian public land estate has been Greens Bush on the Mornington Peninsula, a valuable remnant of native vegetation that has now been added to Point Nepean National Park. Little of the Peninsula carries native vegetation, and all of the remaining larger parcels are now at least partially protected by either State or federal government management. A number of plant

communities in the 900 ha of Greens Bush have become regionally rare, and several faunal species have State or regional significance. Acquisition occurred in several stages, with purchases commencing in 1975 and further purchases in 1988 (170 ha) and 1989 (270 ha).

A number of other parks have had significant areas of private land added since 1977, as a result of land purchases and donations, as shown in Table 23. Considerable consolidation of the French Island State Park has also occurred, with 600 ha added. Several other parks have been enlarged

significantly, including Mt Worth State Park (from 200 to 1040 ha) and Warrandyte State Park (from 100 to 586 ha).

Warrandyte State Park includes a substantial area inside the metropolitan area (which is not covered by the Land Conservation Council's recommendations), as well as additional areas of over 150 ha that have been purchased since 1977.

Purchases of private land have enlarged both Kinglake and the Dandenong Ranges National Parks. Both still have highly irregular boundaries, but these additions contain important remnant areas with conservation

values and limit further urban intrusion adjacent to the parks. Additional lands have been purchased in the Summerlands Estate to enlarge the Phillip Island Penguin Reserve.

Disposal of several blocks of public land was recommended by Council in its special investigation of the La Trobe Valley; this investigation is described further below.

Acceptance and implementation of LCC recommendations

Council's recommendations, when accepted or varied by government, are implemented at the direction of an Order-in-Council or, if

Table 24

RECOMMENDATIONS: APPROVAL AND IMPLEMENTATION

Category	Approval		Implementation	
	Recommendations 1977 (Melbourne Area, District 2 only)	Order-in- Council or Ministerial approval	Number implemented - original purpose	Number implemented - other purpose
Parks				
national	1	1	1	0
State	7	6	6	1
regional	11	10	4	5
multi-purpose	1	1	0	0
Reference areas	16	16	13	0
Wildlife	14	14	8	0
Water production	69	46	8	0
Hardwood production	13	13	1	0
Softwood production	12	12	0	0
Forest area	1	1	0	0
Flora reserves and flora and fauna reserves	17	17	12	2
Bushland reserves	70	69	40	1
Coasts	5	5	2	0
Rivers and streams	15	15	3	3
Roadside conservation and highway parks	1	1	0	0
Education areas and school plantations	9	8	0	0
Historic areas	1	1	0	0
Recreation	22	21	6	0
Scenic reserves	3	3	1	1
Agriculture	5	5	0	0
Mineral and stone production	14	14	3	1
Utilities and survey	6	6	0	0
Township land	3	2	1	0
Uncommitted land	4	2	1	0
Total	321	289	110	14

Note: Number of recommendations refers to land-use recommendations; policy recommendations are excluded.

they are varied, by Ministerial approval. Implementation involves taking the necessary legislative and/or administrative action. Entries in the *Government Gazette* are the primary record of implementation; although other instruments, such as amendments to the *National Parks Act 1975*, may be used. Table 24 summarises current status of approval and implementation of Council's previous recommendations for the Melbourne Area, District 2.

Council made 540 recommendations for districts 1 and 2 of the original Melbourne investigation. Analysis in its State-wide Assessment (LCC 1988) showed that, of those 540, 194 have been fully implemented and, 28 partially so, some 19 were policy recommendations, and 36 were not accepted, which leaves 263 yet to be implemented.

Within the study area, 321 of Council's final recommendations referred to land use (as distinct from 'policy' type recommendations), and 289 of them have been approved by government. Of these approved recommendations (including the variations to the Yarra Valley Multi-purpose Park by Ministerial letter), 110 have been implemented for the purpose Council intended and a further 14 implemented but varied by government. Currently, 165 of Council's approved recommendations still require implementation.

Of the recommendations not accepted by the government of the day, most were contrary to government policy or related to special circumstances following publication of the final recommendations.

As described in Chapter 1 of this report, the Council's final recommendations are presented to government for consideration. If approved or varied, Orders-in-Council directing the responsible agencies to implement the recommendations are forwarded to the appropriate departments. Most recommendations require some form of administrative implementation, including reservation under relevant legislation (such as the *Crown Land (Reserves) Act 1978* or the *National Parks Act 1975*).

Highest priority for implementation has been accorded to the major conservation reserves - national and State parks, reference areas, and

flora and fauna reserves. Many bushland reserves have also been gazetted.

Each administrative process involves some element of delay, and agencies have limited resources for work programs that include implementation of approved recommendations. Most of the approved recommendations involve land under the administrative authority of the Department of Conservation and Environment.

For many of the areas still requiring administrative action (through legislation, reservation, or proclamation), the Department of Conservation and Environment reported to the Council (LCC 1988) that management was, in any case, in accordance with Council's recommendations.

However, the gap between government approval and implementation is obvious. These delays stem partly from the lack of resources available to agencies and the complexity and duration of some administrative procedures. In some instances, revocation of an existing reservation, which is administratively complex, is necessary prior to implementation.

Notable among the approved areas yet to be implemented is Lake Mountain State Park. The approved park area contained a portion of 590 ha that is now included, by legislation, in the Lake Mountain Alpine Resort. Matters relating to the management and use of Lake Mountain are discussed in Chapter 20, as are the implications of the delay. Western Port Wildlife Management Co-operative Area, has also not been implemented.

Yarra Valley multi-purpose park

Council recommended a Yarra Valley multi-purpose park (LCC 1977) of 113 000 ha, which included the water supply catchments of Maroondah, O'Shannassy, Upper Yarra, and the Yarra tributaries. The system of multiple use proposed for the park included timber production, recreation and education, and nature conservation. The Park was divided into zones to accommodate the range of designated uses. Government varied Council's recommendation for the area and provided for a 33 500 ha multi-purpose park, with zones for particular uses, but excluded

the Board of Works water supply catchments, which were to remain under the control of the Board. Zones for the following land uses were to be created for the park: recreation; recreation and hardwood production; hardwood production; scenic landscape; education; bushland area; utilities; and minerals and stone. To date, the park has not been implemented (that is, it has not been gazetted), although it has Government approval by virtue of being presented as a variation of Council's recommendation.

Alpine resorts

Council recommended an alpine resort for Mt Baw Baw, which government accepted and implemented. Government also created two further resorts within the study area - Mounts Donna Buang and Lake Mountain. All these resorts are the management responsibility of the Alpine Resorts Commission.

Subsequent LCC special investigations

Two subsequent Land Conservation Council special investigations, completed since the original Melbourne investigation, both cover part of the Melbourne Area, District 2: La Trobe Valley (LCC 1987a, 1987b); and Hill End (LCC 1982, 1983). Council's final recommendations for these investigations supersede those of the earlier Melbourne Area investigation.

Two State-wide special investigations are also currently under way: Rivers and Streams; and Wilderness.

In the La Trobe Valley Special Investigation, Council was required to investigate a number of parcels of land under State Electricity Commission control and some smaller areas of uncommitted land. In making recommendations for the best use of the land, Council was to consider disposal of land surplus to SEC requirements, where appropriate, and conditions for continuing use of land to be retained by the SEC. Table 25 shows the final recommendations for lands within the Melbourne, District 2 study area.

All Council's final recommendations were subsequently approved by government (on 12 April 1988).

In the Hill End Special Investigation, Council was required to identify areas of public land suitable for softwood plantations, both publicly owned and for Australian Paper Manufacturers Ltd, to replace company land that may be required for coal extraction and other purposes. Because the possible uses for APM land had not been identified by the conclusion of the investigation, Council's final recommendations (LCC 1983) made no recommendations for future APM requirements.

Table 25

LA TROBE VALLEY SPECIAL INVESTIGATION - FINAL RECOMMENDATIONS

Rec. no.	Purpose	Area (ha)
Land to be retained by the SECV		
H1	Significant vegetation	14.0
H7	Education area	49.9
H8	Agriculture or forestry	1470.0
H11	Residential (existing use)	2.0
H12	Agriculture (existing use)	24.7
Land for disposal		
I1		36.8
I16		73.0
I17		62.4
I18		26.0
I19		30.0

Note: Only includes public land within Melbourne Area, District 2 Review study area.

Source: LCC (1987b)

Government policy for replanting hardwood forests with softwood plantations was under review during Council's investigation. Council proceeded to identify those areas suitable for softwood plantations and a number of other land-use recommendations, which Table 26 summarises. Current government policy prohibits the clearing of native forests for the purpose of establishing softwoods.

Of Council's final recommendations, only three have been approved by government (on 26 June 1984): B1 and B2 (flora and fauna reserves), and F1 (bushland reserve); none has been implemented.

Council's rivers and streams special investigation identifies the scenic, recreational, cultural, and nature conservation values of rivers and streams and recommends measures for the protection of these values and uses of the watercourses (LCC 1989). Council's final recommendations (LCC 1990) cover Victorian heritage rivers, essentially natural catchments, representative rivers, other river values, public land water frontage reserves, and management guidelines and policy. Those for Victorian heritage rivers, essentially natural catchments, and representative rivers applicable to the study area are shown in Table 27.

Table 26

HILL END SPECIAL INVESTIGATION - FINAL RECOMMENDATIONS

Recommendation	Area (ha)
A1 Softwood production - existing and previously recommended	1700
Softwood production (forested land)	
A3 Harold Creek	1880
A4 Good Hope Creek	2130
A5 Serpentine Creek	1180
Hardwood production	
C1 Neerim East	640
C2 Tanjil Tyers	3630
C3 National Features Zone - Tyers River, West Branch	-
Water production	
D1 Blue Rock	-
D2 Tanjil River	-
Flora and fauna reserve	
E1 Sweetwater Creek	1240
E2 Bull Beef Creek	1390
Bushland reserve	
F1 Gooding	31
Uncommitted land	
H1 Various blocks	-
Other public land	
I1-10 Various blocks	-

Source: LCC (1983).

Table 27

RIVER AND STREAMS SPECIAL INVESTIGATION - FINAL RECOMMENDATIONS

Victorian Heritage rivers

Rec. No.	Watercourse	Length of reach in study area (km)
A3	Howqua River	(study area boundary to Eildon Reservoir -20)
A4	Big River	51
A5	Goulburn River	(Eildon Pondage to study area boundary -137)
A13	Thomson River	(Thomson Reservoir to study area boundary -49)
A14	Yarra River	103

Essentially natural catchments

Rec. No.	Catchment	Area (ha)
B4	O'Shannassy River	12 230
B11	Williams Creek (a tributary to Howqua River)	1 010

Representative rivers

None in study area

Source: LCC (1991).

Council's wilderness investigation identifies areas to be protected and other areas of high wilderness quality that should be protected, and also specifies permitted uses and identifies management guidelines for wilderness areas. Among Council's recently released proposed recommendations, the only one within the study area is a portion of the Baw Baw plateau which has been identified as 'an other area with remoteness and naturalness attributes' (LCC 1991).

References

Land Conservation Council (1977). 'Melbourne Area - Final Recommendations.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1987a). 'Report on the Latrobe Valley Special Investigation.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1987b). 'Latrobe Valley Special Investigation - Final Recommendations.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1982). 'Special Investigation Melbourne Area Hill End.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1983). 'Special Investigation Melbourne Area Hill End - Final Recommendations.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1988). 'Statewide Assessment of Public Land Use.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1989). 'Rivers and Streams Special Investigation Report.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1991). 'Rivers and Streams Special Investigation Final Recommendations.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1990). 'Wilderness Special Investigation Descriptive Report.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1991). 'Wilderness Special Investigation Proposed Recommendations.' (Victorian Government Printing Office: Melbourne.)

12. NATURE CONSERVATION

With the advent of European settlement, a process of change began for the flora and fauna across Victoria. The flora and fauna of the Melbourne Area, District 2, have been particularly affected.

In excess of 60% of the State has been cleared of its forests and woodlands (Woodgate and Black 1988). More than 35% of wetlands have been drained and 95% of fresh-water wetlands have been lost or substantially modified (DCFL *et al.* 1988). Clearing of more than 95% of private lands has made the conservation of the remaining flora and fauna primarily dependent on the condition and use of public lands.

Native flora and fauna have been greatly reduced in their range and extent: many communities and populations of individual species have been damaged greatly, and extinctions have occurred. Two bird, 20 mammal, 2 reptile, 2 fish, and 21 plant species are known to have become extinct in Victoria since European settlement. Significantly, a large proportion of the remaining flora and fauna are now 'threatened', that is, endangered, vulnerable, rare, indeterminate, or insufficiently known. Of the State's 700 to 800 native vertebrate animal species, 183 are presently considered under threat, as are more than 500 of the 3160 native vascular plants.

Many of the effects of European settlement have been pervasive, leaving few biotic communities of the State unaffected.

Species rarity and threat of extinction attract much attention. A high risk of extinction in a community or ecosystem may indicate continuing environmental degradation; in such places, the 'risk of extinctions' may be 'contagious' to species not presently affected (Ahern 1982). Species rarity, which can be the result of natural or human agencies, can occur in several situations: species in stressed sites; widespread but locally infrequent species; and those occurring in large numbers at a few localities.

The major cause of such extinction and threatened status has been vegetation clearance of extensive areas, plus the

fragmentation and alteration of many remnant patches. Introduced species, changed fire regimes, chemicals, accelerated erosion, resource harvesting, and a wide variety of land-use practices have also contributed to loss of species and loss of other conservation values.

Lasting aspects of human influences include the widespread disruption of normal ecological processes. Much of the research into conservation biology has revealed the effects of reduced populations and distributions on population dynamics and evolutionary processes. Human activity has altered these processes for many species and has itself become a major evolutionary force.

Natural ecosystems are dynamic, with natural communities the product of evolutionary pressures. Species are interdependent and the extinction of a key species can have long-term environmental consequences on whole communities. Genetic and demographic processes are frequently altered by human activities, and the effects on floral and faunal populations can be immediately chaotic or may be more subtle or even delayed in time.

Plant and animal communities with the highest risk of extinction are those that include:

- * peripheral populations
- * geographically localised species
- * genetically impoverished species
- * specialised species
- * annuals
- * those inhabiting fragile environments, such as coasts

What is nature conservation?

Nature conservation is that activity directed to ensuring the long-term continuation of natural processes and values. It can be achieved through a range of actions, directed at whole ecosystems, communities, or individual species of plants or animals, but the principal means is through habitat protection. It is a long-term activity with the following goal, described by UNESCO:

'to conserve for the present and future use the diversity and integrity of biotic communities of plants and animals

within natural ecosystems, and to safeguard the genetic diversity of species on which continuing evolution depends'.

Nature conservation is therefore generally best achieved through setting aside areas of natural land as protected areas, such as national parks and nature reserves. Conservation through reservation has its limitations (Recher 1990), as many reserves may not achieve conservation of all present values because of their small size or the positioning of their boundaries. Conservation cannot be achieved simply by reserves in circumstances where species rarity is the result of diverse causes.

In practice the location of reserves is the outcome of a decision-making process involving nature conservation as only part of a suite of considerations. Where nature conservation values occur outside of reserves, it is also most important to protect them and, in Victoria, nature conservation activities extend beyond reserves.

Recommendations by the Land Conservation Council have aimed at protecting nature conservation values in a range of different public land-use categories, as described below.

Why conserve natural values?

A wide range of reasons have been identified for conserving natural values. The biosphere and its component natural ecosystems provide the basis for human existence, and the loss of any components can threaten the whole and can ultimately threaten human life and welfare. In addition to the direct benefits of food, clothing, shelter, and other resources, it provides the environment offers educational, recreational, and cultural inputs.

Issues of nature conservation are associated with the state of scientific knowledge. Not all the species of plants and animals that exist in Australia have yet been named or even recognised, and the species inventory is especially deficient for insects. In putting a case for increased international effort into listing the world's species, Wilson (1985) estimated that Australia has about 108 000 insect species, of which only 45% are named, 16% are known but unnamed, and the remainder have not even been collected. In this context, extinctions represent an irreplaceable loss.

Distinct from the human benefits resulting from conservation are the philosophical arguments for conserving natural values. Humans and their activities are now a major evolutionary force affecting the survival of many species, and with this capacity comes a moral obligation for humans to act responsibly towards other species. This principle is promoted in both the World Conservation Strategy (IUCN 1980) and the Victorian Conservation Strategy (Victoria 1987).

Studies to assess conservation values

There are several typical ways of assessing conservation values: thematically, such as examining ecosystems, communities, or species, or geographically, by sites, regions, or even larger units. Whatever unit is adopted for assessment, difficulties arise when comparing and interpreting the validity and significance of factors assessed in different studies.

The conservation status of individual species of plants and animals in Victoria is generally evaluated using the standards set by the International Union for Conservation of Nature and Natural Resources (IUCN). The categories used for fauna are:

- * extinct
- * endangered
- * vulnerable
- * rare
- * indeterminate
- * insufficiently known
- * threatened (a general term encompassing endangered, vulnerable, rare, indeterminate, and insufficiently known)

Assessment of the nature conservation values of particular areas has been less uniform, although it is usually based on the concept of significance. A number of studies have identified sites or features of scientific significance based on criteria such as rarity, diversity, representativeness, or extent of disturbance. In some studies, 'naturalness' has been a criterion.

Table 28 lists examples of studies of conservation values within the Melbourne Area, District 2, while Table 29 lists other studies of relevance.

Table 28

**REGIONAL STUDIES OF SITES OR FEATURES OF NATURE
CONSERVATION SIGNIFICANCE (1976-1989)**

Biological values examined	Area covered	Reference
Botanical	Upper Yarra	McMahon <i>et al.</i> (1989)
Botanical	Plenty Valley	Molnar <i>et al.</i> (1989)
Botanical	Central Gippsland	Gullan <i>et al.</i> (1984)
Botanical	Western Port	Opie <i>et al.</i> (1984)
Botanical	Central Gippsland	Gullan (1982)
Botanical	Upper Yarra	Gullan <i>et al.</i> (1979)
Botanical	Victoria-coastal region	Barson and Calder (1976)
Zoological	Upper Yarra	Mansergh <i>et al.</i> (1989)
Zoological	Plenty Valley	Beardsell (1989)
Zoological	Western Port	Andrew <i>et al.</i> (1984)
Zoological	Upper Yarra	Fleming <i>et al.</i> (1979)
Zoological	Victoria-coastal region	Dorwood (1976)
Nature Conservation	Gippsland-rivers and catchments	Meredith <i>et al.</i> (1989)
Nature Conservation	Western Port region	Seymour (1987)
Ecological	Victoria-rivers and streams	Biosis and E.H. (1988)
Environmental	Upper Yarra Flood Plain	Rosengren <i>et al.</i> (1983)

Table 29

MAJOR STUDIES OF FLORA AND FAUNA CONSERVATION STATUS

Biological values examined	Area covered	Reference
Flora	Australia	Briggs and Leigh (1988)
Flora	Victoria	Gullan <i>et al.</i> (1988)
Flora	Victoria	Scarlett and Parsons (1984)
Flora	Australia	Leigh <i>et al.</i> (1981)
Flora	Victoria, by regions	Beaulehole (1983)
Fauna	Victoria	Ahern (1982)
Fauna	Victoria	Ahern <i>et al.</i> (1985)
Flora and fauna	Victoria	DCFL (1987)
Flora and fauna	Victoria	Frood and Calder (1987)
Freshwater fish	Victoria	Koehn and Morison (1990)
Freshwater fish	Victoria	Cadwallader <i>et al.</i> (1984)
Freshwater fish	Victoria	Cadwallader and Backhouse (1983)

Note: A more detailed list of studies may be found in Frood and Calder (1987).

Population and genetics

Each plant and animal species must comprise adequate population numbers in order to survive and continue to evolve into the long-term future. Numerous studies have shown that the persistence of particular populations is heavily dependent on population size. The science of genetics contributes a crucial understanding of what constitutes adequate population size for long-term viability.

Small populations can develop a range of genetic problems, many of which arise through the reduction of genetic variability in populations (for example, interbreeding, bottleneck effects, small effective population size, and genetic drift). A reduction in genetic variability, generally means a reduced adaptive ability, which increases the chances of a population or entire species simply failing in response to natural or human-caused effects (such as disease).

Role of reserves

Nature conservation reserves can be set aside to protect particular species, complex ecological settings, or modified and simplified ecosystems. Four specific roles for conservation reserves have been identified.

- * Reserves may protect biological/ecological processes. A full range of ecological processes, such as succession of plant communities or longer-term evolutionary processes, cannot continue in the highly modified landscape of Victoria without special efforts of protection. Long-term conservation, which often has direct benefits to humans, requires the protection of evolutionary opportunities.
- * Some preserve genetic and biological diversity, including particular communities of plants and animals. Examples of communities or entire ecosystems that are in good condition may be reserved as 'representative areas'. Where few such examples remain, reserves are a crucial means of conservation.
- * Others protect individual species (and their gene pools), especially those considered rare or endangered and occupying a restricted or remnant habitat.
- * Reserves created for other purposes, such as social values, may also have an incidental but very important role in the protection of flora and fauna.

Design of reserves

Research into reserve design (Soule and Simberloff 1986, for example) has examined size, shape, and boundary conditions of reserves in relation to the viability of plant/animal populations they contain.

It is generally accepted that large reserves will contain more species than small ones, and that reserves with proportionally long or irregular boundaries will retain fewer than those with a greater area:boundary-length ratio. Reserves must be of sufficient size to encompass the processes of succession, ecological gradients, and spatial ecological processes (Saunders *et al.* 1987, pp.103--21).

Small reserves may not be effective in protecting endangered populations, such as Yellingbo Reserve's helmeted honeyeater.

The relationship between reserve area and the number of species is, however, highly variable, and area on its own only accounts for some of the variation. However, as the area of a particular type of habitat increases, the number of species associated with that habitat will also increase.

In planning a reserve for nature conservation purposes, the factors to be considered in determining its appropriate size include the:

- * ecological requirements of the species present
- * minimum genetically effective population sizes of these species
- * space needed by a genetically effective population, given the type of habitat available
- * 'edge effect' of a reserve boundary with land and habitat of a contrasting type (such as agricultural land)
- * particular problems that may cause population decline

As sufficiently large populations must be preserved in order to be self-sustaining in the long term, it follows that the reserve must be large enough to contain these. Although present-day understanding of naturally functioning ecosystems is still quite limited, decisions have to be made about the reserve's size and placement. If its size is based on the needs of species with naturally low population densities (such as 'top of the food chain' carnivores, large-bodied animals, or other species with specialised or demanding habits), then the habitat requirements of other smaller or less demanding members of the community should also be met.

It is generally recognised that a single large reserve is more effective for long-term conservation than several small ones with the same total area. Although they can contain as many species as a large single reserve at the time of demarcation, too small reserves probably suffer more severe subsequent damage when surrounding areas are modified by human activities. They are more at risk from a single catastrophic event, or they may contain a breeding population too small to be genetically effective. Also, their management costs may be disproportionately high.

Habitat or species are much more vulnerable in single reserves than if protected by multiple reserves. Severe physical disturbance, fire, disease, or introduced predators can obliterate a species in a reserve. Ideally, other reserves need to be available to ensure the survival of the species at risk. In extreme and carefully studied cases, humans may even intervene, using stock from an undamaged reserve as a source to recolonise the degraded one.

Long-term survival of a species depends upon its ability to adapt to changes in its physical or biotic environment, and such adaptability is a product of genetic diversity. Maintaining a species across its geographic range should improve its genetic diversity, and so multiple reservation of apparently similar habitats and communities is the best way of preserving the greatest possible genetic diversity within a species. This in turn provides its best chance for preservation.

Maintenance of continuity between habitats, both within and between reserves, is often held to be a necessary feature of a conservation reserve system. Within reserves, it is achieved by including a series of contiguous habitats or communities, while habitat continuity between reserves involves maintaining corridors of natural habitat. Such linkages are deemed to enhance the dispersal of individuals through components of the reserve and increase gene flow. They effectively increase population size and the recolonisation rates of depauperate areas, and thus reduce the extinction rate of semi-isolated groups.

Victoria's nature conservation system

Identifying and recommending areas for nature conservation reserves has been one of the Land Conservation Council's major tasks.

The administrative requirements for protection have been achieved by recommending permanent reservation under the *Crown Land (Reserves) Act 1978*, the *National Parks Act 1975*, or the *Reference Areas Act 1978*.

Chapter 11, Public Land Use, lists each category of such use. While nature conservation is associated with many of these categories, those with a principal aim of nature conservation are: national, State, and coastal parks, flora reserves, flora and fauna

reserves, reference areas, wilderness, wildlife reserves, and marine reserves (LCC 1988). These land uses are all recommended by the Land Conservation Council to have permanent reservation under one of the previously mentioned acts.

Other categories also protect nature conservation values under Council's recommendations, as a secondary aim: State forest (which now includes hardwood production areas and uncommitted Crown land designations); regional parks; natural features reserves; scenic reserves; and lake reserves. Council recommends permanent reservation for these land uses also with the exception of uncommitted Crown land.

To date, the Council's recommendations for public lands in Victoria to be permanently reserved for the primary purpose of nature conservation cover 3.1 million ha (some 13% of the State). Those providing nature conservation as a secondary aim total 3.8 million ha (17% of the State area). A large proportion of this public land is State forest, as is the case within the Melbourne District 2 study area, where protection of conservation values is considered under the Code of Forest Practice or by temporary reservation under the *Forest Act 1958*. In addition, more than 24 areas of marine habitat have been identified and are subject to some level of protection.

Council recognises the State's obligations under the National Conservation Strategy for Australia (Australia, DHAE, 1983), and the State Conservation Strategy (Victoria 1987).

Five main aims for the Victorian Conservation Strategy are to:

- * maintain essential ecological processes and life-support systems
- * preserve sustainable use of renewable resources
- * ensure sustainable use of renewable resources
- * ensure the wise use of non-renewable resources
- * protect natural areas and ecosystems for the non-material needs of society'

Its aims for conserving flora and fauna have specific relevance to Council's approach to nature conservation. These are to:

- * ensure that all Victorian native species of flora and fauna, native ecosystems and communities can survive, flourish and retain their potential for evolutionary development
- * protect representative and ecologically viable samples of all Victoria's natural ecological systems, including land systems, native vegetation types and native animal communities
- * preserve genetic variability within Victorian plant and animal species
- * preserve remaining areas of high wilderness quality, and
- * protect areas of special value for natural heritage, flora and fauna habitat, or for maintenance of ecological processes or life support systems'

One of the specific actions of the Strategy endorsed Council's approach to nature conservation, by stating that the government will 'add to the parks and reserves systems in line with those Land Conservation Council (LCC) recommendations already adopted by the government'.

Achieving the Strategy involves three levels of action:

- * establishment of a system of reserves with nature conservation as the primary land use and restriction of conflicting activities
- * management to preserve nature conservation values on areas of public land where this is not the primary land use
- * encouragement and promotion of practices on public land to enhance its nature conservation values

A major State initiative in protecting endangered species and their critical habitat is the *Flora and Fauna Guarantee Act 1988*. Its aims include: to enable native species to survive, flourish, and retain an evolutionary potential; to conserve flora and fauna communities; to manage threatening processes; to ensure that any use of flora and fauna by humans is sustainable; and to maintain genetic diversity. The Guarantee covers all types of native flora and fauna on land and water. Those species threatened with extinction are listed, as are potentially threatening processes, and are given extra

management attention. Habitat critical to the survival of any species or community can be protected by enforcement procedures, voluntary agreements, or other measures.

Nature conservation in the study area

In the Melbourne Area Final Recommendations (LCC 1977), Council listed a series of reserves in which nature conservation was either the primary or secondary use. The government subsequently adopted most recommendations for reservation and has since added a number of other areas; all the recommendations and present land uses are described in Chapter 11.

National parks

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 enjoyment, education, and inspiration in natural environments' (LCC 1977). The study area contains five such parks: Baw Baw, Dandenong Ranges, Fraser, Kinglake, and Point Nepean.



Snow gums in Baw Baw National Park

Baw Baw National Park covers the granitic Baw Baw plateau and steep slopes of Mt Erica in the far east of the study area, and also includes the steeply dissected terrain of the Thomson and Aberfeldy valleys. It has high geomorphological and botanical significance, and contains a complex of sub-alpine vegetation and several open forest types. Snow gum, alpine ash, mountain ash, messmate stringybark, red stringybark, silvertop, and associated species are prominent. This area together with the Baw Baw Alpine Resort, contains the entire range of the Baw Baw frog.

Dandenong Ranges National Park comprises a collection of public land blocks - the former Ferntree Gully National Park, Sherbrooke Forest Park, and Doongalla Forest Reserve - interspersed with areas of private land. Council originally recommended the land as two regional parks (Ferntree Gully and Dandenong), but the Parliament elevated its status to that of a national park. Now at the fringe of urban Melbourne, it is highly popular and heavily used. Forests around Ferntree Gully contain messmate stringybark, narrow-leaf peppermint, long-leaf box, mountain grey gum, and manna gum. Some 20 species of ferns and 30 species of orchids, more than 100 species of native birds, and 20 native mammal species have been recorded (LCC 1977). Forests in the Dandenong area vary from open forest to 15- to 28-m-tall mountain ash open forest and dense fern gullies. Maintenance of the existing conservation values in areas of high recreation use, and adjacent to urban land uses, is a difficult management task.

Kinglake National Park, centred on the Kinglake Plateau, comprises three large separate parcels and some smaller outliers. It is a popular area for picnics and day walks; major attractions are fern gullies, waterfalls, and panoramic views. Open forests cover the plateau area and dissected terrain.

Fraser National Park, established in 1956, abuts part of Eildon Reservoir, and forms part of its catchment. Open forest, less than 15 m tall, is the dominant vegetation, although the park includes former farmlands that were cleared. Council recommended the area as a regional park (LCC 1977).

Point Nepean National Park covers the Nepean ocean coast plus areas at Point

Nepean given to the State by the Commonwealth in 1988, and Greens Bush. The history of this park is described in Chapter 11. This is essentially a narrow, linear park along the coast and includes associated dunes and cliff-top areas.

None of the Dandenong Ranges, Fraser, and Point Nepean National Parks meets the Land Conservation Council's criteria for national park status; they are too small, do not have national significance, and on a State-wide level cannot be described as possessing diverse land types. From a nature conservation perspective, the Dandenong Ranges, Kinglake, and Point Nepean Parks all have lengthy boundaries around relatively small areas, and like several other natural areas in the study area, experience problems from adjacent private land.

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' (LCC 1977). Its functions include representation of land types not already within national parks. State and national parks are designed to be complementary, each as part of a State-wide system.

In 1977 the Land Conservation Council recommended six State parks for the District 2 portion of the Melbourne Area, and all have subsequently been reserved under the *National Parks Act 1975* except Lake Mountain, which remains partly as reserved forest, and partly as the Lake Mountain alpine resort.

Eildon State Park comprises three blocks around Eildon Reservoir, including in the south the steeply dissected Enterprise Range and Rocky Spur.

Moondarra State Park, on the Tyers River north of Yallourn, features heathy woodlands and open forests dominated by silvertop and messmate stringybark.

Bunyip State Park, on the south-west edge of the Central Highlands, east of Gembrook, supports a rich flora and fauna, including species endemic to the Melbourne Study Area. Forest cover ranges from heathy

woodland to open forest with mountain ash, messmate stringybark, and silvertop.

French Island State Park covers much of the island and has very high conservation value, as it is little disturbed by human influence and contains a diverse flora and fauna. Viable heath woodland communities remain within the park, in contrast to the largely cleared areas on the adjacent mainland. The park is part of an area of national geological significance, and contains excellent examples of salt-marsh and mangrove communities.

Lying on the north-west fringe of the Central Highlands, Cathedral Range State Park comprises the spectacular ridge of the Cathedral Range, and contains the gorge of the Little River.



Cathedral Range State Park

Boundaries for the Council's recommended Lake Mountain State Park enclose a relatively small area around Lake Mountain, which contains a rich assemblage of alpine and sub-alpine flora. It is used for cross-country skiing and its close proximity to Melbourne has ensured high visitor usage. A portion of it is now an alpine resort under the management of the Alpine Resorts Commission.

Three other State parks have been created by Parliament since Council's original final recommendations - Arthurs Seat, Mt Worth, and Warrandyte. Arthurs Seat is a popular tourist destination, which features remnant eucalypt forest, the Seawinds property, and outstanding views of Port Phillip Bay. Mt Worth has been expanded in area through land acquisition, and comprises eucalypt forest, with fern gullies and waterfalls. Warrandyte covers two sections of the Yarra River, together with separate blocks south of

the river. The blocks adjacent to the river areas have retained much of their original eucalypt cover, and the area is popular for recreation.

Regional parks

As defined in the earlier Melbourne Area, Final Recommendations, a regional park is 'an area of public land, readily accessible from urban centres or a major tourist route, set aside primarily to provide recreation for large numbers of people in natural or semi-natural surroundings' (LCC 1977). At that time, the Council recommended 11 parks in the study area, with its proximity to Melbourne. Due to various circumstances, the number has fallen to five. These range from the 220 ha Yea River Park to the 2650 ha Gembrook Regional Park. Crossover regional park is an isolated block of public land, while those at Gembrook, Tyers, Wandong, and Yea River adjoin contiguous areas of forest.

Reference areas

Reference areas contain viable samples of one or more land types in a relatively undisturbed condition, that are reserved in perpetuity. Such areas may be used in comparative studies against modified ecosystems.

Measures are taken to ensure protection of the natural ecosystems. Access is restricted, experimental manipulation is not allowed, and a protective buffer is maintained to provide protection from potentially damaging processes.

Council recommended 16 reference areas within the study area, ranging from 100 ha at Yan Yean to 1090 ha at Disappointment, and totalling 7270 ha. All have been subsequently implemented.

Flora reserves and flora and fauna reserves

Flora reserves contain native flora of high value remaining in a natural or near-natural condition. Species rarity, endangeredness, and the extent of representation on public land determine the level of values. Flora and fauna reserves additionally contain important fauna or fauna habitat, flora and fauna communities in natural or near-natural condition, often on relatively small blocks of land.

Council recommended 12 flora reserves and four flora and fauna reserves. These range in size from 7 ha to 580 ha, with most less than 200 ha.

Wildlife reserves

As explained above, wildlife conservation depends on protection of each species' habitat; in many places this role can best be fulfilled on public land containing large areas of diverse natural habitats.

In the nature conservation reserve system, wildlife reserves are areas with high wildlife values used to protect endangered and/or ecologically significant species or with value for migratory or nomadic species. They may also be used to conserve wildlife of economic value.

Nature conservation on other public land

Since other areas of public land can also protect these values, nature conservation is not restricted to the system of formal reserves. In fact, that system on its own would be inadequate to maintain all nature conservation values in Victoria. The success of a nature conservation program depends on proper recognition and management of the values in other natural or near-natural land.

The Board of Works controls water supply catchments that contain sites with high conservation values, as described in Chapter 20.

Hardwood production areas and uncommitted Crown lands (now collectively known as 'State forest') comprise a substantial proportion of the study area. Currently State forests are the single largest public land use category (42% of all public land), and as such are essential to Victoria's nature conservation effort. They exhibit nature conservation values - high in some locations - and considerable management and administrative resources are directed towards the protection of those values.

Protection of nature conservation values in State forests may involve different actions from those exercised in parks and reserves because of the need to achieve a balance with other competing land uses, principally timber production. Victoria's Timber Industry Strategy (Victoria 1986) recognised the conservation values within State forests and

integrated environmental protection into the timber production planning process. Both the forest planning process and the 'Code of Forest Practices' are fundamental in protecting nature conservation values in areas used for timber harvesting; these items are further described in Chapter 15.



State forests have a role in Victoria's nature conservation system

Council's 1977 Final Recommendations cited the protection of native plants and animals as a major secondary aim in State forests, with the primary aim being hardwood production. Council also allowed for special values to be given maximum protection in reserves within State forests under the *Forests Act 1958*.

Several studies of botanical and zoological significance (described below) and information in Chapters 7 and 8 have identified extensive areas of high nature conservation value in State forest used for timber production. For instance, much of Leadbeaters possum habitat is within State forest, an issue discussed in Chapter 20.

Small remnants of native bushland, that may not be large or natural enough to warrant separate reservation as flora or fauna

reserves, are protected under the 'bushland reserve' classification. Such remnants have frequently been modified by grazing and weed invasion, although native tree species remain. They are retained primarily to provide landscape character distinctive to the region. Allowable activities may include grazing, timber production, and gravel extraction as long as the retention of native flora - especially tree species - is not unduly disturbed. Bushland reserves can, however have value for nature conservation.

Land has also been set aside as 'education areas' in previous Land Conservation Council recommendations. Parcels of undisturbed land have been designated for educational use for long-term studies, collection of biological material, observation, and experimentation. Council identified 13 of these in the study area, ranging across a spectrum of ecosystems.

Interconnected areas of native vegetation have high nature conservation value, for reasons outlined above. Linear remnants of native vegetation - such as occur within roadside, railway, or streamside reserves - may also serve as corridors or connections between larger natural tracts. Remnant vegetation has inherent high values, but additional values accrue when it connects remnant patches of fauna habitat or provides a migratory or other movement path for fauna.

Re-establishment of native vegetation on cleared public land is another way of benefiting nature conservation and this is occurring across the study area. 'Landcare' and salinity programs both feature re-vegetation of cleared country. Local government has also undertaken re-vegetation of public land with indigenous species, primarily for the aesthetic upgrading of public parks.

Nature conservation on private land

Those remnant areas of indigenous native vegetation on private land have high nature conservation value. While larger remnants are likely to support communities in better condition and for longer than smaller ones, even small areas can provide valuable flora and fauna habitat.

Some areas of high value have been purchased by the State government (through its agencies) and added to the public land

estate, for example, around the margins of the Dandenong Ranges National Park. Another significant purchase was at Greens Bush on the Mornington Peninsula, discussed in Chapter 11.

Sometimes acquisitions are made by the Victorian Conservation Trust. Under the *Victorian Conservation Trust Act* (1972), its role is the preservation of significant lands and native flora and fauna. To date the Trust has purchased many properties and assisted in the acquisition of others. These purchases are then vested in a managing authority (such as local government) or the State (managed under the *National Parks Act* 1975); alternatively the land is retained by the Trust and managed by an appointed committee.

A recent Trust initiative produced the 'conservation covenant', which adds considerably to the effort of nature conservation on private land. Land-owners may seek the assistance of the Trust in drawing up a voluntary agreement to conserve natural features of the property. Such features may include native tree stands, individual trees, geological features, wetlands, and cultural features (such as buildings). When agreement is reached, the covenant is registered on the land title and henceforth becomes binding on the present and future owners of the land.

Local government can protect nature conservation values by various means. Planning schemes by individual local governments and the Upper Yarra Valley and Dandenong Ranges Authority regional strategy plan offer protection to particular areas and values through controls and policies on land use and management. Three shires within the study area also have conservation strategies - Eltham, Mornington, and Sherbrooke.

A State-wide amendment to a planning scheme to control clearance of native vegetation is currently in place and operating. Under this amendment a permit is required prior to any clearing, although there are a number of exemptions for normal farming and domestic activities.

National estate register

Areas of the natural and cultural environmental with aesthetic, historical,

scientific, or social significance may be placed on the national estate register. Operated by a Commonwealth government agency, the Australian Heritage Commission, the register lists places of national estate value, and provides decision-makers with information about the sites. Private land-owners and local and State governments are not restrained by national estate listings, although Commonwealth agencies are. Table 30 lists a number of natural places in the study area, while other nominated sites may be added if each satisfies the nomination criteria. Not all the criteria are equivalent to nature conservation values, but most registered natural places have identified biological and ecological values.

Rivers and catchments

Indications of the condition of the study area's rivers and streams in Chapter 6 highlighted the loss of nature conservation

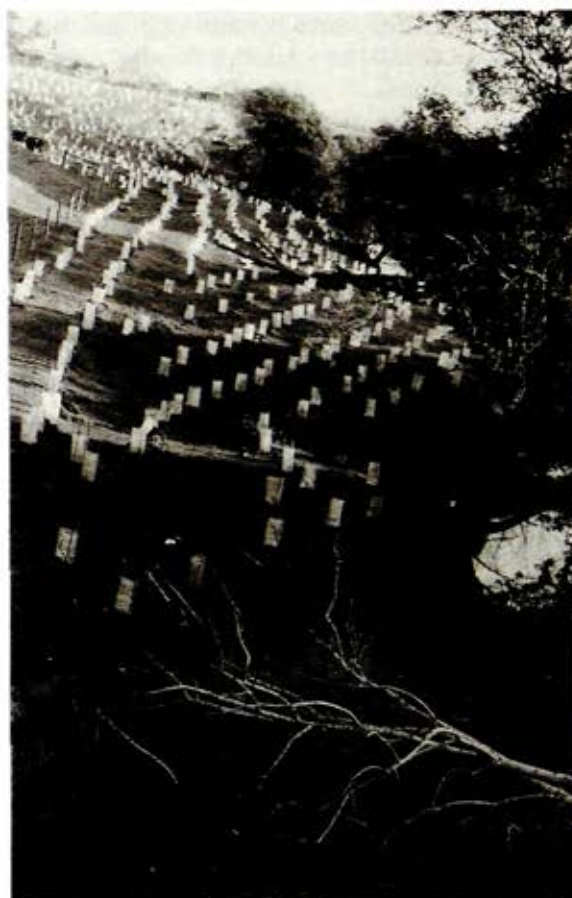
Table 30

NATIONAL ESTATE REGISTER: NATURAL PLACES

Number	Place	Status
004375	Fraser National Park	Registered
004377	Cathedral Range State Park	Registered
004378	Eildon State Park	Registered
004379	Warburton-Marysville Highlands	Registered
004381	Cathedral Range	Registered
004502	Howqua Hills Historic Area	Registered
004503	Delatite Education Area	Registered
004504	Mt Russel Education Area	Registered
004819	Baw Baw National Park	Registered
004822	Aberfeldy River Upper Catchment	Registered
04829	Mt Worth State Park	Registered
005600	Kinglake National Park	Registered
004380	Acheron River (Upper Catchment)	Registered
005696	Ferntree Gully National Park	Registered
005718	Yellingbo State Faunal Reserve	Registered
005807	Nepean State Park	Registered
005808	Cape Schanck Coastal Park	Registered
005863	Cardinia Creek Area	Registered
005871	Langwarrin Military Reserve	Registered
005877	Seal Rocks State Fauna Reserve	Registered
005878	Cape Woolamai State Fauna Reserve	Registered

Note:
Sites within study area

Source: Australian Heritage Commission



Restoration of riparian conditions - tree planting on the Bass River

values in the lower reaches of many major rivers. These losses resulted from catchment modifications, riparian and in-stream disturbances, and river management works.

Studies of catchment naturalness provide indications of watercourses that have been altered as a result of human activities in the catchment. A study of catchment naturalness for the Council's Rivers and Streams investigation only classified two third-order stream catchments as 'undisturbed' in the present study area: Matlock Creek and Mt William Creek. Subsequent Land Conservation Council field work revealed that forestry had once occurred in Matlock Creek catchment, leaving only the small Williams Creek catchment classified as 'undisturbed'.

These undisturbed catchments do not necessarily indicate ecological values, as 'naturalness' was only one attribute in assessing natural values. Catchments with slight alterations can retain the highest ecological values. Very stringent conditions

were applied to these catchments, and many catchments, smaller than third-order, met the criteria applied.

Data in the Natural Resources Inventory and a review of environmental conditions (Mitchell 1990) gave a broad indication of riparian and physical stream conditions within the study area. Records and work programs of river management authorities provide a more detailed appraisal of the physical condition of selected river reaches, and of the catchment and river programs to address river management problems.

Catchment management and restoration of riparian and in-stream conditions is a key issue in reducing the degradation of the aquatic environment. Greater awareness of environmental values is evidenced in the establishment of catchment co-ordination groups and in guidelines for operating such groups, and in environmental guidelines for river management works.

Chapter 17 describes the Council's special investigation on rivers and streams which involves the identification and making recommendations on the protection of values associated with Victoria's watercourses.

Environmental flows in rivers and streams

Significant initiatives have been taken to formally recognise environmental values in rivers, wetlands, and estuaries affected by water resource development.

Under Victoria's new *Water Act* 1989, all future water resource developments are required to make provision for the maintenance of environmental values. A key feature protecting such values in aquatic systems managed for water supply is the allocation of a guaranteed minimum flow, at certain times, to meet environmental water requirements. Such an allocation has been called an 'environmental flow'.

Environmental values of riverine and wetland ecosystems are reduced when stream flows are artificially changed from natural conditions. Water storages can cause, on a seasonal basis, an over-, under-, or infrequent supply of water downstream of the impoundment. Environmental flows provided by releases from the storages are used to maintain or restore environmental values.

Determining the desirable quantity and pattern of releases for environmental flows is complex: efforts to achieve this involve analysis of the biological requirements of key species and the effects of different stream-flow regimes. Investigations to determine environmental flows have been conducted for a few river reaches in the study area (such as the Thomson River), and preliminary assessments have been conducted for sections of the Thomson and La Trobe Rivers (Hall 1989). Only two other rivers in the State have environmental flow determinations (although not implemented): Wimmera River (Anderson and Morrison 1989) and Gellibrand (Tunbridge and Glenane 1988).

Minimum flow requirements have been in place on the Thomson River since the construction of the Thomson Reservoir, with associated downstream biological monitoring prior to, and following, storage construction. Studies monitoring fish and invertebrate populations have been undertaken to determine the effects of the Reservoir on the river ecology. Results to date suggest that fish and invertebrate populations have returned to pre-dam levels, despite releases from the storage not meeting the recommended environmental flows for several months each year.

In addition, there is an agreed minimum stream flow for the Yarra River, comprising 245 ML per day to be maintained at Warrandyte and 70 ML per day at Milgrove; however, there are no environmental water requirements.

Protection of the aquatic environment from future water harvesting must involve the choice between further impoundments or the reallocation of waters in existing storages from low-value uses to high-value ones, namely from irrigated pasture to urban use. The response to increase Melbourne's water supplies by new storage construction cannot continue indefinitely without incurring higher water-harvesting expenditure and environmental costs.

Effectiveness of existing reserves

Unfortunately, the present state of knowledge about the flora and fauna within existing reserves makes it impossible to definitively assess the effectiveness of existing reserves for flora and fauna conservation.

However, data on the habitat requirements of many species are available and have partly formed the basis for the location of many of the existing reserves, along with other factors such as the representation of land systems and vegetation types.

Identification of vegetation types and associations across the State has enabled those types not yet protected within any reserves to be given a high priority for future protection. An assessment of the conservation of plant communities is available (Frood and Calder 1987), and Council further assessed the extent to which each community was represented (LCC 1988). Table 31 lists those communities within the study area deemed by Frood and Calder to have deficient protection. Of these, Council considered there was adequate representation of coastal salt-marsh and mangrove

communities, mature coastal vegetation, and *Casuarina littoralis* open scrub (all three occur in the study area). Council made this distinction by assuming that all recommended reserves are to be implemented, and by excluding any activities that may lower the level of protection.

Assessing reserve effectiveness requires information on the area of each vegetation type being conserved, the degree of disturbance, and an estimate of the size of a reserve necessary to ensure long-term viability. Such assessments are more complex in areas where nature conservation is only one of many resource uses, such is the case for State forests. Surveys have revealed very high zoological and botanical values in the catchments controlled by the Board of Works - areas currently managed primarily for water-harvesting.

Table 31

CONSERVATION OF PLANT COMMUNITIES - CURRENT DEFICIENCIES IN PROTECTION

Category I - Conservation measures urgently required, particularly in refuge sites

- * Grasslands of lowland plains
- * Grassy woodlands of lowland plains and fertile hilly areas
- * Open forests, woodlands, and grassland communities of lower-altitude snowplains and cold montane plateaux
- * Montane bog communities of lower-altitude snowplains, cool-air drainage lines, and various montane plateau areas
- * Other open forests and woodlands of relatively fertile soils in hilly areas and near the coast
- * Wetlands and riparian communities

Category II - Further conservation measures in high need

- * Melaleuca scrubs and low woodlands
- * Coastal salt-marsh and mangrove communities
- * Wet sclerophyll forest-cool temperate rainforests
- * Riverine forests

Category III - Further conservation measures required

- * Forests and heathy woodlands of the ranges and coastal areas

Category IV - Additional features requiring particular attention

- (a) localised areas
 - (b) mature coastal vegetation
 - (c) areas of high botanical importance that can be underestimated by broad structural descriptions
 - (d) relics of scrub or heath grassland
 - (e) *Casuarina littoralis* open scrub
-

Source: Frood and Calder (1987)

A number of issues related to nature conservation values are discussed in Chapter 20: old-growth forests, rainforests, Leadbeaters possum, and nature conservation in Western Port.

References

- Ahern, L.D. (1982). Threatened wildlife in Victoria and issues related to its conservation. *Fisheries and Wildlife Paper* No. 27.
- Ahern, L.H., Brown, P.R., Robertson, P., Seebeck, J.H., Brown, A.M., and Begg, R.J. (1985). A proposed taxon priority system for Victorian vertebrate fauna. *Arthur Rylah Institute Technical Report Series* No. 30.
- Anderson, J.R., and Morison, A.K. (1989). Environmental flow studies for the Wimmera River, Victoria - summary report. *Arthur Rylah Institute Technical Report Series* No. 78.
- Andrew, D.L., Lumsden, L.F., and Dixon, J.M. (1984). Sites of zoological significance in the Western Port region. *Ministry for Conservation Environmental Studies Program* No. 327.
- Australia Department of Home Affairs and Environment (1983). 'National Conservation Strategy for Australia.' (AGPS: Canberra.)
- Barson, M.M., and Calder, D.M. (1976). Sites of special scientific interest in the Victorian coast region. A report on the botanical aspects prepared for the Town and Country Planning Board.
- Beardsell, C. (1989). 'Report on the Plenty Corridor Terrestrial Fauna Survey.' (Department of Conservation, Forests and Lands: Victoria.)
- Beaughole, A.C. (1983). 'The Distribution and Conservation of Vascular Plants in the Melbourne Area, Victoria.' (Western Victorian Field Naturalists Clubs' Association: Portland.)
- Biosis Research Pty. Ltd. and Ecological Horticulture Pty. Ltd (1988). Report on the ecological values of Victorian rivers and streams. Report to the Land Conservation Council.
- Briggs, J.D., and Leigh, J.H. (1988). Rare or threatened Australian plants. *Australian National Parks and Wildlife Service Special Publications* No. 14.
- Cadwallader, P.L., and Backhouse, G.N. (1983). 'A Guide to the Freshwater Fish of Victoria.' (Victorian Government Printing Office: Melbourne.)
- Cadwallader, P.L., Backhouse, G.N., Beumer, J.P., and Jackson, P.D. (1984). The conservation status of the native freshwater fish of Victoria. *Victorian Naturalist* 101:112-14.
- Department of Conservation, Forests and Lands (1987). 'Conservation in Victoria. 1. Plants and Animals at Risk'. (Victorian Government Printing Office: Melbourne.)
- Department of Conservation, Forests and Lands, Department of Water Resources, and Ministry for Planning and Environment (1988). 'Wetlands Conservation Program for Victoria.' (Victorian Government Printing Office: Melbourne.)
- Department of Water Resources (1989a). 'Water Victoria - an Environmental Handbook.' (Victorian Government Printing Office: Melbourne.)
- Department of Water Resources (1989b). Guidelines for incorporation of environmental water requirements in planning new water projects. *Water Resource Management Report Series* No. 48.
- Dorwood, D.F. (1976). 'Sites of Specific Scientific Interest in the Victorian Coastal Region - a Report on the Zoological Aspects.' (Town and Country Planning Board: Melbourne.)
- Fleming, M.R., Temby, I.D., and Thomson, R.L. (1979). Sites of zoological significance in the Upper Yarra region. *Ministry for Conservation Environmental Studies Program* No. 247.
- Frood, D., and Calder, M. (1987). 'Nature Conservation in Victoria Study Report.' Volume 1. (Victorian National Parks Association: Melbourne.)
- Gullan, P.K. (1982). Sites of botanical significance in Central Gippsland. *Ministry for Conservation Environmental Studies Program* No. 381.

Gullan, P.K., Cheal, D.C., and Walsh, N.G. (1988). Rare or threatened plants in Victoria. Department of Conservation, Forests and Lands, Victoria.

Gullan, P.K., Parkes, D.M., Morton, A.G., and Bartley, M.J. (1979). Sites of botanical significance in the Upper Yarra region. *Ministry for Conservation Environmental Studies Program* No. 246.

Gullan, P.K., Earl, G.E., Forbes, S.J., Barley, R.H., and Walsh, N.G. (1984). Sites of botanical significance in Central Gippsland. *Department of Conservation, Forests and Lands Environmental Studies Program* No. 400.

Hall, D.N. (1989). Preliminary assessment of daily flows required to maintain habitat for fish assemblages in the Latrobe, Thomson, Mitchell and Snowy Rivers, Gippsland. *Arthur Rylah Institute Technical Report Series* No. 85.

International Union for the Conservation of Nature and Natural Resources (1980). 'World Conservation Strategy - Living Resource Conservation for Sustainable Development.' (International Union for the Conservation of Nature and Natural Resources: Morges.)

Koehn, J.D., and Morison, A.K. (1990). A review of the conservation status of native freshwater fish in Victoria. *Victorian Naturalist* 107 (1):13-25.

Land Conservation Council (1977). Melbourne Study Area - Final Recommendations. (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1988). 'Statewide Assessment of Public Land Use.' (Victorian Government Printing Office: Melbourne.)

Leigh, J., Briggs, J., and Hartley, W. (1981). Rare or threatened Australian plants. *Australian National Parks and Wildlife Service Special Publication* No. 7.

Main, A.R. (1984). Rare species: problems of conservation. *Search* 15: 94-7.

Mansergh, I., Beardsell, C., Bennett, S., Brereton, R., O'Connor, W., Sandiford, K., and Schulz, M. (1989). Report on the sites

of zoological significance in the Upper Yarra Valley (Western Sections) and Dandenong Ranges. Report to the Upper Yarra Valley and Dandenong Ranges Authority.

Margules, C.R., and Usher, M.B. (1981). Criteria used in assessing wildlife conservation potential: A review. *Biological Conservation* 21: 79-109.

McMahon, A.R.G., Frood, D., Bedggood, S.E., and Carr, G.W. (1989). A review of the sites of botanical significance in the Upper Yarra Valley and Dandenong Ranges region, Vol. 1. Report prepared for the Upper Yarra Valley and Dandenong Ranges Authority.

Meredith, C., Goss, H., and Seymour, S. (1989). Nature conservation values of the rivers and catchments of Gippsland. A report to the Department of Water Resources. *Water Resource Management Report Series* No. 44.

Mitchell, P. (1990). 'The Environmental Condition of Victorian Streams.' (Prepared for the Department of Water Resources.) (Victorian Government Printing Office: Melbourne.)

Molnar, C.D., Dickins, M.J., and Cheal, D.C. (1989). Vegetation survey and sites of botanical significance in the Plenty Valley growth corridor. *Department of Conservation, Forests and Lands Ecological Survey Report* No. 37.

Office of the Commissioner for the Environment (1988). 'State of the Environment Report - Victoria's Inland Waters.' (Victorian Government Printing Office: Melbourne.)

Opie, A.M., Gullan, P.K., Van Berkel, S.C., and Van Rees, H. (1984). Sites of botanical significance in the Westernport region. *Ministry for Conservation Environmental Studies Program* No. 328.

Recher, H.F. (1990). Wildlife conservation in Australia: state of the nation. *Australian Zoologist* 26(1):5-11.

Rosengren, N.J., Frood, D., and Lowe, K. (1983). Sites of environmental significance in the floodplain of the Upper Yarra River. Report to the Upper Yarra Valley and Dandenong Ranges Authority.

Saunders, D.A., Arnold, G.W., Burbidge, A.A., and Hopkins, A.J.M. (eds) (1987). 'Nature Conservation: the Role of Remnants of Native Vegetation.' (Surrey Beatty and Sons in association with CSIRO and the Department of Conservation and Land Management: Western Australia.)

Scarlett, N.H., and Parsons R.F. (1984). Register of rare and endangered native plants in Victoria. Department of Botany, Latrobe University.

Seymour, B.S. (1987). Assessment of the conservation values of the rivers and streams in the Western Port region. *Dandenong Valley Authority Technical Report No. 31.*

Soule, M., and Simberloff, D. (1986). What do genetics and ecology tell us about the

design of nature reserves? *Biological Conservation* 35: 119-40.

Tunbridge, B.R., and Glenane, T.J. (1988). 'A Study of Environmental Flows Necessary to Maintain Fish Populations in the Gellibrand River and Estuary.' (Victorian Government Printing Office: Melbourne.)

Victoria, Government (1987). 'Protecting the Environment: A Conservation Strategy for Victoria.' (Victorian Government Printing Office: Melbourne.)

Wilson, E.O. (1985). The biological diversity crisis. *Bioscience* 35(11): 700-706.

Woodgate, P. and Black, P. (1988). 'Forest Cover Changes in Victoria, 1869-1987.' (Victorian Government Printing Office: Melbourne.)

13. RECREATION

Outdoor recreation includes those outdoor activities pursued by the individual during discretionary time for the purpose of personal satisfaction. Recreation is a major use of the public land estate, and a high concentration occurs in the Melbourne Area, District 2, due to its proximity to metropolitan Melbourne.

Public land has a crucial role to play in Victoria's outdoor recreation. Informal recreation - recreational driving, beach visits, fishing, bushwalking, skiing, and picnicking - usually involves public land. More formal recreation is often catered for on public or municipally owned lands, such as sports ovals, race tracks, and various sports clubs, although some may be on private land.

Following consideration of these factors in its earlier investigation, Council suggested that the majority of public land be available for some form of outdoor recreation and recommended a variety of land classifications providing a wide range of recreation opportunities. This general approach ensured that most activities are accommodated somewhere on the public land estate. Rather than address particular recreation activities and where they should occur, the Council established settings in which a range of recreational activities could occur. In the earlier Melbourne Area investigation (LCC 1977) some specific areas - 'recreation reserves' - were allocated to recreation. These only represent a small proportion of the total area in which recreation was a recommended land use.

Where recreation activities cause unacceptable environmental damage or are incompatible with a range of other land uses, the Council has specifically excluded them. Council's alternative to prohibition is to recommend that management authorities create appropriate management zones for some recreational activities, with suitable management.

Economic significances of recreation

As well as the physical and emotional benefits that confers on participants, recreation is a major element in the State

economy (Victoria 1986). With travel away from home usually involved in outdoor recreation, most of this activity in the study area can be regarded as tourism. Tourism has been described as one of the fastest-growing industries in the world and has major economic and social importance (IAC 1989). In addition to local government tourist promotions and regional plans, such as the Upper Yarra Valley and Dandenong Ranges Authority 1990 tourism overview, the State government intends that Victoria further invest in, and promote, tourism to increase numbers and boost its contribution to the State economy. Tourism contributed some 7.0% to the Victorian GDP and accounted for 7.3% of the State's employment in 1987. Alpine resorts, national parks, and sport have been targeted for promotion as features. Tourist and visitor expenditure can form the major source of income at popular destinations and contribute substantially to regional economies.

Recreation demand

Since the 1973 Melbourne investigation, a number of the factors that influence recreation demand have altered, resulting in changes to the participation levels of particular activities. Recreation demand is influenced by population, economic conditions, car ownership, education, leisure time, government policies, fashions, knowledge, and skills. Examining the available statistics on selected indicators at the State and regional levels provides some impressions of the influences on recreation demand.

Melbourne's population has increased significantly during the period. In 1973 some 2 652 700 people lived there; by 1987 the population had reached 2 965 600 (ABS 1990). Projections of population growth are fickle, especially given the uncertainty of future migration levels, but four scenarios prepared by the Australian Bureau of Statistics for Victoria gave a total population for the year 2010 that ranged from 4.8 to 5.5 million, with that for the year 2020 ranging from 5 to 6 million. Assuming that Melbourne continues to have 70% of Victoria's population, this gives projected Melbourne populations between 3.46 and

3.45 million in 2010 and between 3.5 and 4.2 million in 2020.

Some 71% of the State work-force works a 5-day week, with Saturday and Sunday free. A majority of the work-force and educational institutions take holidays at Christmas and Easter. Outdoor recreation activity thus peaks on weekends and over the summer and Easter holidays. Several commentators have observed a general and long-term increasing demand for recreation, as affluence and mobility have increased and expectations for recreation have shifted towards active participation. Average hours worked per week in Victoria fell from 39.1 hours in 1971 to 35.7 in 1983, but have since changed minimally (ABS 1985, 1990).

Since the 1970s the population has had a higher proportion of older people, and the Bureau's future population scenarios assume this trend continuing, with proportionally fewer children and more elderly people (up to 16.2% of the population will be 65 years or older in the year 2021, compared with 14.4% in 1981).

Population growth will boost total recreation activity. Changes in population age structure could further increase recreation demand and alter the demand levels for some activities. Demand for areas to accommodate recreation may increase, and have greater potential environmental impacts, requiring an increased land management effort. With Melbourne's expansion concentrated along the Plenty Valley and south-eastern corridors, increased recreation demand is likely to be greatest in adjacent areas. Those likely to be influenced by the Plenty Valley corridor include: Kinglake National Park, the State forest at Mt Disappointment and Toolangi, and reservoir parks at Sugarloaf, Yan Yean, and Toorourrong. Around the south-eastern corridor, the Mornington Peninsula, Western Port, Dandenong Ranges National Park, Bunyip State Park, Gembrook Regional Park, and the State forests in the Tarago and Neerim areas may experience substantial increases.

Measuring recreation demand

Measurement of recreation demand can be difficult, especially for the more informal, irregular, and disparate activities. Many of the most popular ones, such as beach swimming, have virtually no data. Suitable

indicators for pleasure driving and picnicking are also difficult to find (Chalmers 1986). Available data on recreational use of public land areas are discussed below.

Various indicators have been identified to measure recreation in circumstances where no direct measure of participation is available. Data relating to licences, registrations, equipment sales, club memberships, and visits to parks, have been used in the past. A range of indicators were assessed by Mackay (1981), and Chalmers used several in his study of recreation growth.

Interpretation of recreation participation data is difficult and extrapolation of trends has often been unreliable. Many of the factors involved are variable and unpredictable. Recreation fashions can quickly alter demand, exemplified by recent phenomena such as windsurfing, jetski-riding, and triathlons. Recreation planning and management can also greatly influence recreation participation (Mercer 1977).

Chalmers' research into trends examined indicators of growth for particular forms of recreation in Victoria. Although no correlation can be drawn between these results and Melbourne Area, District 2, the estimates are probably broadly applicable. Of particular relevance to the study area is that four-wheel-driving, sailing, skiing, and motor-boating all showed high rates of growth between 1979 and 1985. However, club membership, the indicator used for four-wheel-driving and skiing, has limited application in several ways. Participants may not belong to a club; and club members may only represent one aspect or style of the activity (such as competition), or may not actively participate.

Visits to public land parks and snow resorts can be measured by visitor statistics - some of which are described below. Wide variability characterises annual attendance at many parks over the last decade, but a general trend of increased patronage is evident, with sustained increases at some locations.

Fluctuations in demand

Weekly and seasonal fluctuations in demand can produce overcrowding at peak periods and low usage at other times. Environmental

damage can occur with low levels of use as well as high. Periods of restriction may allow 'recovery' of areas damaged by over-use, although recovery usually occurs at a slower rate than damage. Impacts resulting from high use can be reduced by a variety of planning techniques. These include: offering alternative venues; limiting use by direct means (for example, permits, pricing) or indirect ones (say, site design to regulate access or parking); or educating users with the aim of changing user behaviour.

Influence of population centres

Recreational use of a site is strongly influenced by the length of journey faced by participants. The number of journeys taken diminishes with increasing distance and travel time, and with falling standard of access; as long journeys or those in mountainous areas are usually perceived as requiring more time, effort or cost (Pigram 1983). It follows that the number of visits to a site increases when the distance travelled or travel time falls. Economists modelling recreation use often use distance as a proxy for price in calculating demand functions.

Those areas with the greatest numbers of tourists (predominantly day visitors) are the Yarra Valley, Mornington Peninsula, Phillip Island, and Dandenong Ranges, all of which lie relatively close to Melbourne.

As metropolitan Melbourne expands along the Plenty Valley and south-eastern corridors, a greater number of people will live closer to the public lands adjacent to the metropolitan area. A zone of high recreation demand is likely to expand in association with this changing pattern of Melbourne's urban growth. Population growth will continue to be largely confined to urban centres and the growth of Melbourne's population, particularly along the above corridors, will probably produce a greater level of demand for recreation in the study area.

Recreation opportunity spectrum

Planners have developed the concept of the 'recreation opportunity spectrum' as a useful tool to help identify available opportunities for recreation, which they can then plan to provide or maintain. The concept allows the highly diverse range of recreational activities to be matched with a range of setting

requirements. It describes a range of recreational settings based on physical, biological, social, and managerial conditions of a place (Clark and Stankey 1979). Recreation planners in the Department of Conservation and Environment have defined five settings (remote, semi-remote, roaded--natural, semi-developed, and developed) where the range of recreation opportunities may be found. Table 32 sets out the definitions.

A preliminary assessment of opportunities available on public land (Byrne and Vize 1990) indicates the following possible range of recreation opportunities available in 1986 in Melbourne, District 2:

Remote	2 700 ha
Semi-remote	127 800 ha
Roaded--natural	435 600 ha
Semi-developed	77 300 ha
Developed	700 ha

Visits to parks

The Department of Conservation and Environment's records and estimates of visits to parks and reserves indicate the sites of greatest popularity and changes in visitor patronage over time. Differences in the collection methods and frequencies of the statistics collected preclude close analysis of changes in demand and detailed inter-park comparisons. However, records suggest that the most frequently visited areas in the study area, are the Dandenong Ranges National Park, Mornington Peninsula ocean coast, and the Phillip Island Penguin Reserve.



Phillip Island Penguin Reserve receives nearly half a million visitors annually

Table 32

RECREATION OPPORTUNITY SPECTRUM

The Department of Conservation and Environment has adopted five classes to describe the spectrum of recreation opportunities available on public land in Victoria.

Class I Remote

Essentially unmodified environments generally over 2000 ha in size and at least 3 km from public motorised vehicle tracks and private property. They have very low interaction between users, minimal evidence of other users and no evidence of restrictions and controls. Motorised access and horse-riding by the public are not permitted. The recreation emphasis is on self-reliance, independence, closeness to Nature, and tranquillity. Such areas offer a high degree of challenge and risk.

Class II Semi-remote

Predominantly natural environments of moderate to large size generally greater than 800 ha and at least 1 km from primary and secondary roads and private property. Interaction between users is low, but there may be evidence of other users. Obvious on-site controls and restrictions are minimised. Limited vehicle (predominantly four-wheel-drive) tracks exist, for which access is permitted. High to moderate probability of experiencing isolation from the sights and sounds of humans, independence, closeness to Nature, tranquillity, and self-reliance. Such areas offer a moderate degree of challenge and risk.

Class III Roaded—natural

Natural-appearing environments (which may be within 1 km of primary and secondary road access) with moderate evidence of the sights and sounds of humans. Interaction between users may be low to moderate, but evidence of other users is prevalent. Scattered structures may be present and site hardening may occur. Opportunities for both motorised and non-motorised forms of recreation are available with a high degree of interaction with the natural environment. Modifications and recreation facilities do not dominate general impressions of Nature.

Class IV Semi-developed

Substantially modified natural environments. Sights and sounds of humans are readily evident, and interaction between users is often moderate to high. Facilities include those designed for use by large numbers of people and those provided for special activities. Management controls may be obvious and numerous.

Class V Developed

Substantially urbanised and heavily modified environments, although the background may have natural- looking elements. Vegetative cover is often exotic and usually heavily managed. Sights and sounds of humans are predominant and large numbers of users can be expected. Opportunities for competitive and spectator sports and for passive users are common. Management controls and regimentation are obvious and numerous.

Table 33
SELECTED PARKS VISITOR STATISTICS
No. of Visitors ('000)

Park		1981/82	1982/83	1983/84	1984/95	1985/86	1986/87	1987/88	1988/89	1989/90
Arthur's Seat	DV	53	66	65	58	570	-	57	63	46
	CN	4	4	5	4	-	-	-	-	-
Baw Baw National Park	DV	30	26	30	36	76	-	76	20	62
	CN	1	1	1	2	4	-	4	26	5
Cathedral Range State Park	DV	5	5	56	6	23	27	29	22	20
	CN	10	11	10	11	15	20	21	23	37
Dandenong Ranges National Park	DV	307	399	419	355	257	-	400	400	800
Eildon State Park	DV	5	5	3	48	5	6	8	10	10
	CN	12	12	4	46	5	6	7	8	7
Fraser Regional Park	DV	58	46	41	389	41	101	114	50	46
	CN	69	39	48	520	52	51	61	53	44
Kingslake National Park	DV	126	147	134	123	162	143	148	152	144
	CN	2	2	>1	>1	>1	1	1	1	1
Langwarrin Flora Reserve	DV	3	2	3	3	3	-	3	15	15
Lysterfield Lake Park	DV	-	1	>1	1	1	-	134	173	214
Phillip Island Penguin Reserve	DV	-	-	-	315	315	-	476	495	470
Point Nepean National Park	DV	3 324	3 556	2 762	23 740	2 271	2 635	2 107	2 124	1 625
	CN	4	4	5	4	-	4	4	3	4
Mt Worth State Park	DV	1	1	1	3	5	-	12	12	17
Silvan	DV	327	257	251	244	248	296	314	363	278
Upper Yarra	DV	133	169	212	201	207	207	207	226	192
Maroondah	DV	205	193	215	201	216	223	205	185	235
Sugarloaf	DV	-	-	63	115	121	163	155	131	133
Coranderrk	DV	118	109	113	117	127	130	136	134	162
Donnelllys	DV	17	16	14	13	14	12	12	8	9
Fernshaw	DV	110	104	111	132	138	142	168	157	219
Thomson	DV						165	67	60	50

Notes:

1. Arthur's Seat State Park formerly called Nepean State Park.
2. Lysterfield Lake Park opened officially in December 1986.
3. Dandenong Ranges National Park included Ferntree Gully National Park, Sherbrooke Forest park, and Doonpalla Forest Reserve.
4. Point Nepean National Park formerly included as Cape Schanck Coastal Park, part of Nepean State Park, and Commonwealth land at Point Nepean.
5. DV - Day Visitors; CN - Camper Nights. Figures rounded to nearest thousand.
6. Data supplied by DCE (1990) and Board of Works (1991)

Visitor use at many other reserves is also high. In 1989/90 Lysterfield Lake Park received more than 200 000 visitors, Fraser National Park more than 45 000 day visitors and 44 000 camper nights, the Cathedral Range State Park more than 20 000 day visitors and 36 500 camper nights, and Lake Mountain 190 000 visitors, mostly during the snow season. Table 33 gives visitor statistics for selected parks.

Recreation reserves operated by the Board of Works, such as Maroondah and Silvan parks, feature developed areas that are popular destination points for vehicle touring in the region. Some 1.3 million visitors in total entered these reserves in 1989/90.

While there is no single explanation of visitor usage, several factors contribute to high visitor use. Proximity to Melbourne and motor vehicle access combine with the broad range of recreational opportunities available in particular areas to account for much of it.

Annual variability is a feature of park visits, against a trend of sometimes-rapid growth. Seasonal factors can influence visitor use; for example, poor snowfalls reduce the demand for cross-country skiing and snow play.

Environmental consequences

Recreation can have a direct influence on the physical environment, and may reduce ecological, social, economic, and landscape values. Council believes that land managers should aim at controlling the levels and patterns of recreational use according to the capability of the area to sustain such uses without irreversible damage or conflict with the primary purposes of the area, while avoiding unnecessary restrictions on usage.

Losses of environmental values are usually greatest in developed recreation areas, often as a result of the installation of facilities, such as sports grounds, car parks, and buildings. Coastal amenities such as marinas, boat harbours, car parks, and launching ramps necessitate removal of vegetation, alteration of the shore-line, and the construction of facilities. Riparian areas are also sensitive to the disturbances created by construction of recreation aids such as camping areas. And alpine environments can suffer the loss of significant environmental and landscape values through the

development of alpine resorts and other facilities. Creating access to recreational areas can also involve environmental losses, as a consequence of road and car-parking construction and use.

Recreation activities can lower environmental values. As the bulk of the study area does not have developed recreation facilities, but is the setting for a large variety of activities and large numbers of participants, the effects of those activities require evaluation.

Vehicular and water-craft have a role in providing access to most recreation settings and as recreation activities themselves. For land managers, controlling the effects of vehicles is an activity requiring significant resources. Damage to many unsealed roads can result from excessive use or use during wet weather. Illegal off-road use can create further problems of vegetation loss, soil erosion, loss of water quality in waterways, and disturbance of wildlife. Power boats can also disturb bird habitat, such as roosting and nesting sites in Western Port, with detrimental consequences for bird populations.

Recreation activities involving the harvesting or extraction of natural resources - such as fishing, shell collection, and fossicking - can have adverse environmental consequences. For example, as described in Chapter 9, the collection of intertidal invertebrates has the potential to damage marine ecosystems, and regulations have been enacted to control this activity. Other activities also have the potential to disturb the environment - their effects being influenced by the type and popularity of the activity, the intensity of use, and the environmental characteristics of the recreational setting. A number of popular activities are described below, together with some of the environmental effects.

Problems can arise from conflicts between recreationists, either between different activities sharing a common environmental setting or as a result of overcrowding of participants in the same activity. For example, conflicts may arise when bushwalkers, horse-riders, and motor-vehicle drivers all wish to use the same tracks at the same time.

Recreation activities

Major recreation activities were described and mapped in the earlier Melbourne

Investigation (LCC 1973). Since that investigation levels of participation have changed and some new forms of recreation have emerged. From the available evidence and expert opinion, the most popular recreation activities include: recreational driving (with conventional vehicles, four-wheel-drives, and trail bikes), beach visits, fishing (fresh-water and marine), car-based camping, boating, bush-walking, hunting, snow-skiing, and nature observation.

There is insufficient space to describe all the popular activities, where they occur, the levels of use and current trends, and their current management. However, a number of them are described below, with an emphasis on those with public land-use implications.

Boating

This term covers a wide variety of water craft, including power boats, yachts, houseboats, and dinghies. Inland use is based around the larger water bodies where boats are allowed (notably Eildon Reservoir) and the large watercourses, such as the Goulburn and Yarra Rivers. Marine use involves Western Port and the off-shore areas. Boating is associated with a range of activities, such as sailing and yacht-racing, fishing, cruising, racing, and water-skiing. Associated facilities include marinas (at Hastings and Yaringa), boat ramps, and car parks, which are concentrated around Port Phillip Bay and Western Port. Boating experiences range from those in developed areas (such as Jerusalem Inlet, Eildon) to boat-based camp sites with minimal or no facilities.

Boat registrations can indicate the popularity of recreational boating, but few data are available on level of use. In 1986/87 registrations in Victoria totalled 113 919 and between 1982/83 and 1986/87 they increased by about 3%. On inland waters in the study area, houseboats are only permitted on Eildon Reservoir, where the Rural Water Commission imposes a limit of 630 permanent moorings. Increased demand for boating facilities in Western Port, Port Phillip Bay, and Blue Rock Reservoir is likely to follow the expected population growth in Melbourne's south-eastern corridor. As most boat-owners have trailable craft, existing boat ramps and associated facilities will face greater demand.



Power boats and houseboats at Jerusalem Inlet, Eildon Reservoir

Bushwalking

Nearly all public land is available for bushwalking, the notable exception being the restricted-access water supply catchments, where day walking is permitted on a limited number of tracks, and reference areas. Although concentrated on the extensive network of tracks in the Central Highland forests, bushwalking also involves hiking in more remote areas such as Baw Baw Plateau. It includes short walks and day and over-night trips, and may incorporate other pursuits such as Nature study or photography. Parks and reserves are the focus for most activity.

Popular tracks include:

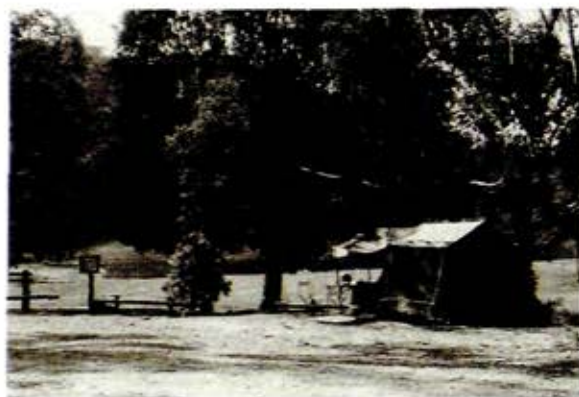
- * Lilydale--Warburton railway line
- * 'Walk into History' (Warburton to Powelltown)
- * Mt Donna Buang tracks
- * Upper Yarra Goldfields Walk - McMahons Creek
- * Lal Lal Falls
- * Reids tramline at Powelltown
- * Seven Acre Rock
- * Upper Yarra track (links to Alpine Walking track)
- * Ada tree
- * Dandenong Ranges area and Lysterfield Park area
- * Alpine Walking Track

Other popular walking tracks and areas include: Point Nepean National Park--Sorrento, Bushrangers Bay, Greens Bush, Cape Woolamai, Cathedral Range, Lake Mountain, Kinglake National Park, Fraser National Park, Eildon, Steavenson Falls, Ada valley, Maroondah Reserve, Cumberland Reserve, and the Alpine Walking Track at Walhalla (Bardwell 1982, Thomas 1984).

Over-use can result in localised effects on walking tracks, principally trampling of native flora and soil compaction and erosion, and in the creation of shortcuts, site degradation, and loss of vegetation. Overcrowding at popular locations can reduce the recreationists' enjoyment.

Camping

Various forms of camping are available in the study area. These range from developed camp sites with many facilities (as in Fraser National Park), through designated areas with minimal facilities (Cathedral Range), to dispersed, remote sites with no facilities. Camping is often associated with other recreation, such as walking, angling, canoeing, boating, and hunting. Parks and reserves typically provide the focus for this activity, but State forests appear to be increasing in popularity, especially those adjacent to rivers and streams. Many areas used frequently for 'informal' camping (that is, no developments) suffer trampled vegetation and soil compaction. 'Formal' campsites have facilities such as toilets, shelter areas, fire-places, and rubbish bins. Camping within 30 m of streams can have particular impacts on streamside vegetation and soils.



Camping in Fraser National Park

Car touring, day trips

Car touring involves driving for pleasure and associated activities. An extensive two-wheel-drive road network in the Dandenong Ranges and Yarra Valley supports considerable car touring. The most popular destinations include the Yarra Valley: Healesville, Warburton, Board of Works' parks, Mornington Peninsula and southern Western Port, Phillip Island, Dandenong Ranges, and the Central Highlands: Marysville and Walhalla. Popular tourist drives include:

- * Maroondah Highway, over the Black Spur
- * Mt Donna Buang and the Acheron Way
- * Mt Donna Buang--Ben Cairn road to Healesville
- * Upper Yarra Dam, Cumberland Junction
- * Mt Dandenong Tourist Highway, Dandenong Ranges
- * Arthurs Seat State Park
- * Point Nepean State Park
- * Phillip Island
- * Walhalla
- * designated 'Forest Drives' in the Central Highlands

Cycling

With the advent of 'mountain bikes', cycling on unformed roads, tracks, and walking trails has become more popular. Possible conflicts may occur between cyclists and other groups over the use of the more popular tracks. High-use tracks may suffer erosion problems in the future.



Cycling on French Island State Park

Canoeing

Rafting and canoeing are popular activities on a number of larger watercourses and larger water storages, where permitted.

In a report to the Land Conservation Council, the Victorian Amateur Canoe Association

described the canoeing resource of Victoria in 1989, and Table 34 lists the canoeing streams of national and State significance within the study area. Those with regional significance are the Aberfeldy, Acheron, La Trobe, Tanjil, and Taponga Rivers. Other canoeable watercourses include the Yea River and King Parrot Creek.

Table 34

CANOEING STREAMS

Name of river	Section of river	Discipline supported	Canoeing significance
Big River	Frenchmans Creek to Enoch Point	T	2
	Enoch Point to Jamieson Bay	E	2
Delatite River	Merrijig to Hearn's Road	T	2
Goulburn River	Blue Gums Caravan Park	S	1
Thomson River	Dam wall to Coopers Creek	T	2
	Coopers Creek to Bruntons Bridge	T	2
Yarra River	15 reaches	T	2,4
	5 reaches	S	2
	1 reach	E	2

Key:

Canoe discipline: E - education; M - marathon; S - slalom; T - touring
 Canoeing significance: 1 - national; 2 - State; 4 - local

Source: VACA



White-water kayaking in the Goulburn River

No comprehensive data on levels of canoe use are available. A survey of 11 canoe clubs by the Department of Conservation and Environment's Alexandra Region revealed that more than 900 canoeists used watercourses in the region, which includes

the popular Acheron, Big, and Goulburn Rivers. Several commercial canoe-hire firms operate in the study area.

Fishing

People can fish (or angle) from boats or banks, either in-stream or on the seashore, and any accessible water with desired species has fishing potential. Participation rates in the State are high: a 1987 poll indicated that almost 28% of Victorians over 14 years of age had fished in the preceding year.

Within the study area, nearly all waters are open to fishing, the restricted-access water-supply zones, reference areas, and most domestic water supply storages being the exceptions.

A pilot survey of angling clubs (Barnham *et al.* 1984) suggested that about 40% fished from boats and about 60% from the beach, bank, or shore, and that 47% fished inland



Surf-fishing at Gunnamatta Beach, Point Nepean National Park

and the remainder fished marine or estuarine waters. Survey respondents nominated the species caught most often: the fresh-water

natives species were Murray cod, golden perch, blackfish, bony bream, Macquarie perch, catfish, and eels; introduced fresh-water fish comprised trout, redfin, chinook salmon and carp; while estuarine and bay, surf or rock, and marine or off-shore fishing mainly yielded snapper, bream, whiting, Australian salmon, flathead, and tuna.

An unpublished 1988 report to Council quotes data usage for major watercourses, two of which are within the study area: Goulburn - 600 000 angler days; Yarra - 300 000 angler days.

Table 35 identifies inland waters with high value for sport angling. Trout are of significance for recreational fishing, being sought by many anglers. Snobs Creek Fish Hatchery, a wildlife reserve (LCC 1977), breeds, hatches, releases, and conducts research on trout, salmon, and native fish. Trout stocking has occurred in the Acheron, Big, Rubicon, and Yarra Rivers and in Eildon Reservoir and Eildon Pondage. The Murrindindi, Yea, and Goulburn Rivers and King Parrot Creek are considered suitable for stocking with native species such as Macquarie perch, Murray cod, and trout cod.

Horse-riding

This popular activity involves day trips and overnight trips with camping, and it is often

Table 35

FRESH WATERS WITH HIGH VALUE SPORT ANGLING

Fish species	Water	Location	Type
blackfish	Bunyip River Tarago River Yarra River	total u/s Tarago Reservoir u/s Warburton	fresh/river fresh/river fresh/river
brown trout	Eildon Reservoir Howqua River Little Yarra River Goulburn River Tarago River Tarago Reservoir Yarra River	total total total Yea pondage u/s Tarago Reservoir total Healesville	fresh/reservoir fresh/river fresh/river fresh/river fresh/river fresh/reservoir fresh/river
rainbow trout	Howqua River	total	fresh/river
short-finned eel	Lang Lang River	total	fresh/river

Source: Tunbridge and Glenane (1984)

in groups. Several commercial groups operate in the Central Highlands; for example, 12 operate in the Dandenong Forest Management Area. Most activity occurs in State forests.

Currently, no estimates are available on the number of horse-riders in the study area. As with many activities where participants often have no club or commercial associations, the number of people involved is difficult to determine.

Areas adjacent to watercourses are favoured locations for trails and camp sites. Horse-riding is permitted in some national parks on specified tracks - for instance in Kinglake National, Cathedral Range State, Dandenong Ranges National, and Gembrook Regional Parks. Areas where it is not permitted include Baw Baw plateau, Bunyip State Park, Fraser National Park, and Lysterfield Park. A portion of the Bicentennial National Trail, which begins in Healesville and finishes in Cooktown, Queensland lies within the study area.

Overseas research and local evidence have identified environmental effects of horse-riding, which include: spread of weeds, track erosion, overgrazing at specific sites, and trampling of native vegetation (Whinam 1991).

Recreational driving

Both four-wheel-drives and motorcycles use the extensive formed (that is, unsealed) and unformed road network throughout the public land estate. Much of this network was not constructed to link specific destinations, but results from timber-harvesting access roads and fire-protection and access tracks, many of which were not designed for all-weather access or high traffic levels.

Recreational driving can be an activity in its own right, or associated with other activities such as bushwalking, camping, canoeing, fishing or hunting.

Four-wheel-drive vehicles have increased in popularity, and reports from public land managers suggest increased traffic on four-wheel-drive-only roads. Forest areas such as Toolangi, Big River, and Mt Disappointment are popular destinations. Commercial tours for cars and motorcycles operate across the



Motor cycling

Central Highlands. These involve an escorted tour, with the operator supplying meals and amenities. Car and motorcycle rallies also take place; these require a DCE licence and are subject to DCE supervision. For example, in 1989/90 the Central Forest management area had seven major car and two motorcycle rallies. Trail-bike use, especially illegal off-road riding, has caused problems in Bunyip State Park, Big River State forest, Gembrook Regional Park, and around Warburton.

Legal vehicle use is confined to the defined road, but even low levels of use on roads may cause environmental and management problems in some regions. To date the total length of roads and tracks has continued to increase, with an increasing financial burden to management authorities involved in maintenance activities.

Hunting

Of the introduced species legally sought by hunters, the sambar deer is the most popular. Other species hunted are the feral goat, feral pig, fox, and rabbit. Most deer-hunting involves stalking, although trailing (by trained hounds) is also undertaken. Most hunters use rifles, although some use bows and arrows.

Sambar deer are distributed throughout the Central Highlands, usually in tall open

forests. They are frequently hunted in Eildon State Park (only seasonal hunting is permitted), the catchments of Howqua, Upper Goulburn, Big, Thomson, Tanjil, Tyers, Bunyip, and Tarago Rivers, and along the Upper Yarra and around Healesville and Warburton. Hunting is illegal in the catchments under Board of Works control and within the Central Highlands Sanctuary. However, despite the extensive tracts of public land currently available legally, it occurs frequently.

The Central Highlands sanctuary (223 000 ha) was first proclaimed in the early 1920s to protect native game. With the addition of deer to the *Wildlife Act* 1975, the species under the sanctuary's protection became extended to include them. It was not the original purpose of the sanctuary to protect deer within the area. Hunting is prohibited in parks (other than Eildon), in flora and fauna reserves, flora reserves, reference areas, and education areas, along licensed water frontages, and on some other small parcels of public land.

Deer-hunting on public land, involving firearms and sometimes hunting dogs, causes concern to some sections of the community. Hunting by stalking is a low-impact activity, but gaining access to remote areas may have environmental consequences.

Snow skiing and snowplay

Skiing covers cross-country, cross-country touring, and various forms of downhill skiing and snowboarding. 'Snowplay' describes a range of snow-related activities, usually conducted close to snowline car parks or shelters: tobogganing, picnicking, sight-seeing, walking, and general play.

Principle snow recreation areas are Mt Donna Buang (snowplay), Lake Mountain (cross-country skiing, snowplay), Mt Baw Baw (cross-country skiing, downhill skiing, and snowplay), and Mt St Gwinear (on the eastern side of the Baw Baw Plateau) (cross-country skiing, snowplay). Visits to these locations are among the most popular winter recreation activities in the study area.

Lake Mountain is a highly popular destination in the season, and in 1990 the Alpine Resort received 213 000 snow-season

visits. Visitor use at Mt Donna Buang is only measured on those snow season weekends when the Alpine Resorts Commission conducts ticket sales. In the 1990 season, 40 000 people entered over those five weekends.

The Commission manages both Lake Mountain and Baw Baw Alpine Resorts (important for downhill and cross-country skiing), while the DCE takes responsibility for cross-country skiing and snowplay in Baw Baw National park (principally at Mt St Gwinear).

Proposed future development of the Lake Mountain Resort may entail additional car parks, ski trails, and buildings as discussed in the issues Chapter 20.

References

- Alpine Resorts Commission/Department of Conservation and Environment (1990). *Lake Mountain: Management and development plan*.
- Australian Bureau of Statistics (1985). 'Social Indicators - Victoria No. 1,' (Australian Bureau of Statistics: Melbourne.)
- Australian Bureau of Statistics (1990). *Victoria Year Book* No. 103.
- Bardwell, S. (1982) '50 Day Walks near Melbourne.' (Ann O'Donovan: Melbourne.)
- Barnham, C.A., Hopgood, B.W. and Lewton, W.F. (1984) A pilot survey of recreational fishing in Victoria. *Fisheries and Wildlife Service Technical Series* No. 8.
- Byrne, N., and Vize, R. (1990). An inventory of recreation opportunity settings on major areas of public land in Victoria. *Occasional Paper Department of Conservation and Environment* No. 4.
- Chalmers, J. (1986). 'Growth Trends in Outdoor Recreation Activities in Victoria.' (Department of Conservation, Forests and Lands).
- Clark, R.N., and Stankey, G.H. (1979). The recreation opportunity spectrum: A framework for planning, management, and research. *United States Department of*

Agriculture Forest Service General Technical Report pnw-98 .

Department of Conservation, Forests and Lands (1986). 'Lysterfield Lake Park: Recreation Use Plan.' (Victorian Government Printing Office: Melbourne.)

Department of Conservation, Forests and Lands (1987). Victorian public land planning manual.

Department of Conservation and Environment (1990). Draft firewood policy For public discussion and comment.

Department of Conservation and Environment (1991). Yarra Forests - Forest Management Plan.

Industries Assistance Commission (1989). *'Papers and Proceedings of a Seminar on the Environmental Impacts of Travel and Tourism'*.

Land Conservation Council (1973). 'Melbourne Study Area.' (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1977). Melbourne Study Area - Final Recommendations. (Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1988). 'Statewide Assessment of Public Land Use.' (Victorian Government Printing Office: Melbourne.)

Mackay, J. (1981). Growth in resource-based recreation: A pilot study of indicators. *Ministry for Conservation. Environmental Studies Program No. 353.*

Mercer, D. (ed.) (1977). 'Leisure and Recreation in Australia.' (Sorrett Publishing: Melbourne.)

Pigram, J. (1988). 'Outdoor Recreation and Resources Management.' (Croon Helm: Beckenham.)

Thomas, T. (1984). '120 Walks in Victoria.' 4th ed. (Hill of Content: Melbourne.)

Tunbridge, B., and Glenane, T.G. (1984). 'Fisheries Value and Classification of Fresh and Estuarine Waters in Victoria.' (Fisheries and Wildlife Division: Melbourne.)

Upper Yarra Valley and Dandenong Ranges Authority (1990). Tourism overview for the Upper Yarra Valley and Dandenong Ranges Region.

Victoria, Government (1986). Sport and recreation strategy. *Economic Strategy for Victoria, Statement No. 10.*

Victoria, Government (1987). 'Victoria - the Next Decade.' (Victorian Government Printing Office: Melbourne.)

Whinam, J. (1991). Horse riding in the national parks: a response. *Australian Parks and Recreation* 26 (4):41,44.

14. PRIMARY PRODUCTION

Agriculture occupies the bulk of the study area's private lands, (as it does across the State). Major agricultural products are: cattle, both beef and dairy herds; vegetables; orchards (particularly apples); and poultry; minor production involves sheep (mainly fat lambs), pigs, horses, wine, and crops.

This chapter presents a statistical profile of the major activities, and describes a number of environment-related issues. Apiculture as a significant use of public land is covered in greater detail than the other agricultural activities, which mostly occur on private land.

Agriculture and public land

In the earlier Melbourne investigation, the Land Conservation Council recommended (LCC 1977) that a relatively small area of public land, some 69 ha, be made available for agriculture, of which 27 ha are within the present study area. In 1987 following the La Trobe special investigation, Council recommended that 191 ha of public land be disposed of for agriculture.

Several agricultural research stations are located on, and use, public land: Potato Research Station at Toolangi (60 ha); Vegetable Research Station at Frankston (30 ha); and Dairy Research Institute at Ellinbank (210 ha).

Public land may be used for private agriculture under licence agreements with the government. The licences set conditions of use, such as the stocking rate and licence fee. Most run for 12 months. Grazing licences, the predominant type in Victoria, cover a relatively small proportion of the study area.

Description of agricultural activities

The study area contains a wide variety of agricultural activities ranging from grazing in the north, to dairying in the east and intensive horticulture and poultry production on the fringes of the metropolitan area. Agricultural uses comprised about 70% of the study area. The gross value of agricultural production for the 1988/89 year was \$664M.

Every year the Australian Bureau of Statistics (ABS) surveys agricultural enterprises and collates the resultant data. Table 36 gives some of these statistics for the financial year 1987/88, which are used to describe the major agricultural activities of the study area and to put them in a State context.

Local Government Areas (LGAs) are the smallest units for which the ABS publishes such data. As several LGAs (Kilmore, Seymour and Mansfield), cross the study area, data for the entire LGA are included here, which exaggerates the extent of some activities in the study area.

Australian Bureau of Statistics figures show that between the years 1976 and 1986 the number of agricultural holdings fell by 2608 from 9156 to 6548. A further fall of 834 occurred between 1986 and 1989.

However, as the Bureau excludes small-scale or 'non-commercial' enterprises from its survey, on the rationale that such establishments contribute little to total agricultural production, these figures are a little misleading as the ABS changed its definition over this period. For its survey in 1986/87, it significantly raised the threshold level of determining commercial enterprises (called the Estimated Value of Agricultural Operations). Exclusion of 'hobby farms' and other small enterprises causes the produce records of several minor commodities - often associated with these types of enterprises - to be under-represented.

The apparent increase in the total area of holdings over the last 15 years may also be an artefact of the change of definition. The average size of holdings rose from 90 ha to 202 ha over this period. In the shires of Alexandra, Eltham, Flinders, Hastings, Lillydale, Mornington, and Sherbrooke, the total area of agricultural holdings fell. In all but Alexandra, this can readily be explained by the increase in the use of land for residential purposes that has occurred in shires close to the metropolitan area. There are a number of small sub-commercial holdings that will be contributing to agricultural production but are not included in ABS figures.

Table 36

**AREA AND PROPORTION OF
AGRICULTURAL ESTABLISHMENT BY
LOCAL GOVERNMENT AREA (LGA) -
1988/89**

LGA	Area of establishments with agricultural activity (ha)	Proportion of LGA as agricultural establishments (%)
Alexandra	53 899	24
Bass	41 900	81
Broadford	16 820	29
Buln Buln	40 334	32
Cranbourne	42 304	58
Diamond Valley	444	6
Eltham	3 399	12
Flinders	10 473	32
Hastings	7 617	25
Healesville	5 282	12
Kilmore	21 288	41
Korumburra	49 540	81
Lillydale	15 645	40
Mansfield	91 177	23
Mornington	1 663	18
Narracan	45 528	20
Pakenham	29 220	33
Phillip Island	4 400	44
Seymour	67 152	72
Sherbrooke	1 820	10
Upper Yarra	4 188	3
Warragul	22 116	63
Wonthaggi	2 651	44
Yea	64 295	47

Source : ABS 1989b

Available results for large scale activities with few establishments involved, such as poultry production, are likely to be highly influenced by the number of respondents to the survey.

Distribution of agriculture

Table 36 which shows the area of agricultural activities within each LGA, gives some indication of the extent of agricultural activity within the study area. The proportion of each LGA used for agriculture indicates the extent of commercial agricultural development. Those LGAs with a low proportion of agricultural land have either been developed for urban and 'hobby farm' style uses (such as Diamond Valley, Eltham, and Mornington) or retain extensive native vegetation cover (such as Mansfield and Upper Yarra).

Urban expansion is having an increasing effect on agricultural activities in the study area, particularly in areas on the metropolitan fringe. The increasing demand for urban and rural residential land is forcing land prices upwards and favouring the production of higher value agricultural commodities such as fruit, vegetables and grapes, over the lower value grazing industries. Economic pressures have tended to force commercial farms to get bigger in order to maintain income. The result of this is evident in the increases in average farm size, particularly in the shires of Alexandra, Broadford, Kilmore, and Mansfield.

Table 37 shows how the numbers of cattle, pigs, and poultry in the study area have fallen while sheep numbers and areas of horticultural crops have risen.

The number of hobby farms in the study area is unknown. However, in a recent study of the Western Port region, the Department of Agriculture made an estimate of around 4500.

Unfortunately, present ABS practice of using an estimated value of agricultural operations of \$20 000 as their baseline figure has excluded most hobby farms from the data. This gives a misleading picture of agriculture in many parts of the study area as small hobby farms make a significant contribution to agricultural production.

The beef industry

Beef production is widespread across Victoria, in fact about half of all Victorian farms carry some beef cattle, although many are run in conjunction with other activities. However, the beef industry is concentrated in the study area, specifically the East Central and Central Gippsland statistical divisions. In 1988/89 this contained 349 709 beef cattle, a substantial portion of the State total of 2 037 966. Most of its LGAs have a density 0.5 cattle per hectare. Those with the largest numbers of beef cattle are shown in Table 38.

Beef cattle are one of Victoria's most valuable agricultural commodities; some 37 to 54% of Victorian production is exported annually, mainly to the United States, Japan, United Arab Emirates, and Saudi Arabia. Fluctuations in the value of beef production are frequent and depend to a large extent on

the availability of overseas markets. Beef cattle numbers reached a peak in 1976. This was followed by a collapse in the market and a rapid fall in numbers until 1983, when the market peaked up again. Since then numbers have been increasing slightly (ABS). Declining cattle numbers in the mid 1880s resulted in the closure of several export abattoirs.

Table 37

CHANGES IN STOCK NUMBERS AND AREAS OF CROPS BETWEEN 1976 AND 1986

Item	1976	1986	Change (%)
Dairy cattle	342 904	250 421	- 27
Beef cattle	511 722	388 476	- 24
Sheep	664 104	789 887	+ 18
Pigs	35 198	26 656	- 24
Poultry	N/A	7 222 643	
	(ha)	(ha)	
Hay crops	55 314	53 194	-3.8
Vegetable crops	7 549	9 120	+ 21
Fruit crops	3 370	3 998	+ 19
Vineyards	40	204	+ 410
Nurseries/cut flowers	515	N/A	

Source: ABS 1989b

Beef cattle are generally found throughout the study area, particularly areas further from the city and those favoured with a higher rainfall in the Gippsland area where perennial

pastures allow cattle to be run all-year round. Many sub-commercial or hobby farms run beef cattle and ABS figures are likely to underestimate actual numbers and the importance of the industry to the area.

Family farms, ranging in size from 200 to 500 ha, remain the dominant production unit. Hereford, Angus, and Beef Shorthorn are the most commonly used pure breeds, although there is a growing tendency to use cross-bred animals.

In the shires of Pakenham, Cranbourne, Buln Buln, and Warragul rising land prices have tended to reduce the viability of full-time beef farming. Land previously used for commercial beef production is being subdivided and used for hobby and part-time farming or for more intensive agriculture.

The current outlook for beef is reasonably favourable. Beef cattle numbers tend to vary with market prices and are likely to rise during the coming years given the present downturn in the wool industry.

The dairy industry

Dairying is restricted to the high-rainfall and irrigated pasture areas. Several LGAs in western Gippsland have suitable conditions



Hereford beef cattle

Table 38

BEEF CATTLE: LOCAL GOVERNMENT AREAS (over 15 000 HEAD) - 1988/89

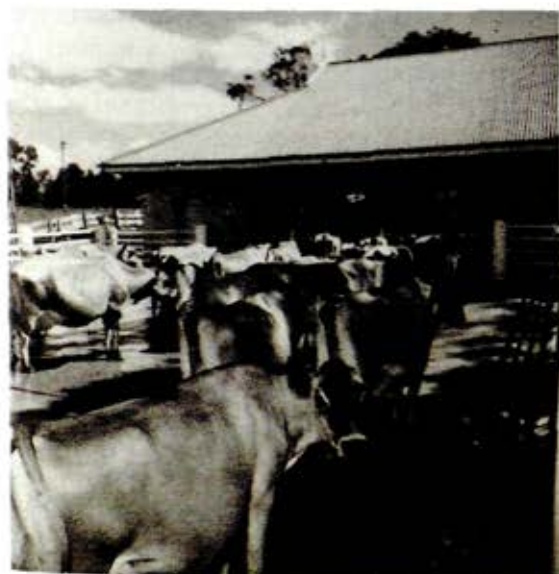
LGA	Number of beef cattle
Alexandra	26 719
Bass	38 433
Buln Buln	24 310
Cranbourne	29 180
Korumburra	42 102
Mansfield	30 883
Narracan	28 162
Pakenham	19 284
Yea	30 566

Source: ABS 1989b

and have high numbers of dairy cattle, as shown in Table 39, which lists seven of the LGAs being examined in the study area. By contrast, 14 have less than 1000 head.

Victoria had 1 435 562 dairy cattle in 1987/88. Of these, 219 362 were in the LGAs wholly or partly in the study area.

Those areas suitable for dairying have high rainfall (more than 750 mm annually) and mild winters, with a growing season of 9-12 months. Perennial ryegrass and white clover predominate in the dairy pastures, which are usually fertilized with phosphorus, potassium, and molybdenum.



Dairy cattle entering milking shed

Herd size and production per cow have been increasing over the last 30 years. Improvements in pasture production and quality, the genetic improvement of herds, and better disease control are cited as the reasons for increased productivity. Most dairy herds comprise Friesians, Jerseys, or crossbreeds involving either or both.

Since the mid 1970s the total number of dairy cattle in the State has suffered a general decline. Nevertheless, dairying remains one of the four major agricultural commodities in the Victorian economy, and contributes significantly to the economy of the study area.

As land prices closer to the metropolitan area continue to rise, dairying will tend to relocate to other areas - further east, the Goulburn Valley and the south-west - where land prices are comparatively lower. The pressure to increase productivity has forced dairy farms to become concentrated in the higher rainfall and irrigation areas.

Table 39

DAIRY CATTLE: LOCAL GOVERNMENT AREAS (over 15 000 HEAD) - 1988/89

LGA	Number of dairy cattle
Bass	24 250
Buln Buln	48 387
Cranbourne	19 468
Korumburra	46 515
Narracan	30 952
Pakenham	15 236
Warragul	25 395

Source: ABS 1989b.

As land prices closer to the metropolitan area continue to rise, dairying will tend to relocate to other areas - further east, the Goulburn Valley and the south-west - where land prices are comparatively lower. The pressure to increase productivity has forced dairy farms to become concentrated in the higher rainfall and irrigation areas.

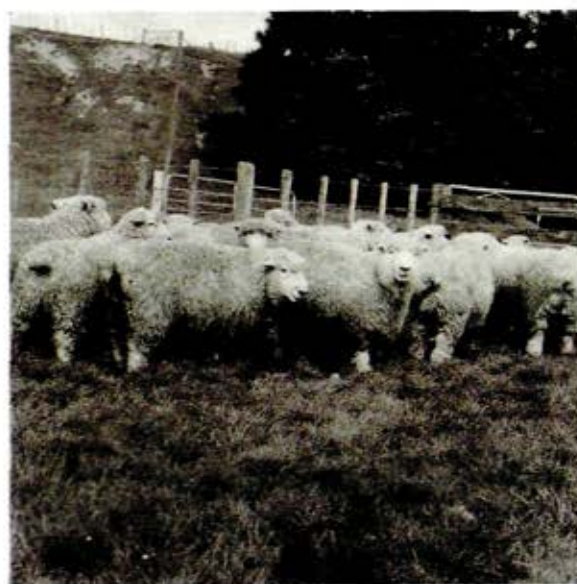
The profitability of dairying in the future will be influenced by any changes to the current milk marketing arrangements. The current

downturn in the industry will see further reduction in farm numbers.

In the future, it is likely that dairying land in the study area, especially that to the west of Warragul will become increasingly used for horticultural production. Dairying will contract to other areas where the trend to increased farm size is expected to continue.

The sheep industry

In 1987/88, the study area contained 943 597 sheep and lambs, which is only a small proportion of the almost 27 million sheep in Victoria. The range of sheep and lamb numbers varies greatly between LGAs. Thirteen LGAs have less than 10 000, while seven have in excess of 50 000. Table 40 lists those shires with over 15 000 sheep and lambs.



Sheep are most numerous in the north of the study area

Most of the sheep in the area are used for fat lamb production. The sheep population rose by 5% over the 10 years to 1989 with increases of 11% in Narracan Shire, 130% in Warragul Shire, and 16% in Yea Shire. That increase was mainly due to rising sheep meat prices which encouraged producers to buy in stock for fattening. If prices for sheep meats fall, the drop in sheep numbers could be equally as rapid. In most cases sheep and beef cattle are run on a single holding with the ratio of sheep/beef cattle varying with relative prices.

The recent fall in the price of wool is likely to result in a drop in the number of sheep run in the area over the next few years.

Production for wool for crafts is becoming popular with hobby farmers in the area although this represents only a small part of the industry. There was a growing interest in carpet wool production in the late 1980s but this has declined because of poor returns.

Table 40

SHEEP AND LAMBS: LOCAL GOVERNMENT AREAS (OVER 15 000 HEAD) - 1988/89

LGA	Number of sheep and lambs
Alexandra	81 588
Bass	36 074
Broadford	52 306
Kilmore	58 206
Korumburra	26 618
Mansfield	186 868
Narracan	56 755
Phillip Island	17 952
Seymour	222 894
Yea	141 691

Source: ABS 1989b

Horticulture

Horticultural production includes vegetable, grape and fruit crops. Most significant in the study area are the pome fruits (apples and pears) and vegetables, notably the potato, the crucifers (cabbage, cauliflower, broccoli, and brussel sprouts), root crops, and a number of other vegetables, berry fruits, and cut flowers.

Vegetable production

Vegetables grown for human consumption covered 8910 ha of agricultural land in 1988/89, a significant portion of the state total of 29 362 ha. Production is relatively widespread, but heavily concentrated in Cranbourne, Narracan and Pakenham Shires, as Table 41 shows.

Potatoes are the most popular crop in the study area, with some 5336 ha sown in 1988/89. This amounted to some 41% of the total area of potatoes sown in Victoria for

that season. Thorpdale, south of Warragul is the second-largest potato-growing zone in the State, while Koo-Wee-Rup, Cranbourne, Kinglake, and Dandenong also have significant plantings. Although the total area planted has declined over a long period, the level of production has continually increased. More than 30% of the Victorian crop is processed into frozen chips and potato crisps, with accompanying by changes in cultivars, more extensive contract growing, and developments in storage and handling.

Table 41

**VEGETABLE PRODUCTION:
SIGNIFICANT LOCAL GOVERNMENT
AREAS - 1988/89**

LGA	Area (ha)
Buln Buln	255
Cranbourne	2839
Flinders	287
Lillydale	373
Narracan	2252
Pakenham	1799
Warragul	303

Source: ABS 1989b

Crucifers are grown in the market gardens of Cranbourne, being close to the Melbourne market. Some exports of broccoli and cauliflower have occurred in recent years.

Carrots and parsnips thrive in the red friable soils of the Dandenongs, which is one of the major production areas, along with Koo-Wee-Rup.

Other important vegetable crops from the region include mushrooms, lettuce, peas, and asparagus. Minor ones are beetroot, leeks, parsley, parsnip, radish, silverbeet, spinach, spring onions, sweet corn, and swedes.

The area planted to vegetables in the district decreased between 1979 and 1989 by 5%. However, there were large increases in the area planted to vegetables in Buln Buln (23%), Flinders (32%), Narracan (39%), and Warragul (50%) shires which reflect a move away from the traditional vegetable growing areas. Cranbourne and Pakenham are still the major vegetable growing areas within the district, providing a wide range of vegetables for local, interstate, and export markets.

Uncertainty relating to possible rezoning of land to residential areas is having detrimental effects on development and productivity of agricultural industries in the important market gardening areas around Cranbourne/Clyde.

The main factor limiting agricultural production in the Cranbourne/Clyde area is the lack of suitable water. There is potential to utilise recycled water to improve production in this area.

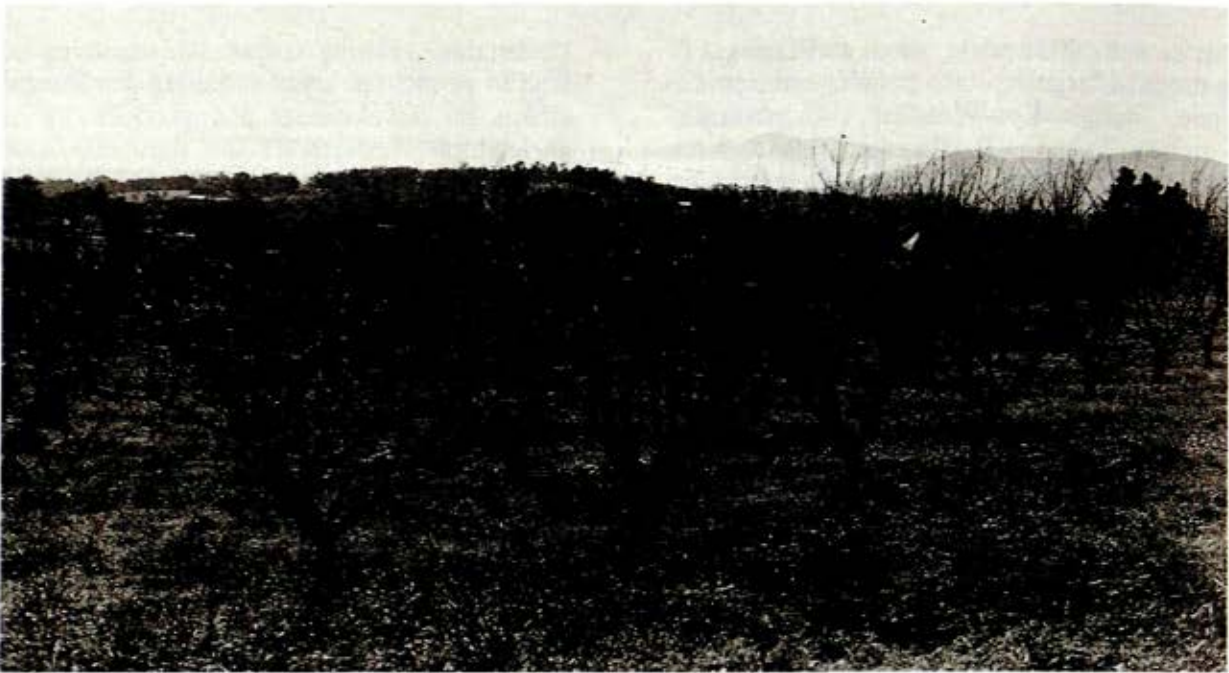
Orchards

In 1987/88, the study area supported 2875 ha of orchards out of a State total of 19 638 ha. Hastings and Lillydale have the largest areas, as shown in Table 42. A large proportion of Victoria's apples come from Pakenham and the Mornington Peninsula.

The area of fruit crops in the district has fallen by 350 ha (11%) over the 10 years from 1979 to 1989. The areas where the major falls occurred were Flinders (56%), Hastings (34%), and Lillydale (12%).

The main fruits grown are applies which constitute over 50% of the area planted to orchard fruits. Total numbers of stonefruit trees (peaches, nectarines, cherries, and plums) in the study area have not changed much between 1979 and 1989. However, the proportions of different fruits have changed, with numbers of peaches and nectarines increasing and cherries and plums decreasing. There has also been a big change in distribution of trees throughout the study area with trees appearing in Alexandra, Bass, Buln Buln, Narracan, and Warragul where previously they had not been recorded. Decreases in the numbers of cherry and plum trees occurred mainly in Lillydale Shire.

Berryfruits and kiwifruit occupy relatively small areas within the districts, but make an important contribution to the total Victorian production. Vineyards have increased from 68 ha in Lillydale and Healesville in 1979 to 257 ha spread throughout the district in 1989. Most of the grapes produced are used for wine production both within and outside the district. A number of small wineries producing quality varietal wines have been established in the Yarra Valley in recent years.



An orchard in the Shire of Lillydale

The main changes in fruit growing in the future are likely to be the relocation of growers from some of the traditional fruit growing areas to areas further from Melbourne, and further increases in the areas planted to vines and berry and kiwifruit. Production of some berry and kiwifruit will increase as existing plantings reach maturity.

Intensive Animal Production

Poultry

Victoria's poultry farms produce eggs and meat. Approximately two-thirds of the meat production occurs in the study area. It is

concentrated in a few locations, mostly Cranbourne, Flinders, Hastings, Healesville, Mornington, and Pakenham shires (see Table 43), with very little in the remainder. There has been a significant increase in the number of birds produced in the study area over the past three years. Egg production is more widespread.

Table 42
ORCHARDS: SIGNIFICANT LOCAL GOVERNMENT AREAS (OVER 100 HA) - 1988/89

LGA	Area of orchards (ha)
Eltham	111
Flinders	206
Hastings	625
Lillydale	859
Pakenham	410
Sherbrooke	315
Upper Yarra	159

Source: ABS 1989b

Table 43
POULTRY-MEAT PRODUCTION: LOCAL GOVERNMENT AREAS (OVER 5000 BIRDS) - 1988/89

LGA	Number of birds in flock
Alexandra	450 000
Cranbourne	7 137 461
Flinders	4 789 054
Hastings	7 397 967
Healesville	925 000
Lillydale	2 124 979
Mornington	1 176 507
Pakenham	1 638 300

Source: ABS 1989b

Transport economics have drawn chicken-meat producers close to Melbourne in order to minimise the distance to feed, processing, and markets. A few very large firms with considerable vertical integration dominate the market, which has exhibited increasing demand over the 1980s.

Many shires have egg-producing flocks, ranging in size from a few dozen to more than 300 000 birds; Table 44 lists those with the largest numbers of birds, which tend to be closer to Melbourne, but the industry is not tied to processing factories as are the chicken-meat producers. One-third of Victoria's egg production occurs in the study area.

Table 44

EGG PRODUCTION POULTRY: LOCAL GOVERNMENT AREAS (FLOCKS EXCEEDING 10 000 BIRDS) - 1988/89

LGA	Number of birds
Cranbourne	356 457
Diamond Valley	41 600
Eltham	51 090
Flinders	14 000
Hastings	81 158
Healesville	41 982
Kilmore	62 510
Lillydale	89 745
Mornington	71 690
Pakenham	28 395
Sherbrooke	91 760
Warragul	75 957
Yea	75 000

Source: ABS 1989b

Pigs

Only 27 376 pigs were kept in the study area in 1988/89, a small portion of the 422 538 kept State-wide. Lillydale had the largest total of those shires holding in excess of 12 000 animals; other significant numbers were in Narracan (5566), Diamond Valley (3417), and Eltham (1589) (ABS 1989a,b).

Pig numbers in the district have been declining as piggeries are being developed in areas around Bendigo which are closer to the major crop growing areas that provide feed. The number is likely to continue to fall due to incompatibility with surrounding land uses, and the disadvantages of being remote from grain growing areas.

Apiculture

Although apiculture is a relatively minor agricultural industry in the study area and indeed in Victoria, a detailed description is

given here in view of the fact that it is the major agricultural use of public land in the study area.

Victoria has approximately 2600 registered beekeepers. These include 111 commercial operators averaging 400–800 hives, which produced 3107 tonnes of honey and 52 tonnes of beeswax in 1987/88 from the total of 58 948 hives.

Annual production can vary considerably; between 1982 and 1986 (for which comparable results are available) it ranged from 2705 to 5388 tonnes. Recent changes to the ABS analysis of data have resulted in an understatement of total honey production.

Honey is the major product of the industry, and approximately half of it is exported, principally to the United Kingdom, but also to Germany, United States, Spain, Singapore, and Portugal (AHB 1989). Significant minor products include beeswax, pollen, and royal jelly.

Products of the Victorian industry are worth more than \$8M annually. In addition, the value of pollination of agricultural crops by bees has been estimated at \$70M. This compares with the gross value of agricultural production of the study area of \$664M in 1988/89.

Apiarists use the exotic bee *Apis mellifera*, and depend on eucalypt forests as the predominant source of honey.

Commercial beekeeping is migratory, as keepers move hives to different locations in pursuit of nectar availability and honey quality. Apiarists may transport hives several hundred kilometres, especially to 'overwintering' sites in northern Victoria.

Industry has estimated that an average commercial operator in Victoria regards 800 ha as an economically efficient foraging area, and will occupy 20 such occasional sites annually, thus utilising a total area of 16 000 ha per annum. October to March is the most productive season, during which some 70% of the total honey crop is harvested.

Since 1973 there has been a steady increase in plantings of berryfruits and kiwifruit within the study area. These crops and

traditional horticultural crops (apples, cherries, plums, and pumpkins) require bee pollination. Several thousand colonies are leased for pollination, with fees of \$25 per hive being typical. It is expected that this trend will combine with increasing demand for bees for pollination.

Beekeeping is often restricted by local governments in rural residential areas where lot sizes are smaller than 4 ha. Thus the increase in this kind of land use in the study area is decreasing the area of land available to commercial apiarists.

Beekeeping in the study area

The study area is considered of medium significance to Victorian apiculture. The area has seen more use by commercial apiarists since the last report. Remnant stands of native forest are utilised by commercial apiarists migrating from outside the area from time to time. Three commercial apiarists regularly utilise flora in the Mansfield Shire particularly *E. delicatessens*, *E. obliqua*, *E. globulus* and the white gums for honey production.



An apiary site in use by a commercial operator

The Healesville Shire has significant stands of *E. regnans* and *E. delicatessens* which provide significant crops of honey for up to five commercial apiarists approximately every five years. Other shires with these species are also used when flowering is heavy.

The south-eastern Shires are utilised for the production of clover honey, and some hive building is done on various teatree species in this area.

It is estimated that the area would produce approximately 400 tonnes of honey in favourable seasons, with an approximate value of \$0.5M.

While the study area is of medium significance for commercial apiculture, it has a high density of hobbyist and sideline beekeepers. About 25% of the State's beekeepers live in the study area, and own 10% of the total beehive numbers. Table 45 presents a shire breakdown of the number of beekeepers living in the study area.

Table 45
NUMBER OF BEEKEEPERS AND HIVES
IN THE STUDY AREA

Shire	Number of beekeepers	Number of hives
Seymour	13	832
Broadford	14	688
Yea	9	501
Alexandra	14	288
Mansfield	10	140
Kilmore	2	24
Whittlesea	36	464
Eltham	72	1853
Healesville	17	154
Upper Yarra	23	378
Narracan	40	633
Buln Buln	38	491
Pakenham	24	737
Sherbrooke	79	792
Lillydale	74	1892
Warragul	9	62
Moe	19	301
Korumburra	13	232
Bass	3	141
Wonthaggi	2	100
Phillip Island	2	3
Hastings	17	207
Flinders	32	637
Mornington	5	34
Diamond Valley	25	603

Source: Department of Agriculture
beekeeper registration list

Use of public land

The industry considers continued access to public land essential for its continued commercial viability. Public land contains the bulk of Victoria's melliferous flora, including most eucalypt forests, although agricultural lands do provide some important food sources.

Apiary is currently only excluded from reference areas in order to maintain ecosystems in natural conditions. However, wilderness areas also effectively exclude apiary as motor vehicles are prohibited, including those used to transport hives. Conservation reserves have apiary as a permitted use where it is an established practice.

Apiarists require licences to occupy sites on public land. These sites are usually clearings used to accommodate 100 hives and are in close proximity to water (AHB 1989). Licences are either permanent (issued annually, but permanently available) or temporary (issued for 3 or 6 months). Exclusive apiary use is allowed within a radius of approximately 1.6 km of the site. Apiarists often have a number of sites across a region to provide both flexibility and security in response to variations in the quality and quantity of flowering at a particular site.

Environmental issues

Australia has a large native bee fauna, with some 3000 native species, many of which have yet to be scientifically described. Current knowledge of individual species life cycles, and their function in forest ecosystems, is poorly developed.

A great majority of the native bees are solitary and Australia is the only continent where bees largely depend on a single family of plants, the Myrtaceae. Native bees vary in the specificity of the flowers on which they feed.

Escaped commercial bees over the 150 years since introduction to Australia have formed feral populations, nesting in hollow trees and other suitable sites.

Concern has arisen about the possible harmful environmental impacts of the honey

bee on native flora and fauna. Until we have an adequate body of research dealing specifically with these issues, the environmental effects of the honey bee will remain contentious. Much of the current debate covers the applicability of the available research results to different conditions and the interpretation of the results, notably in relation to feral populations and commercial operations, the number of hives and different levels of nectar availability, and the scale, range and timing of effects. The following key issues have been raised to date.

- * Competition with the honey bee may lead to reduction of the available nectar to native species, and displacement of those species. Research to date has described the honey bees competition with native bees, beetles, and honeyeater species for nectar.
- * Aggression from honey bees may displace native fauna species.
- * Pollination by the honey bee of native plant species may be inefficient due to several factors. These include damage to native flowers when extracting nectar, avoidance of contact with anthers, and concentration of foraging on individual plants rather than spreading it across several plants. This may cause a failure or reduction in pollination and seed-set.
- * Increased hybridisation between related native plant species could result from the wide range of flowers that attract the honey bee. Native pollinators may be more species-specific, and cause only limited hybridisation.
- * Competition between honey bees and native fauna for nesting sites may displace birds and mammals from tree hollows. Displacement of hollow-nesting birds by feral honey bees has been observed, and the use of hollows by bees may also displace hollow-dependent mammals.

Issues in Agricultural Production

This section identifies and briefly describes a few of the key agricultural issues. The issues are of environmental significance and may

have an impact on public land, water resources, flora, and fauna, as well as currently or potentially affecting agricultural production, which may influence commercial agricultural viability.

Agricultural chemicals

Chemicals have a broad spectrum of uses on Victorian farms. Agricultural chemicals include biocides (insecticides, herbicides, fungicides), fertilisers, growth promotants, stock pharmaceuticals, ripening agents, disinfectants, and numerous others. As an industry, agriculture currently relies on these to lower production costs, reduce production loss and/or increase production, and increase product quality. Horticulture, an important activity in the study area, involves high fertiliser and biocide applications.

Controversy now surrounds agricultural chemical use, and farmers, conservationists, industry groups, and government agencies are now addressing many key issues (Cribb 1990).

Contamination appears to be the major issue at present. Chemical applications may not be confined to the site or ecological component initially exposed to them, but air, surface and groundwaters, soils, flora, and fauna may be contaminated. Agriculture has been frequently cited as a source of environmental damage from chemical use, although many environmental consequences were unknown or unforeseen at the time of such use.

Residues of persistent chemicals in agricultural produce concern because of their implications for human health, and their effects on marketing produce. For example, in 1987 Australia's \$2 billion beef export trade to the United States was threatened by the detection of chemical residues, notably dieldrin and DDT. Bioaccumulation in natural ecosystems, magnification of residues in food chains, and uncertainty about the fate and the effects of many chemicals have contributed to community concern.

Responses to this concern have taken many forms. Bans have been placed on several chemicals, such as DDT, dieldrin, and arsenic sheep dip. More than 40 active constituents have either total or limited prohibition applying to their sale or use in Victoria (Matthews 1987).

Regular monitoring for residues in agricultural produce is carried out by the Department of Agriculture and Rural Affairs. Properties and produce with chemical residue contamination have been identified and, in many cases, successful management practices have greatly reduced on-farm problems.

Current trends in chemical use are worth noting. Pesticides have traditionally been used for horticulture and intensive agriculture, but reduced-and minimum-cropping systems will lead to a significant increase in total area receiving applications. Research into the impact of pesticides on soil has been minor to date, but in future it needs to examine the effects on soil fauna and flora (Swarbrick 1986). Changes in consumer preferences appear to be increasing the demand for 'organic' produce - that is, grown with few or minimal agricultural chemical additives.

In response to mounting community concern about the use of chemicals in food production systems, the Department of Agriculture recently introduced its 'Cleaner Agriculture' program in 1989.

As well as encouraging a more responsible attitude to the use of agricultural chemicals, the program encourages the adoption of integrated pest management systems. Such systems involve the use of improved crop and animal husbandry methods which reduce the need for agricultural chemicals.

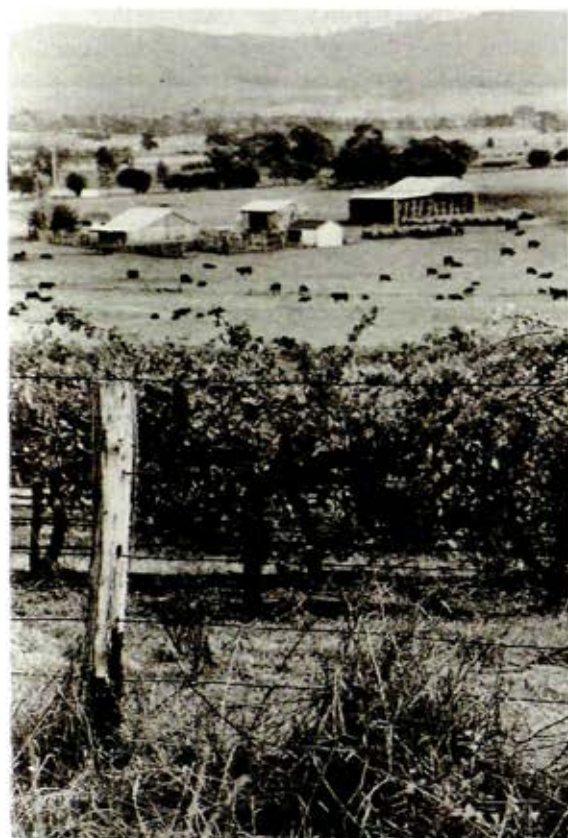
Effect of subcommercial farms on agricultural productivity

As more agricultural land close to Melbourne is subdivided into residential blocks and hobby farms, the influence of subcommercial farmers on agricultural production and productivity will become more important.

Wills (1983) surveyed land in the shires of Lillydale and Kilmore to determine the changes in ownership, land use, and farming activities occurring between 1974 and 1978, particularly in relation to the effect of part-time farming on agricultural productivity. Both these shires fall within the study area and the trends observed by Wills are likely to be similar within other shires on the metropolitan fringe.

During the 4 years between 1974 and 1978, Wills found decreases in the numbers of full-time farmers and in land used by them, and a corresponding increase in part-time farmers. There was very little change in the percentage of the sample area devoted to agriculture, and full-time farmers or farming companies still occupied most of the agricultural land. Because part-time farming accounted for only 12% of the survey area in Kilmore and 11% in Lillydale in 1978, the direct effect on rural land use is not great.

The main land use on part-time farms in 1978 was raising beef cattle, followed by running horses. There has been a dramatic increase in the area of vineyards since then, and it is likely that many of these are run as part-time or retirement operations, although beef is probably still the most common land use on part-time farms.



Vineyards and mixed farming in the Yarra Valley

Part-time farmers were generally found to be in farming for lifestyle/recreation/retirement reasons rather than financial reasons. During the study period, particularly as a result of depressed beef prices, part-time farms were not found to be profitable. However, the

advantage of using farm losses as tax deductions against off-farm income was recognised. The results of the survey indicated that productivity per hectare was not significantly less on part-time farms than on full-time farms, although per worker it was much lower.

Most of the community benefits of rural land such as scenery, native flora and fauna and pollution absorption are more closely related to the size of that land rather than the number of holdings on the land. It is only when rural land is subdivided into small blocks, e.g. less than 5 ha, that houses tend to dominate the landscape and the expense of returning the land to farming becomes prohibitive.

In the future, land in the Melbourne Area, District 2 will become increasingly devoted to rural residential and hobby farm use. The Department of Agriculture encourages the retention of prime quality agricultural land for agricultural use.

Genetic engineering

The benefits to agriculture of recent advances in biochemistry include the products of 'genetic engineering'. This involves the transfer of genetic material (piece of DNA) from one organism to another, and the offspring may inherit the genetic change. Work has progressed in Australia for over 10 years. In 1987 the first genetically engineered organism was released here - a bacterium to control crown-gall disease in fruit trees.

Genetic engineering has many potential uses in agriculture and research is under way in many fields. Agricultural applications include sprays for pests, disease, and frost damage, vaccines for stock, detergents to clear up toxic chemicals, and, importantly, plants and animals with greater productivity and health.

Biological control - the use of introduced organisms to control pest, plants, or animals - has been undertaken in many forms for much of this century. Genetic engineering adds considerably to its potential. Australia has experienced severe environmental problems resulting from attempts at biological control, such as the introduction of the cane toad, which highlighted the need for careful research prior to the release of

introduced species. Conversely, genetically engineered species may be more fragile and less able to survive than natural species. Generally speaking, results from research into biological control methods have often been very disappointing.

Environmental concern has arisen about genetic engineering (Phelps 1989), relating to the release of genetically engineered species into the natural environment. Designed to survive and multiply, some genetically engineered species carry an inherent risk that they will have harmful environmental effects in the same manner as introduced species such as the rabbit, European carp, and blackberry. It has proved difficult to predict the effects of known organisms in the environment, so predicting the effects of unknown ones will be more difficult (LRCV 1989).

At present, no federal or State legislation, or regulatory authority, specifically relates to the release of genetically altered organisms, although most releases will come within the responsibilities of a federal or State government agency.

As the results of genetic engineering become more widely applied in agriculture, the associated health, environmental, legal, and economic issues are likely to become more complex and widespread.

Soil loss

Erosion is considered the major soil-degradation problem in the study area, while salinity and other problems are less widespread. Soil compaction, from the effects of stock may be affecting soil structure in some areas. Water erosion is described in the Chapter 19.

Soil loss is now regarded as a major agricultural issue. For example, the Australian Conservation Foundation and the National Farmers Federation presented a joint submission for a national land management program to the federal government in 1989. In the past considerable funds have been spent on local and regional works focused on sites of high erosion.

Agricultural activities have caused accelerated soil losses. As soil provides the medium for nearly all agricultural production, loss of it through erosion reduces

productive capability. Edwards (1988) suggested that the major criterion for determining whether too much of a soil was being lost was the ability of that the soil sustain present levels of productivity in perpetuity. Erosion can have serious off-site effects - through lowering water quality and damaging water-course bed and banks, associated flora and fauna, and property such as roads (Chittleborough 1986).

If sustainable long-term production is desirable, then the balance between soil loss and soil formation (including deposition from upslope) is of concern. Degradation results from erosion exceeding formation and deposition. Thinning of the soil profile causes diminution of plant nutrients and plant-available water (Beckmann and Coventry 1987).

Rates of soil formation are difficult to define, and overseas research has proved to have limited applicability to Australian soils. Natural rates of soil formation are usually established by measuring soil loss from undisturbed sites, but Sargeant (1990) notes that these rates apply to uplands where weathered rock forms the soil material.

As soil has either ceased to form or is forming at an extremely low rate, it can be regarded as a non-renewable resource with a finite lifetime. Weathering of hills and accumulation on alluvial flats illustrate one landscape where soil forms at a natural rate, albeit an almost negligible one.

Agricultural land uses accelerate the natural rates of erosion through clearing, vegetation changes, and stock grazing. Cultivation is a major cause of erosion; the rate of soil loss can exceed 30 times the normal rate (Neil and Fogarty 1990).

Erosion in relatively undisturbed areas may occur at much the same level as soil formation, but under more intense land use its rate may exceed that of formation by one or two orders of magnitude.

Current soil losses exceed the level of natural replenishment for much agricultural land, although it will take at least another 1000 years for the resource to be exhausted. Balancing production against the need to greatly reduce soil loss is a challenge the agricultural industry must meet in order to

protect its long-term viability and the related environmental values.

References

- Australian Bureau of Statistics (1989a). *Victorian Year Book* 1989.
- Australian Bureau of Statistics (1989b). *Agricultural Census* 1987-88.
- Australian Honey Board (1989). Honey industry. In 'Australian Agriculture: the Complete Reference on Rural Industry', ed. J. Cribb, Vol. 2, pp.181-7. (National Farmers Federation: Melbourne.)
- Beckmann, G.G., and Coventry, R.J. (1987). Soil erosion losses: Squandered withdrawals from a diminishing account. *Search* 18(1): 21-6.
- Chittleborough, D.J. (1986). Erosion and pollution. In 'Australian Soils: The Human Impact', J.S. Russell and R.F. Isbell. (University of Queensland Press: St Lucia.)
- Connor, D.J., and Smith, D.F. (eds) (1987). 'Agriculture in Victoria.' (Australian Institute of Agricultural Science: Melbourne.)
- Cribb, J. (1990). Farm chemicals: the marketing issue of the 90s. *Australian Rural Times*, Jan 18, 14-15.
- Edwards, K. (1988). How much soil loss is acceptable? *Search* 19(3):136-40.
- Land Conservation Council (1977). Melbourne Study Area - Final Recommendations. (Victorian Government Printing Office: Melbourne.)
- Land Conservation Council (1987). 'Latrobe Valley Special Investigation - Final Recommendations'. (Victorian Government Printing Office: Melbourne.)
- Land Conservation Council (1990). 'Wilderness Special Investigation.' (Victorian Government Printing Office: Melbourne.)
- Law Reform Commission of Victoria (1989). Genetic manipulation. *Land Reform Commission of Victoria Report* No. 26.
- Matthews, D. (1987). What is this prohibition anyway? *Rural Quarterly*, (6)4:5-7.
- Neil, D.T., and Fogarty, P.J. (1990). Land use and sediment yield on the Southern Tablelands of New South Wales. *Proceedings, ANZAAS Conference, Hobart*.
- Phelps, B. (1989). The genetic engineering debate. *Search* 20(3):77-81.
- Sargeant, I. (1990). Soils in southeast Australia - lifetimes of the endowment. *Search* 21(3):99-101.
- Swarbrick, J.T. (1986). Pesticides. In 'Australian Soils: the Human Impact,' ed. J.S. Russell and R.F. Isbell. (University of Queensland Press: St Lucia.)
- Wills, I.R. (1983). Changes in rural land use and part-time farming, Central Victoria 1974-1978. *Review of Marketing and Agricultural Economics* 51(2):109-130.



Tall timber at Neerim around the turn of the century

15. TIMBER PRODUCTION

Hardwood Production

Eucalypt forests cover most of the public land in the study area. Utilised for timber production since the earliest days of European settlement, they continue to provide timber and timber products. This section outlines the history of timber production within these forests, forest types, the current availability of forests for timber production, the quantity of timber available, native forest management, as well as the industry it supports and its products.

History

The more accessible forests near Melbourne provided building materials and firewood for the growing city in the 19th century. Gold discoveries in the 1850s vastly increased the timber demand but, because most gold-mining activity occurred elsewhere, forests in the study area remained relatively unaffected. Notable exceptions are those at Walhalla, Healesville, Toolangi, and Warburton, where large areas of forest were clearfelled and used for fuel, building materials, and mining timbers.

Timber provided split palings and shingles from the earliest days of settlement, but sawn-timber uses were restricted by seasoning problems. By 1910 seasoning techniques had been developed and sawmills, associated settlements, and tramways for transporting sawlogs were established, firstly in the Yarra Valley near Warburton, and soon after in the La Trobe and Thomson Valleys (Anon 1974). Those tramways remaining after the 1939 fires fell into disrepair from the 1940s and some of them have become popular walking tracks. Settlements and tramways were also established at Mt Disappointment, Yea, and Goulburn.

Inadequate and unsafe water supplies in early Melbourne necessitated official action in securing a water supply for the city. Those water supply catchments near Melbourne first selected were also used for agricultural production, and the quality of this untreated water soon fell. Restricted access and land-use policies were subsequently applied to a number of catchments specifically

designated for water supply and vested in, or leased to, the Board of Works (see Chapter 17).

Prior to the development and application of regeneration techniques suitable for eucalypts, logging was selective and trees and logs considered to be low quality for sawn timber were usually left. Investigations subsequently proved that low-quality eucalypt logs were suitable for paper-making, and in 1936 Australian Paper Manufacturers Ltd entered into an agreement with the government to obtain pulpwood from both foothill and mountain forests within a region that includes much of the study area. This agreement was ratified by Act of Parliament and has been revised several times, most recently in 1984. Harvesting pulpwood in conjunction with sawlog-harvesting operations has therefore been a feature of forests in the study area for more than 50 years.

The fire history of the mountain forests here had a critical influence on the development of the hardwood sawmilling industry in Victoria. In 1926, large tracts in the Acheron Valley and south of the Yarra, extending to Toorongo, Toolangi, and Noojee, were burned by wildfire. Black Friday 1939 devastated the forests; most were severely burnt. Between them, the 1926 and 1939 fires killed and regenerated most of the mountain forest in the study area. More recently, in 1983, 17 600 ha of mountain forest in the Upper Yarra Valley were burned. Also burnt were Mt Disappointment and parts of the Black Range.

World War II resulted in increased demand for timber, which accelerated in the post-war boom in housing construction. Salvage of sawlogs from 1939-fire-killed trees largely provided Victoria's requirements for sawn hardwood timber until the early 1950s, when the older trees had deteriorated and the harvesting operations would have caused unacceptable damage to the developing regrowth. As a result, the timber industry in the study area was scaled down. Access to timber resources in the east and north-east of the State led to the development of sawmills in those areas.

The extensive eucalypt forests within the study area are characterised by relatively small tracts of old-growth mountain forests, and large regrowth stands that date from 1939. Significant but considerably smaller areas date from 1926 and 1983, and there are some other very small areas of mountain forest of other ages.

As the timber industry in other parts of the State (for example, East Gippsland) reduces the volume of timber it harvests annually so that sustainable yields can be achieved, the forests within the study area will become increasingly important for timber production in the next 20 years, as the 1939 regrowth forests approach an age optimal for harvesting.

Forest Types

Differences in climate, landform, and fire history have resulted in a wide range of forest types being represented in the study area. A full description of plant com-

munities appears in the chapter on flora, but, in terms of hardwood production, five important forest types are present: mountain ash, alpine ash, shining gum, mountain mixed-species, and foothill mixed-species.

Table 46 shows the extent of each major forest type, by age class. Regrowth forests (primarily from the 1939 fires) account for the bulk of mountain ash, alpine ash, and shining gum forests. Some of those classified as 'mature/overmature' have high conservation value, an issue discussed in Chapter 20.

Significantly, foothill mixed-species forests are the most extensive type, accounting for more than half the total forest area. As explained below, age class determines the suitability and productivity of forests for commercial timber production, and age-classes are critical in the future harvesting of these forests. Boland *et al.* (1984) have described individual species.

Table 46

TOTAL FOREST AREA BY FOREST TYPE AND AGE CLASS

Forest type	Area (ha)			
	Mature/overmature	Pre-1940 regrowth	Post-1940 regrowth	Total
Mountain ash	27 060	92 531	13 727	133 318
Alpine ash	5 234	34 180	4 353	43 767
Shining gum	579	3 370	13	3 962
Mountain mixed-species	33 677	6 251	2 021	41 949
Foothill mixed-species	320 092	42 121	36 848	399 061
Other	28 179	2 143	-	30 322
Total	414 821	180 596	56 962	652 379

Source: DCE HARIS Database

Mountain ash and alpine ash have an attractive appearance to their timber, low incidence of defect, and relatively low density make them among the most important commercial timber species in Australia. Shining gum is also very productive, but covering a small portion of the study area. Mountain mixed-species forests can also produce good-quality sawlogs, while foothill mixed-species forests, which grow at lower elevations than the four other forest types, have lower productivity. Nonetheless, foothill mixed-species forests can produce timber suitable for sawlogs, as well as other timber products.

Mountain ash

One of the world's tallest trees, mountain ash (*Eucalyptus regnans*) is exceeded in height only by the giant redwoods of California. Average mature height ranges from 55 to 75 m, although trees more than 100 m have been recorded. Mature trees have a diameter of about 2.5 m, with a straight, unbranched trunk commonly two-thirds or more of the tree height.

The species grows at altitudes between 150 and 1100 m, where summers are cool and frosts and snowfalls may occur in winter.

The study area contains 133 320 ha of mountain ash forests, of which 106 260 ha comprise regrowth forest, mostly originating from the bushfires of 1939. It is an important tree species for the timber industry, because of its good form and variety of uses - including engineering, building construction, and specialty uses such as furniture and architraves - and it is considered the best of the eucalypts for pulp and paper.

Alpine ash

Also a very tall tree, alpine ash (*E. delegatensis*) usually grows 25 to 80 m in height, and occasionally up to 90 m. Diameters of old growth range between 1 and 2 m, mostly with straight trunks and medium-sized crowns. With senescence, trees may develop to be more open with large branches and widespread crowns. 'Old growth' trees are uncommon in the study area; most are regrowth with diameters under one metre.



Ash species forest

The species grows at altitudes between 900 and 1500 m, where summers are cool and frosts and snowfalls are common in winter.

The study area contains 43 770 ha of alpine ash forest, including 38 530 ha of regrowth forest, mostly originating from the bushfires of 1939. Alpine ash is the main commercial species for the timber industry in the cooler, high-altitude regions of Victoria, and has a variety of uses. A wood commonly used for building and house-framing and mouldings, it is also used for furniture, veneer, and pulp and paper.

Shining gum

This is another tall to very tall tree, usually 40 to 70 m in height. Mature shining gum (*E. nitens*) has a diameter of 1 to 2 m, with a straight trunk that may be up to two-thirds of the tree height, and a moderate-sized crown.

It has an optimum altitude of 1000 to 1300 m, although it may grow at elevations as low as 600 m. Of the 3960 ha of shining gum forests in the study area, 3380 ha are regrowth forest, mostly from the 1939 bushfires. The species produces wood used principally for general building construction. It is also a significant plantation species.

Mountain mixed-species

These forests include the commercial species messmate stringybark (*E. obliqua*) and mountain grey gum (*E. cypellocarpa*), either in pure stands or in a mixture and possibly including candlebark gum (*E. rubida*) and manna gum (*E. viminalis*). Stand height generally exceeds 40 m.

The forests grow at elevations above 450 m, and occupy 41 950 ha of land in the study area. Although not as productive as the ash forests, they provide an important resource for the timber industry, and is used for building and house construction and for pulp and paper manufacture.

Foothill mixed-species

Forests of this type usually consist of manna gum, messmate stringybark, and mountain grey gum, in association with some or all of the following species: candlebark gum, silvertop ash (*E. sieberi*), narrow-leaved peppermint (*E. radiata*), broad-leaved peppermint (*E. dives*), and swamp gum (*E. ovata*). These forests generally have a stand height greater than 28 m.

They cover almost 400 000 ha of public land in the study area, most of which carries mature forest. Foothill mixed-species forests have lower productivity rates than the mountain type, but they are suitable for sawlog production, as well as for pulp and paper and minor produce such as fenceposts, poles, and firewood.

Current availability of timber resources

Assessing timber resources available from the total forest necessitates the identification of those areas both suitable for commer-

cial harvesting and available for such activities.

A summary of the forest resources, by area, for each of the major land-use categories is given in Table 47. Of the net productive area, 75% is State forest, with 11% in parks and reserves and 10% in the protected catchments of the Board of Works. Within the 457 327 ha of State forest in the study area, 27% is not suitable for sawlog production and a further 17% is excluded by prescription, leaving 56% (257 432 ha) both available and suitable for sawlog production.

Table 47
FOREST AREAS BY MAJOR LAND-USE CATEGORIES

Category	Definition	Land-use categories (ha)			
		Entire study area	State forest	Parks and reserves	Board of Works catchments
Total forest area	Total area covered by forest (i.e. predominantly single-stemmed vegetation in excess of 5 m high, with tree crown coverage over 30% of the land area).	652 379	457 327	123 112	71 940
Gross productive area	Forests capable of producing merchantable timber (i.e. unsuitable forest types and those under 28 m high excluded).	453 101	334 222	52 173	66 706
Net productive area	Forests available and suitable for timber production (i.e. unavailable land uses and unsuitable sites excluded).	345 584	257 432	37 353	35 419

Source: DCE HARIS database

Commercial timber-harvesting requires forests of sufficient productivity in timber resources, so that all forests are not suitable. Several factors cause forest to be considered as 'unproductive' for commercial exploitation. An area may not carry an adequate volume of timber, or be unsuitable as the result of its stand age, species present, or condition. Included are areas cleared for pine plantations but subsequently not developed. 'Unproductive' areas may cover high-quality sites that have the potential to reach the required productivity.

Gross Productive Area is the total area of forest capable of producing timber resources. Within the study area it is just over 453 000 ha, comprising 70% of the total forests. Table 48 gives Gross Productive Area for each forest type and age class.

Land-use recommendations determine the forest areas available for timber-harvesting. Commercial harvesting is permitted within areas designated as State forest. In its Final Recommendations for the Melbourne Study Area (LCC 1977), and subsequently

Table 48

**GROSS PRODUCTIVE AREA OF HARDWOOD FOREST BY FOREST
TYPE AND AGE CLASS**

Forest type	Area (ha)			Total
	Mature/overmature	Pre-1940 regrowth	Post-1940 regrowth	
Mountain ash	24 561	88 414	13 719	126 694
Alpine ash	3 572	32 612	4 353	40 537
Shining gum	579	3 232	13	3 824
Mountain mixed-species	27 773	6 015	1 958	35 746
Foothill mixed-species	168 537	39 862	33 304	241 703
Other	2 454	2 143	-	4 597
Total	277 476	172 278	53 347	453 101

Source: DCE HARIS Database

approved by the government, Council made a number of forest areas available for commercial harvesting, listed in Table 49.

Timber is also harvested from some State forest that Council's recommendations classified as 'uncommitted'. Under the Council's land-use recommendations and subsequent land management prescriptions, commercial timber-harvesting is not permitted in:

- * reference areas
- * national, State, and regional parks
- * flora reserves
- * wildlife reserves
- * education areas

Commercial harvesting is not undertaken in the protected water supply catchments under the Board of Works' control. Estimates of the timber resources within these catchments are provided in Chapter 20.

Within the forests available for timber production, portions are excluded from harvesting due to unsuitable site characteristics or management prescription. The Code of Forest Practices (described below), developed by the Department of Conservation and Environment and approved by Parliament, has established guidelines to protect a range of values. These involve the exclusion of harvesting from some forest areas: unproductive areas; those too small for commercial operations; those identified in Forest Management Area prescriptions

relevant to local requirements; and those required by government policy - for example, Flora and Fauna Guarantee, and Rainforest Policy. Once all exclusion zones are removed, the remaining available forest, suitable for commercial timber production is the **Net Productive Area**.

Table 49

**PUBLIC LAND AVAILABLE FOR
TIMBER PRODUCTION**

Recommendation		Area (ha)
State forest		
E4	Tallarook	4 900
E5	Mt Disappointment	16 000
E6	Toolangi	9 000
E7	Murrindindi	16 400
E8	Black Range	7 200
E9	Marysville	22 300
E10	Rubicon	31 800
E11	Big River	36 200
E12	Thomson	45 600
E13	Tarago-LaTrobe	46 000
E14	Neerim East	9 200
E15	Tanjil-Tyers	33 400
E16	Boola Boola	18 000
Yarra Valley Multi-purpose Park		
A29-4.3	Recreation and hardwood	25 012
A29-4.4	Intensive hardwood production	17 072
A29-4.7	Scenic landscape	62 278

Source: LCC (1977)

Net Productive Area within Melbourne District 2 currently totals 257 430 ha, some 40% of the total forest. Table 50 shows it by forest type and age class. There is comparatively little ash forest, in relation to the foothill mixed-species in the 'mature/overmature' age class.

Available timber resource

The 257 430 ha suitable and currently available for harvesting are estimated to contain 12 791 100 cu.m of sawlogs of grade C or better. Sawlogs are produced from trees that are relatively free from defect (such as hollows, limbs, brown rot, and insect attack) and are converted into sawn-timber products.

In addition, the forest can provide 'residual roundwood' from the merchantable portions of trees harvested in conjunction with sawlog operations. This is used for lower-grade sawlogs and pulp products such as paper and hardboard, as well as poles and posts, garden chips, reconstituted wood products, and pulp.

Timber yield varies significantly according to forest type. Mountain ash, alpine ash, and shining gum forests, although currently comprising only 34% of the total Net Productive Area, contain more than 80% of C Class or better sawlog volumes, as shown in Table 51. By comparison, foothill mixed-species forests account for more than 56% of the current Net Productive Area in State forest, but would yield less than 15% of the total timber volumes potentially available. These ratios clearly indicate the importance of the highly productive ash and shining gum forests to the hardwood resources of the study area.

Planning of timber harvesting

A system of integrated management planning was developed in the Timber Industry Strategy (TIS) (Victoria 1986). State-wide principles and guidelines for timber-production operations were established in the Code of Forest Practices.

Following the creation of 15 Forest Management Areas (FMAs) across the State, forest management plans are being prepared for each one. These will contain more detailed principles and prescriptions applicable to the FMA, with harvesting prescriptions to suit local forest types, land and soil types, and climate. Public consultation will be part of the preparation process; each plan is valid for 10 years. Wood utilisation plans will detail wood production (in terms of the type, quality, and allocation to processors). At the most detailed level, forest coupe plans contain detailed prescriptions applicable to individual harvesting coupes.

Native Forest Management

Three Forest Management Areas lie wholly or partly within the study area: Central Gippsland; Dandenong; and Central. Dandenong DCE Region has published its resource statement (the first part of the forest management plan) for the Dandenong FMA; those for Central and Central Gippsland are in preparation.

Code of Forest Practices

The Code establishes principles and standards for timber-harvesting in native forests and the

Table 50

NET PRODUCTIVE AREA OF HARDWOOD TIMBER RESOURCES

Forest type	Area (ha)			Total
	Mature/overmature	Pre-1940 regrowth	Post-1940 regrowth	
Mountain ash	4 478	44 562	10 297	59 337
Alpine ash	1 623	20 178	4 224	26 025
Shining gum	200	2 731	13	2 944
Mountain mixed-species	16 081	5 020	1 815	22 916
Foothill mixed-species	90 158	28 406	25 499	144 063
Other	677	1 470	-	2 147
Total	113 217	102 367	41 848	257 432

Source: DCE HARIS Database

Table 51

FOREST RESOURCES BY FOREST TYPES WITHIN THE NET PRODUCTIVE AREA

Forest type	Volume of Class A, B, and C sawlogs			Residual roundwood (cu.m)
	Volume of C + sawlogs	% of total volume	% of net productive area	
Mountain ash	7 467 200	58.4	23.0	11 777 600
Alpine ash	2 578 300	20.2	10.1	3 431 600
Shining gum	371 800	2.9	1.1	1 405 200
Mountain mixed-species	535 200	4.2	8.9	1 104 200
Foothill mixed-species	1 836 300	14.4	56.0	5 202 100
Other	2 300	<0.1	0.9	4 600
Total	12 791 100			

Source: DCE HARIS Database

associated activities of roading, regeneration, and reforestation. (It also covers softwood and hardwood plantation establishment and tending). Values to be protected by the Code include: water quality; stream flow; soil stability; landscape; flora and fauna; intensive recreation sites; biological, archeological and historical sites; and protection from pest plants and animals.

Sustainable yield

Sustainable production of forest goods and services is one of the goals of timber production from public land native forests (Victoria 1986). Sustainable yield is the level of output that can be maintained in perpetuity without impairment of the land's productivity. For each FMA the sustainable yield for annual sawlog-harvesting from the net available area (under current prescriptions and strategies) has been calculated, and subsequently guaranteed by the *Forests (Timber Harvesting) Act* 1990. However, there is legal provision to alter the sustainable yields where circumstances alter the available timber resource.

As the FMA boundaries do not correspond with the study area boundary, it is not possible to determine sustainable yield for the study area. Table 51 gives sustainable yields for each FMA. These were calculated for the Timber Industry Strategy (Victoria 1986).

Sustainable yields will increase from the year 2002/03 as the timber volume obtainable from regrowth areas increases due to stand growth, as Table 52 shows. However, sustainable yield would decrease if fire burnt

substantial forest areas, or additional data caused downward revisions of current resource estimates. Sustainable yield could also decrease as the result of any fall in net available area through changes to approved public land uses, or land management policies and prescriptions. Data shown in Table 52 are subject to revision as part of the FMA process.

Licences

A feature of the Timber Industry Strategy concerns the provision of sawlogs from public land to privately owned processors, notably the issues of value-adding processing, security of supply, and financial arrangements.

Licences for sawlog supply, negotiated between DCE and sawmill operations, must have a maximum annual total not exceeding FMA sustainable yields. For each 15-year licence, the volume and grade of timber DCE makes available to the licensee are specified. However, the annual volume cut need not equal the total licence volumes, as the arrangement allows for some flexibility. Licensees can vary the timber volume required and the amount specified in the licence by up to 30% in any one year (but no more than 10% over 5 years).

Associated with the log licence system, instituted in 1987, is the government's Value-Added Utilisation Scheme (VAUS), a feature of the Strategy. This Scheme requires sawlogs to be graded and allocated to processors so as to ensure the highest-value end use. Those mills best suited to

Table 52
SUSTAINABLE YIELDS IN
THE STUDY AREA

Forest management area	Sustainable yield (cu.m of Class C+ sawlogs per annum)	
	1986/87-2001/02	2002/03-2014/15
Central Gippsland	183 000	220 000
Dandenong	41 000	67 000
Central	115 000	152 000

Source: Victoria (1986)

producing higher-quality products are allocated higher-quality resources under the licence system.

Table 53 lists the total timber volumes committed to private companies under current long-term licences. Licence totals are generally less than the sustainable level of hardwood sawlog supply.

Landscape values

Management of visual resources is a particularly important aspect of timber-production management in many parts of the study area. Timber-harvesting operations have the potential to scar the landscape and the effects persist for some time after operations cease. The Department of Conservation and Environment has developed a technique called the Visual Management System to assist in integrating changes such as timber-harvesting into the landscape.

The system can be applied at both the broad-scale planning level and at the project level. At the broad-scale level, it establishes a regional perspective by first delineating Landscape Character Types (LCTs). Each LCT possesses similar distinguishing visual

Table 53
LONG-TERM LICENCE
COMMITMENTS BY FMA

Forest management area	Current long-term licences (to 2002) of hardwood sawlogs (cu.m.)	Sustainable yield rates* (cu.m.)
Central Gippsland	160 185	183 000
Dandenong	40 800	41 000
Central	115 600	115 000

Sources: 1 - Timber Industry Council (TIC)
2 - Parliament of Victoria

characteristics, predominantly based on landform and major land cover patterns influenced by vegetation, waterform, and land use.

Nine LCTs have been identified in Victoria (Leonard and Hammond 1983) and four are represented in the study area: eastern highlands; foothills; southern lowlands; and coastal. Most of the elevated public land occurs within the eastern highlands LCT. The foothills LCT flanks this to the south and, further south-west, runs into the southern lowlands LCT, which includes the Mornington Peninsula.

Within each LCT, specific criteria identify three scenic quality classes on the basis of landform, vegetation, and waterform.

Scenic value assessment through the system is based on observer numbers and perceptions. Relative levels of concern for scenic values by different observer types are assessed, and the combination of numbers and concern level is used to assign public sensitivity levels to all travel routes and sites such as lookouts and picnic areas.

The landscape as seen from all travel routes or use-areas (such as lookouts) is mapped and divided into foreground, middleground, background, and unseen zones. Landscape units are then identified based on the combination of scenic quality class, public sensitivity level, and seen-area distance zone. Visual quality goals that specify the maximum acceptable degree of alteration are then set for each of these units.

Many parts of the study area have a high sensitivity to visual alterations, necessitating modifications to some practices to minimise visual impacts. Any activities, such as timber-harvesting, within these areas should be assessed individually and specific design and siting guidelines prepared by the Landscape and Architecture Services section of Department of Conservation and Environment.

Firewood collection

The DCE recognises firewood collection as a significant recreation activity presenting some environmental and management problems. Collection by individuals, gathering one or two cubic metres, is classified as 'domestic

harvesting'; 'recreational harvesting' is for cooking, warmth, and enjoyment by visitors to public land. Demand for firewood has increased over the 1980s, attributed to the rising cost of energy for heating (gas, oils, and electricity) and the increasing appeal of wood heaters.

Although widespread, the activity is greatest close to settlements, especially to metropolitan Melbourne. The DCE makes wood available especially for firewood collection, and operates a management system on a licence and sale basis. However, illegal collection is rife - much probably attributable to public ignorance over existing controls.

Felling of trees and collection of fallen timber can have environmental consequences, especially in small reserves or areas of extensive degradation. Such felling and removal can cause habitat losses for tree-nesting fauna, small mammals, and invertebrates.

A firewood policy is currently being formulated by DCE, which released a public discussion paper in 1990.

The Timber Industry

The industry using the resources from the study area is of economic significance, especially in relation to the ash-species timbers which are being promoted for greater value-adding processing. Estimates of the value of output from the Central Highlands vary - the Timber Industry Council suggested \$200M annually, with greater value added by further processing. Resource use, employment, and the role of ash-species timbers are described below.

Significance of the ash timber resource

Ash timbers form the basis of the supply of high-quality domestic hardwoods in Victoria. They have proved the most suitable local species for drying and subsequent further processing into higher-value products. In addition, ash timbers may have a future role in substituting for imported rainforest species.

Additional processing of low-value timber commodities into higher quality and higher-value goods is a feature of the government's Timber Industry Strategy. High-value uses

of these timbers include furniture, flooring, doors, panelling, and mouldings. The high-value use of ash species is exemplified by its being the most common individual species used by furniture manufacturers in the eastern mainland states. Investment by firms in capital to enable further processing of ash timbers has been taking place in the study area, but the Victorian Association of Forest Industries report that current economic conditions and other factors have stifled these investment programs. However, the VAFI regards this condition as cyclical and predicts a promising future for value-adding.

An indication of the economic value of ash timber is the estimate Squire *et al.* (1987) that a hectare of harvested ash (at the end of an 80-year rotation) can generate over \$500 000 in economic activity up to the point of consumption. Royalty values to the State from such an area may reach \$25 000.

Resource use

A substantial sawmilling industry and a pulp and paper industry operate in the study area, and draw upon its timber resources. Currently 45 sawmills draw on this public hardwood resource. Some of them are located outside the study area, but draw primarily on its resource.



Sawlogs in a timber mill awaiting further processing

The government allocates approximately 312 870 cu.m of sawlogs harvested from the study area annually, under government licence. A small number of firms dominate the industry here: half of the harvested sawlogs are allocated to five companies, while 20 companies have allocations of less than 3000 cu.m.

Analysis of the market destination for timber from the study area revealed that 62% was for unseasonable structural products, 10% for seasoned structural, 25% for seasonal appearance, 2% for unseasonable appearance, and less than 1% for veneer uses.

The APM mill at Maryvale is one of Australia's major pulp and paper installations, and has the most significant role in the Victorian industry. The Central Highlands are the single most important source of eucalypt pulp for the mill, with softwood inputs from large plantations. In 1988/89, some 315 000 cu.m of pulpwood was harvested from a total of 70 sawlog coupes in the study area, in addition to sawmill residues.

Ash pulpwood is the principal furnish of Kraft pulp, which is bleached and used to manufacture a range of printing and writing papers. Packaging material is also made using ash pulpwood at the plant.

The plant is worth in excess of \$1 billion and there are plans for expansion under consideration. As discussed in the issues chapter, there are important economic considerations involved in the relative levels of domestic paper production and of imported pulp and paper.

Employment

The 45 hardwood mills and the one pulp and paper mill that draw on the public hardwood resource of the study area employ staff directly in the primary processing of the resource, and a wide range of contractors such as fallers, drivers, plant operators and supervisors. The Department of Conservation and Environment (DCE) employs staff to supervise these operations and carry out road maintenance and reforestation of these areas.

In current sawmill operations about 30% of the sawlog volume becomes woodchips. Based on the current volume of sawlog input in the study area, it is estimated that some 100 000 cu.m of woodchips are produced annually by the mills. Of these, 44 000 cu.m are sold annually to the APM mill at Maryvale, with further sales to meet demand in Geelong, and the remaining residues sold as firewood, for garden use, or other purposes.

Primary processing

In mid 1989, the Timber Industry Council (TIC) conducted a survey of hardwood mills, to establish employment in primary processing of hardwood resources drawn from the study area. It recorded some 640 employees. Using an estimation system that equates mill employment with sawlog input (20 employees per 10 000 cu.m input), the TIC estimated that the sustainable yield for the three FMAs concerned would generate employment for 682 persons.

Future changes in mill productivity will influence employment. Productivity increases are expected to be 2 to 3% and would be associated with employment reductions of 20 or more persons per annum in the short term. On the other hand, the TIC report noted the intentions of many mills to undertake considerable investments and structural change, which would generate some additional employment. A feature of the VAUS is to encourage further value-added processing.

Maryvale pulp and paper mill employs 1160 persons, of whom, on a pro rata basis, some 336 employees could be attributed to the timber resources drawn from the study area.

Table 54 shows employment and timber allocations on a local-government basis.

Table 54

TIMBER MILLS, ALLOCATIONS, AND EMPLOYMENT, BY LGA

Local government	Number of mills	Annual timber allocation from public forests within study area	Number of full-time mill employees attributable to that resource
Broadford	1	9 100	11
Yea	2	33 000	24
Alexandra	2	41 400	101
Romsey	1	500	6
Creswick	1	400	2
Melbourne metro area	1	500	
Whittlesea	3	4 900	10
Healesville	6	28 300	31
Upper Yarra	10	46 130	73
Lillydale	1	1 800	5
Buln Buln	8	44 130	122
Warragul	2	17 300	9
Narracan	3	7 575	28
Maffra	3	75 700	208
Woorayl	1	2 130	N/A

Source: Timber Industry Council and DCE



Timber mill in the Central Highlands

Forest workers

Timber mills employ a wide range of contractors their forest operations and log cartage. In the past there have been difficulties in obtaining reliable data about the work force because of the seasonal and widespread nature of the industry. However, recent legislation requires forest workers to accredited and licensed.

Up to November 1991, 748 people had been accredited as forest workers in the Dandenong, Alexandra, Melbourne, and Central Gippsland DCE Regions. Not all of them are employed full time. The majority of these people are likely to work in the public forests of the study area. Accreditation is not required for forest workers operating solely on private land - for example, on APM private tree farms. In addition, a considerable number of people are involved in forest-based employment such as tourism and recreation.

Department of Conservation and Environment staff

Three DCE regions cover the study area, with regional offices at Dandenong (Dandenong Region), Alexandra (Central Region), and Traralgon (Central Gippsland). Head Office staff are also involved in tasks relating to these.

The Department estimated that the equivalent of 75 regional staff were engaged in logging supervision, road construction, maintenance, and reforestation within the study area.

Timber towns

As a consequence of the historical development of the timber industry, described in Chapter 3, the study area contains several 'timber towns'. Such towns are based on direct and indirect employment in one or more local sawmills. Dependence on mills for employment is usually more acute in the smaller towns.

Examination of ABS employment statistics (1986 Census data) for selected towns with more than 1000 population reveals a generally low number and percentage of the labour force involved in the timber industry. In Alexandra, Broadford, Drouin, Healesville, Millgrove, Trafalgar, Warragul, Woori Yallock, and Yarra Junction the labour force for 'Forestry and Logging' was usually less than 1%, and only one centre's labour force exceeded 4% in the category 'Wood products and Furniture' (ABS 1986).

The Bureau does not release data on the labour force in towns with populations under 1000 persons. The Timber Industry Council surveyed Marysville and Erica (both with populations under 1000) and results indicated that 19% of the work force were engaged in the timber industry. Similar situations may also exist for other small towns: Crossover, Darnum, Fumina, Murrindindi, Narbethong, Noojee, Powelltown, Rokeby, and Toolangi.

Total employment impact

Adding the number of employees in primary processing, the APM mill, the accredited forest workers, and government staff, gives a total employment of about 1800, some of whom are part-time. Multipliers to determine the wider level of employment generated by use of the resource have not been calculated for the study area, but several studies of other areas have devised approaches of relevance. These suggest that calculations of suitable multipliers for the study area would have to incorporate the level of value-adding processing undertaken, and include estimates for the Maryvale pulp and paper mill.

Softwood Timber Production

History

The first substantial exotic softwood plantations in the study area were established

around Narbethong and in the Loch Valley in the 1930s. Some plantations were established earlier, but only remnants of these survive today. At Narbethong, planting was an attempt to reforest sites burned repeatedly by wildfires. The wide range of species planted included radiata pine (*Pinus radiata*), Douglas fir (*Pseudotsuga menziesii*), corsican pine (*P. nigra*), ponderosa pine (*P. ponderosa*), and bishops pine (*P. muricata*), as well as firs and cedars.

The plantation was severely damaged by wildfire in 1939 and parts were later replanted. This damage and replanting, combined with insect, fungal, and vermin attack and storm damage, have produced a complex mosaic of species mixtures, stand qualities (including eucalypts that regenerated following burning), and age classes in the Narbethong Plantation. Surviving species are predominantly radiata pine, Douglas fir, and corsican pine. Clearfelled stands are replaced with either radiata pine or mountain ash.

Planting in the Loch Valley, north of Neerim South, was on abandoned farmland and covered 616 ha by 1939, when wildfire destroyed all but 12 ha. Replanting with radiata pine commenced in 1940 to give the present plantation area of 983 ha.

Some former farmlands at Childers and Allambee, south of Warragul, were planted with radiata pine, commencing in 1946 and 1948 respectively. Despite problems with vermin and bracken, they have demonstrated exceptional sawlog productivity.

The next stage of plantation establishment in the study area followed the completion and filling of the enlarged Eildon Reservoir in the 1950s. The government purchased some 1940 ha of farmland as portions were to be inundated by the storage, and planted the balance with radiata pine from the late 1950s through the 1960s. Most of this plantation is located on the Delatite arm of the reservoir and in the Goughs Bay area.

Plantation establishment commenced elsewhere in the late 1960s or early 1970s and continued through the 1970s at Kinglake West, Mt Carmel, and Neerim East and in the Acheron Valley, north of Narbethong. Many of the older plantations have been replanted and some are well into their second rotation.



Moondarra plantation

Substantial areas that the government decided could be used for softwood timber production, as recommended by Council (LCC 1977, 1983), have not been used for this purpose. Some plantations did not proceed as the soil types are not conducive to good radiata pine growth without substantial cultivation and fertilisation, and the costs of these treatments would make timber production largely unprofitable. In other cases, a change in government policy prevented the clearing of native forests for softwood plantation establishment.

Management goals

For State plantations, management aims at maximising production of sawlogs and veneer logs (Victoria 1986). These goals are substantially assisted by periodically thinning each stand to remove the weaker and poorly formed trees. Trees felled in the thinning operations may be used to produce small sawlogs, fencing timbers, other material used in round form, and pulpwood.

Many plantations have other important uses that complement timber-production goals. Significant examples of such uses in the study area are listed below.

- * A substantial part of the Narbethong Plantation is managed to demonstrate the growth potential of a range of exotic coniferous species.
- * Plantations established on the Delatite Arm of Lake Eildon provide settings for considerable recreational opportunities,

mostly water-based but also potentially dependent on adjacent native forests that form part of Eildon State Park. Many camping facilities have been provided throughout the plantation area and are in very heavy demand through the summer period.

- * Facilities are not usually provided for recreation in other plantations in the study area, but some of them are nevertheless in demand for such activities as trail-bike-riding along roads and formed tracks.

Timber availability

Table 55 shows the area of State-owned plantation in each locality. There are also substantial areas of privately owned softwood plantation in many parts.

Government policies for the management of State softwood plantation resources include ensuring a capability of sustaining timber supplies to competitive and integrated forest product industries. Achievement of this aim requires establishment of a sufficient area of plantation in close proximity to industry. Plantations are therefore concentrated in Management Areas in which the Timber Industry Strategy (Victoria 1986) set a plantation area target.

A sustainable yield of forest produce is calculated for each Management Area, taking

into account several factors, including age-class distribution, growth rates, and site factors. This yield is used to determine the level at which licences to supply produce are set.

The study area includes all of the Central and small proportions of the La Trobe and Benalla--Mansfield Management Areas. Plantations within the Central Management Area are insufficient to support a large-scale integrated industry. As a result, these will be man/aged in conjunction with Benalla--Mansfield Management Area.

The State softwood plantation resource in the study area is therefore used to contribute to the sustainable yield of the La Trobe and Benalla--Mansfield Management Areas.

Dependent industry

A few timber processors use softwood timber produced within the study area and have processing plants located within it, such as the sawmills located at Narbethong and Crossover.

Plantations within the study area provide a small proportion of the requirements for large industrial developments producing a wide range of timber products at locations such as Benalla, Myrtleford, and Albury and in the La Trobe Valley.

Table 55

SOFTWOOD PLANTATION AREAS

Location	Area (ha) ¹	Majority planted	Management Area
Mt Worth	717	1975-- present	La Trobe
Moondarra	633	1969--1973	La Trobe
La Trobe	1 202	1972--1985	La Trobe
Loch Valley	982	1960-- present	La Trobe
Narbethong & Acheron Valley	3 775	1970s	Central
Kinglake West	1 116	1970s	Central
Delatite Arm (Lake Eildon)	1 940	1959--1968	Benalla-- Mansfield
Total	10 240		

Note:

These areas represent 14%, 100%, and 13% of the government's target plantation area for La Trobe, Central, and Benalla--Mansfield Management Areas, respectively.

Source: Area Statement for Forest Plantations in Victoria, October 1988, DCFL

Future development

The government's Timber Industry Strategy requires substantial increases in the extent of softwood plantations in the La Trobe and Benalla--Mansfield Management Areas - that is, the north and east of the study area - but those in the Central Management Area will decrease as the Old Narbethong Plantation is replanted with eucalypts.

Opportunities for further softwood plantations on public land are few. Within the La Trobe and Benalla--Mansfield Management Areas little or no suitable cleared public land remains and clearing native forests for softwood plantation is not permitted under government policy. Any additional plantations must therefore be established on purchased private land.

References

- Anon. (1974). 'Tall timbers and tramlines.' (Light Railway Research Society of Australia: Surrey Hills.)
- Australian Bureau of Statistics (1986). 'Census of Population and Housing.' (AGPS: Melbourne.)
- Boland, D.J., Booker, M.I.H., Chippendale, G.M., Hall, N., Hyland, B.P.M., Johnson, R.D., Kleinig, D.A., and Turner, J.D. (1984). 'Forest Trees of Australia.' (CSIRO, East Melbourne and Thomas Nelson: Melbourne.)
- Land Conservation Council (1973). 'Melbourne Study Area.' (Victorian Government Printing Office: Melbourne.)
- Land Conservation Council (1977). 'Melbourne Study Area - Final Recommendations.' (Victorian Government Printing Office: Melbourne.)
- Leonard, M., and Hammond, R. (1983). 'Landscape Character Types of Victoria.' (Forests Commission: Victoria.)
- Victoria, Government of (1986). 'Timber Industry Strategy. Government Statement 9.' (Victorian Government Printing Office: Melbourne.)

16. MINERALS AND EXTRACTIVE RESOURCES

This chapter augments and revises information in the Land Conservation Council's earlier report (LCC 1973), which was compiled over the years 1971-73. As a result, reference to the original study would be required for full information.

Since then, the Geological Survey and its parent body, the Department of Manufacturing and Industry Development (DMID), have issued reports relevant to various aspects. In addition, the Victorian Division of the Geological Society of Australia (GSA) has published two editions of 'Geology of Victoria' the more recent of which (Douglas and Ferguson 1988) was used in the preparation of this chapter.

Minerals

Tenements

As of June 1991 the study area contained 267 tenements (see Table 56): 100 held under provisions of the *Mines Act* 1958; and 167

under the *Extractive Industries Act* 1966. Most of these are on public land.

An Exploration Licence (EL) is the tenement taken out for exploration over large areas (up to 500 sq km). A Development Lease (DL) is taken out for more intensive investigation at specific sites, generally not exceeding 260 ha unless the Minister for Manufacturing and Industry Development has given his consent for larger areas to be occupied under lease. Both involve exploration in its broadest sense. In the study area such tenements are concentrated around Walhalla-Woods Point and to the north of Yea and Alexandra. Other tenements include Mining Leases (MLs) (maximum size 260 ha) and Miner's Rights Claims (MRCs) (up to 5 ha).

Expenditure on individual tenements is not readily available. However, the Australian Bureau of Statistics (ABS) publishes figures on total expenditure for each State. These show that \$21.5 million was spent on exploration in Victoria in 1988/89 (\$33.9 million in 1987/88). Based on the number of

Table 56

NUMBERS OF TENEMENTS HELD UNDER THE *MINES ACT* 1958 AND THE *EXTRACTIVE INDUSTRIES ACT* 1966

(As at June 1991)

Type of tenement	Number of tenements
Exploration Licence (EL)	8
Development Lease (DL)	25
Mining Lease (ML)	21
Miner's Right Claim (MRC)	41
Prospecting Area Licence	1
Mining Area Licence (MAL)	4
Licences under the Mines Act (1958)	100
Extractive Industry Search Permit	5
Extractive Industry Licence (Private land)	123
Extractive Industry Lease (Public land)	39
Licences under the Extractive Industries Act (1966)	167
Total	267

Source: DMID

Exploration Licences within the study area, the amount spent on exploration is estimated at \$2 to 3 million.

Production

Production of gold has continued here since Council's earlier investigation. This has come from several Miner's Right Claims (MRCs), a Mining Lease (ML) as well as from Eductor Dredge Licence operations on streams (no eductor dredging licences were issued after 31/10/1990).

Miner's Right Claims have been worked in high-level alluvium along the Goulburn River, while eductor dredging has occurred in the river itself, but neither requires production returns, so there is no record of the gold recovered.

Production returns are, however, required for Mining Leases. Although a number of them are current in the study area, production has been confined to Gaffneys Creek, where the A1 Mine has continued to operate since Council's earlier investigation. The remaining operations licensed under Mining Leases are conducting trial mining. Between 1979/80 and 1989/90 the recorded Victorian production of gold was 10 950 kg. On present-day values this represents about A\$170 million (taking the value for gold as US\$375.00 per oz and an exchange rate of US\$1 = A\$1.28).

Mineral exploration

Exploration - the search for mineral deposits - is necessary in order to locate sufficient

supplies of mineral resources to replace the diminishing supplies from existing mines, and to supply additional resources to meet growing market demand.

It is a dynamic, continually changing research activity. New scientific research and data-gathering techniques lead to a better understanding of mineral deposits and how they formed.

This encourages exploration in new areas and the re-evaluation of previously explored ones. Because of its dynamic, changing nature, exploration requires repeated access to land so that newly developed concepts of mineral deposit formation can be investigated and newly developed exploration methods applied.

Based on present geological knowledge and previous mineral discoveries, Victoria is highly prospective for a wide variety of minerals. However, expenditure on mineral exploration here is only a minor component of the Australian total, outlined in Table 57.

The main reason cited by exploration companies for this low level of expenditure is the plethora of legislation and complex procedures affecting exploration activities. Several administrative procedures have now been simplified under the new *Mineral Resource Development Act* 1990. The area of the State where mining is prohibited is also seen as a deterrent by the companies. However, the area in which mining is prohibited in Victoria, is relatively small and in a national context, the proportion prohibited in Victoria is similar to New

Table 57

MINERAL EXPLORATION (OTHER THAN FOR PETROLEUM) EXPENDITURE BY STATE (\$ million)

Period	NSW	Vic	Qld	SA	WA	Tas	NT	Aust
1984/85	49.5	15.2	79.5	57.6	189.8	17.8	28.0	437.3
1985/86	51.8	12.3	88.6	48.9	205.2	10.6	24.6	442.0
1986/87	47.6	15.5	120.6	11.0	323.3	10.9	27.9	556.8
1987/88	61.5	33.9	159.3	18.9	466.3	10.4	48.9	799.2
1988/89	50.6	21.7	139.8	16.6	387.2	13.1	68.6	697.6
1989/90	55.1	21.0	128.4	13.2	315.2	11.8	62.6	607.3

Source: ABS (1991)

South Wales and less than several other States.

Gold

The study area overlies sediments of the Melbourne Trough, a structural trough of triangular outline in central Victoria. With respect to gold mineralisation, the trough also defines the Melbourne Province, which comprises the Warrandyte Subprovince in its central and western parts and the Walhalla--Woods Point Subprovince in the east.

Gold in the Warrandyte Subprovince occurs in fault-controlled quartz veins in Lower Palaeozoic sediments. In some areas the ore has a low sulphide content; in others it has a strong association with stibnite and arsenopyrite.



A former gold-mine entrance at Walhalla

Since the earlier Council study, a different type of sediment-hosted mineralisation has been discovered near Nagambie to the north of the study area. Comprising an extensive stockwork of discontinuous quartz veinlets within silicified Lower Palaeozoic sediments, the ore has grades averaging 1.5 to 2.5 grams per tonne, with some zones averaging 4 to 5 grams. It is a large outcropping deposit and mining commenced in 1989. In its first year the mine produced 726.9 kg gold. Exploration companies are currently searching for similar deposits within the study area.

Gold in the Walhalla--Woods Point Subprovince is in structurally controlled quartz veins associated with intermediate to ultrabasic dykes of the Woods Point Dyke Swarm. The veins occur in the dyke and/or surrounding host sediments. Substantial

mineralisation is generally localised at 'dyke bulges'. The richest deposit in the subprovince was Cohen's reef at Walhalla. This was also one of the richest ore bodies in Australia, yielding 46 600 kg of gold. Total production from the subprovince was 98 000 kg from ore, averaging 30 grams per tonne. On today's values this would be worth \$A1.6 billion.

Antimony

Stibnite (antimony sulphide) occurs in structurally controlled quartz-filled fissures in Lower Palaeozoic sediments of the Melbourne Trough. Although occurrences are widespread, the only known major deposit is at Costerville to the north of the study area. Production from mines within or immediately adjacent to the study area has been minor (Ringwood, Steels Creek, and Big River).

Bauxite

Many small deposits of bauxite occur in South Gippsland, and a number of these are within the study area. However, the more significant deposits are outside the study area near Mirboo North and Boolarra. These deposits have been worked for many years, and are used as a source of alumina in the manufacture of cement. Bauxite is a weathering product of the Older Volcanics basalts. In general, economically viable deposits are associated with faults and it appears that these structures have enhanced the weathering process.

Coal

Lower Cretaceous black coal was mined in and adjacent to the Strzelecki Ranges between the mid 1890s and the late 1960s. The principal coalfields are at Wonthaggi, Outtrim, Jumburra, Korumburra, and Mirboo North. The majority of the State's production has come from Wonthaggi and Korumburra. The major producer of black coal was the State Coal Mine at Wonthaggi with 16.9 million tonnes, approximately 75% of the State total of 22.8 million tonnes. The State Coal Mine was operated from 1909 to 1968. The coal was used by the Victorian Railways, Newport and Wonthaggi power stations, and for industrial and domestic purposes. Known deposits are now largely exhausted and remaining reserves are currently considered uneconomic.



The former Wonthaggi State Coal Mine now operates as a tourist attraction

The western end of the La Trobe Valley brown coal basin occurs in the study area. Although, there is an extensive brown coal resource within the study, there are currently no plans to exploit it.

Copper

Copper sulphide (principally chalcopyrite) is associated with basic to ultrabasic dykes of the Woods Point Dyke Swarm, which parallels the eastern margin of the Melbourne Trough.

The Thompson River Copper Mine was the most productive deposit, and was worked intermittently between 1864 and 1971. Although ore averaging 10% copper was recovered in the past, the remaining ore is likely to have grades of only 2–3% copper (Cochrane 1982).

Similar copper mineralisation occurs east of Walhalla at Gaffneys Creek, Woods Point, and Toombon (Maynards Gully). Gold, nickel, and platinum group metals are associated with the copper. The above deposits have been the subject of small scale mining. Remaining reserves are probably small and are currently considered uneconomic.

Minor copper mineralisation occurs at Howqua just east of the study area in sheared Cambrian greenstones but no such occurrence is known with District 2.

Mercury

Native mercury was mined in the latter part of the nineteenth century at the Jamieson Quicksilver Mine just east of the study area, where it occurred in a north–south striking fissure in Lower Palaeozoic sediments. Mining was discontinued when cinnabar (mercury sulphide) was encountered at 47m depth.

Mineral sands

A deposit comprising 8 million cu.m of sediments with a mineral sand content of 24 kg per cu.m (1%) occurs in alluvium along the Acheron River valley, 19 km north-east of Healesville. The main mineral is ilmenite with minor zircon. This deposit was extensively examined in the late 1940's, but because of its low grade and small size it was considered to be uneconomic. This deposit is smaller and of lower grade than those in the Wimmera (average grade at WIM 150 is 3%).

Phosphate

Phosphatic shale occurs in early Ordovician sediments in the Mansfield area. A total of 16 334 tonnes were mined between 1916 and 1926 for use as fertiliser.

Platinum group minerals

Copper-rich lodes affiliated with the basic to ultrabasic dykes of the Woods Point Dyke Swarm contain these and other minerals. Grades are of the order of 2–3 ppm each for gold, platinum, and palladium (Cochrane 1982). Silver and nickel may be present. Platinum group minerals have been recovered as a by-product of copper mining. Remaining reserves are probably small from the Thompson River mine and to the east of Walhalla.

Tin

Small deposits of cassiterite (tin oxide) occur in alluvium near Buxton and along the upper reaches of the Bunyip and Upper La Trobe Rivers. It has been suggested that

disseminated cassiterite in adjacent granites may be the source, as no lodes have been discovered. These deposits were intermittently worked between 1866 and 1907.

Tungsten

Wolfram (iron manganese tungstate) was mined for short periods during the two world wars from quartz veins in late Devonian rhyodacite and porphyritic granodiorite at Wilks Creek, near Marysville. In 1980, an Exploration Licence project located tungsten mineralisation in quartz vein systems in porphyritic granodiorites at Monkey Gully, Tin Creek (Warburton), and Wilks Creek (a different type of mineral association from that previously mined at Wilks Creek). Bismuth and molybdenum were associated with the Monkey Gully occurrence.

An occurrence at Britannia Creek is also related to late Devonian granitoids.

Extractive Materials

Since the original report, the Geological Survey has carried out investigations on basalt and sand resources in parts of the study area. In addition, the Extractive Industries Strategy Plan Interdepartmental Committee has issued a draft report which includes a proposed strategy for improving the planning for, and administration of, new and existing extractive industry operations.

Tenements

The government grants an Extractive Industry Licence (EIL) for extraction from private land of extractive materials as defined in the *Extractive Industries Act 1966*; it grants an Extractive Industry Lease (EILse) for extraction from public land, which includes unalienated land at depths in excess of 15m beneath private land.

The study area contained 123 EILs and 39 EILses as of June 1991 (see Table 56). As four of the Leases were for deep operations beneath private land (that is, 15m below the natural surface), and were issued in conjunction with EILs, only 35 of the leases involve extraction from the surface downwards.

The *Extractive Industries Act 1966* is administered by the Department of Manufacturing

and Industry Development, which also supervises the operations. Extraction from public land for commercial purposes and for the construction and maintenance of forest roads can occur under provisions of the *Forest Act 1958* in which case the Department of Conservation and Environment is the administrative and supervising authority. The Department of Conservation and Environment also supervises shallow extraction - 2m or less in depth - from areas exceeding 2000 sq.m on both public and private land.

Local councils and Vic roads also extract material from public land, under their own powers, for road construction and maintenance. Occupational health and safety matters on operations not licensed under the *Extractive Industries Act 1966* are still the responsibility of the Department of Manufacturing and Industry Development.

Production

A little over 11 million tonnes of extractive material was produced from Department of Manufacturing and Industry Development supervised operations in the study area for the year 1987/88; some 26% of the State total for such operations, it had an ex-quarry value of \$91 million. Only 67 000 cu.m or 1% of it came from beneath public land, as shown in Table 58. The bulk of that 1% was sand from the eastern side of Western Port.

In addition, 322 000 tonnes were extracted from DCE-supervised operations on public land in the study area during the same year. A substantial amount of sand was also extracted from shallow DCE-supervised pits on private land on Mornington Peninsula. Table 59 shows the production from areas under DCE supervision.

The materials most produced from public land were sand and gravel (including some from stream-beds), sandstone, and hornfels. By far the commodity most produced from the study area, irrespective of land tenure, was basalt from both the Older and the Newer Volcanics; only a very small amount of this came from public land.

Extractive materials

The study area contains large resources of extractive materials, particularly hard rock, sand, and clay. However, their quality is

Table 58

PRODUCTION OF EXTRACTIVE MATERIALS (DMID SUPERVISION) 1987/88

Commodity	Quantity		Value (\$)
	(Tonnes)	% of District 2 production	
Gravel	182 365	2	528 228
Sand (including silica for glass)	2 621 816	24	16 678 493
Crushed and broken basalt	4 827 039	44	42 541 261
Crushed and broken dacite, Rhyolite, rhyodacite	1 148 681	10	13 928 112
Crushed and broken granite	630 730	6	7 149 806
Crushed and broken hornfels	305 034	3	2 679 816
Crushed and broken limestone	104 273	1	1 478 120
Crushed and broken sandstone	158 370	5	792 308
Earth and soil	216 851	2	913 312
Filling	189 133	2	203 405
Salamander (weathered basalt)	56 102	1	250 253
Limestone (miscellaneous)	37 874	<1	1 401 083
Clay (all types)	547 314	1	2 082 921
TOTAL	11 025 582 ¹	100	90 627 118

Notes:

1. Includes 66 626 tonnes from beneath public land. This is 1% of the total production from the area.
2. Production as defined under the *Extractive Industries Act* 1966.

Source: DMID 1990 and ABS

Table 59

PRODUCTION OF EXTRACTIVE
MATERIALS (DCE SUPERVISION)
- 1987/88 -

Commodity	Quantity	
	(cu.m)	(tonnes)
Gravel (surface and stream-bed)	31 400	53 522 (17%)
Basalt	100	172 (<1%)
Salamander	1 000	1 410
Hornfels/granite	65 000	100 750 (31%)
Shale	23 830	36 218 (11%)
Sandstone	94 120	129 885 (40%)
TOTALS	215 450	321 957

Note:

Sand extracted under DCE supervision from shallow pits on private property on the Mornington Peninsula not included in this table.

Source: DMID, using data from DCE
Regional Offices

extremely variable and difficult to assess. The choice of future quarry sites can be limited by the development of land and by land-use plans that prohibit quarrying in some locations.

Extractive industry is prohibited in parts of, or entire, municipalities within the study area, and planning scheme amendments are often necessary before new extractive industries can be established.

DMID has commenced a program to further refine its information on the geological, planning, and development constraints upon future quarrying. This will lead to a delineation of resource areas which can be recognised in future planning schemes and thereby protected for future use.

Readers seeking descriptions of extractive materials are directed to the earlier Melbourne investigation (LCC 1973) and various Department of Manufacturing and Industry Development reports. Descriptions of the materials given in the original study are not repeated here, although brief descriptions of the more significant commodities and deposits are given.

Hard rock

Currently, the dominant material sought for crushed rock is basalt, most of which occurs on private land. Although geological mapping reveals extensive outcrops, particularly of the Newer Volcanics, good-quality basalt rock has a quite restricted distribution. As current deposits become depleted, attention will be directed to resources outside the study area or to the acid volcanics, hornfels, and granites, as indicated by Council (LCC 1973). Much of this material is on public land and significant resources, particularly close to Melbourne, are unavailable because of land-use

constraints. Nevertheless, the study area contains a good distribution of hard rock types, especially in the north and east, in uncommitted lands and state forest. However, rock quality is extremely variable and further work is needed to define these resources.

Sand

The Heatherton--Dingley area has supplied the bulk of Melbourne's sand requirements for many years, but it is nearing exhaustion. As a consequence, sand is increasingly being sought from sources further to the east and south east.

Areas of importance for sand extraction in the study area are Cranbourne--Langwarrin, Lang Lang, and The Gurdies--Grantville. The reserves within licence areas at Cranbourne and Langwarrin are rapidly being depleted and Melbourne's sand requirements will need to be obtained from the other sources, well outside the developing metropolitan region.

At Lang Lang, the high watertable and planning controls may preclude the optimum

use of this resource. Some deposits at Lang Lang and Grantville occur within vegetated areas with high flora and fauna values, which may lead to land-use conflicts. These difficulties will need to be addressed, as these resources on the eastern side of Western Port are in demand to supplement Melbourne's future sand requirements.

Currently, a number of Extractive Industry Lease and Extractive Industry Search Permit applications cover land near Grantville, plus five applications within Western Port Bay.

DMID in the past has conducted demand forecasts, predicted future shortages and worked towards alleviating them by performing sand resource investigations in selected areas. Planning approvals in these areas are still not complete - full planning control may never be achieved. The procurement of suitable planning controls to protect these identified resources for future use is essential.

Clay

Clay is extracted from a number of locations within the study area and is mainly used in



An extractive industry site at The Gurdies--Grantville

the brick-, tile-, and pipe-making industries. Clay for use in these structural products is widespread and a major factor in the choice of site for clay quarrying and/or processing is the cost of transporting the raw materials and finished articles. Consequently, most clay is worked at several sites within or close to the metropolitan area. Major deposits occur at Campbellfield, Craigieburn, Cranbourne, and Scoresby. All of these deposits are on private land.

White Kaolinitic clay occurs at Hallam. This deposit is a residual clay, formed by the weathering of granite. This clay is used both in the manufacture of bricks and refractory products.

Resource figures collected by DMID suggest the main raw material sources, in currently licensed areas, will be nearing exhaustion in about 20–25 years time. However, some resources of more specialised clays with specific properties, such as fired colour, shrinkage, and elasticity, that are required for blending, will be depleted well before that time.

DMID has plans to identify potential clay resources, within the study area, to try and prevent them being sterilized by planning and/or conflicting development constraints.

Limestone

Limestone of Devonian age occurs on private land at Lilydale and just outside the study area near the Tyers River north-west of Tyers (McHaffie 1980). At Lilydale the limestone occurs as an isolated lens about 220m thick. At present, about 40% of the material quarried is used for agriculture, flux, and processing to quicklime and slaked lime. The remainder is crushed for aggregate and screenings. Planning controls and intensive land development have prevented mining of many of the other limestone deposits close to Melbourne.

Dimension stone

The use of natural stone - granite, marble, bluestone, sandstone and slate - as a building material has experienced a great resurgence since the early 1980's. The study area

contains a number of potential building stone deposits, some of which have past use in a number of buildings.

Two of the more important deposits are the Dromana Granite and the Tynong Granite. The Dromana Granite was used extensively in the base course of many Melbourne buildings of the 1930's and 1940's, whilst the Tynong Granite was used in the Shrine of Remembrance. This latter stone may be required for future restoration of the Shrine. Both of these deposits are on private land.

The Cape Woolamai Granite, now within the Newhaven Flora and Fauna reserve, was initially quarried for the Colonial Mutual Building at 316 Collins Street (now demolished), and was used in a number of other buildings at the turn of the century.

Devonian limestone (marble) from Howe's Creek near Mansfield, and the Thompson River near Toongabbie, have also been used as ornamental stone. The Howe's Creek deposit is on private land, whilst the Toongabbie deposit is in reserved forest.

In addition to the known deposits, potential exists within the study area, for further discoveries of natural stone suitable for building purposes.

References

- Australian Bureau of Statistics (1991). Actual and expected mineral exploration expenditure. Catalogue No 8412.0.
- Cochrane, G.W. (1982). Copper, lead, zinc and barium deposits of Victoria. *Bulletin of the Geological Survey of Victoria* No. 61.
- Douglas, J.G., and Ferguson, J.A. (eds) (1988). 'Geology of Victoria.' (Victorian Division of Geological Society of Australia: Melbourne.)
- Land Conservation Council (1973). 'Melbourne Study Area.' (Victorian Government Printing Office: Melbourne.)
- McHaffie, I.W. (1980). Tyers River Limestone. Geological Survey of Victoria Unpublished Report 1980/112.

17. WATER PRODUCTION AND USE

Chapter 6 describes the characteristics, distribution, and condition of the study area's water resources. This chapter concerns the harvesting, storage, transport, and uses of those resources, and the existing administrative arrangements. It includes a discussion of several associated environmental issues - planning for future developments, environmental flows, and Heritage Rivers. It also describes Board of Works catchment hydrology research, although the implications of the results are discussed in Chapter 20.

Consideration of the use of water from the study area necessitates the inclusion of metropolitan Melbourne. The city's water-harvesting dominates this water-production system in terms of catchment area and volumes harvested. Three major urban supply systems have catchments within District 2: metropolitan Melbourne; Mornington Peninsula and district; and the La Trobe Valley and district. Large amounts of water are also harvested from within the study area for irrigation and rural use in the Goulburn-Murray Irrigation District and the La Trobe Valley. As a result, some of the following material is based on a broader context, extending beyond the boundary of the study area.

Water Sector Agencies

Since the earlier Melbourne Area investigation (LCC 1973), a number of changes have taken place in the institutional and administrative arrangements within the water sector. Prominent among these changes were the formation of the Department of Water Resources in 1984 and a restructuring of the local water boards and water trusts. In 1990, that Department was incorporated into the Department of Conservation and Environment, and re-named the Office of Water Resources; subsequently the Office in turn was dissolved and the activities distributed within the Department of Conservation and Environment.

Readers seeking details on the broad organisation of the water sector prior to 1990 are directed to the Annual Reports of the Department of Water Resources and its

publication 'Water Victoria: a Resource Handbook' (DWR 1989).

Largest of the urban authorities is the Board of Works (BoW) with the Mornington Peninsula and District Water Board (MPDWB) and Latrobe Region Water Authority (LRWA) also operating large systems. Local water authorities operate largely independently in a decentralised system. Irrigation activities are controlled by the Rural Water Commission.

Amalgamations and restructuring of local water authorities under a government rationalisation scheme have resulted in new authorities and revised boundaries. Table 60 lists those operating within the study area.

Catchments

Water supply catchments cover public land, land owned by water authorities, and private

Table 60

WATER SECTOR AGENCIES OPERATING WITHIN THE STUDY AREA

Central agencies and major authorities

Department of Conservation and Environment
Board of Works
Latrobe Region Water Authority
Mornington Peninsula and District Water Board
Rural Water Commission

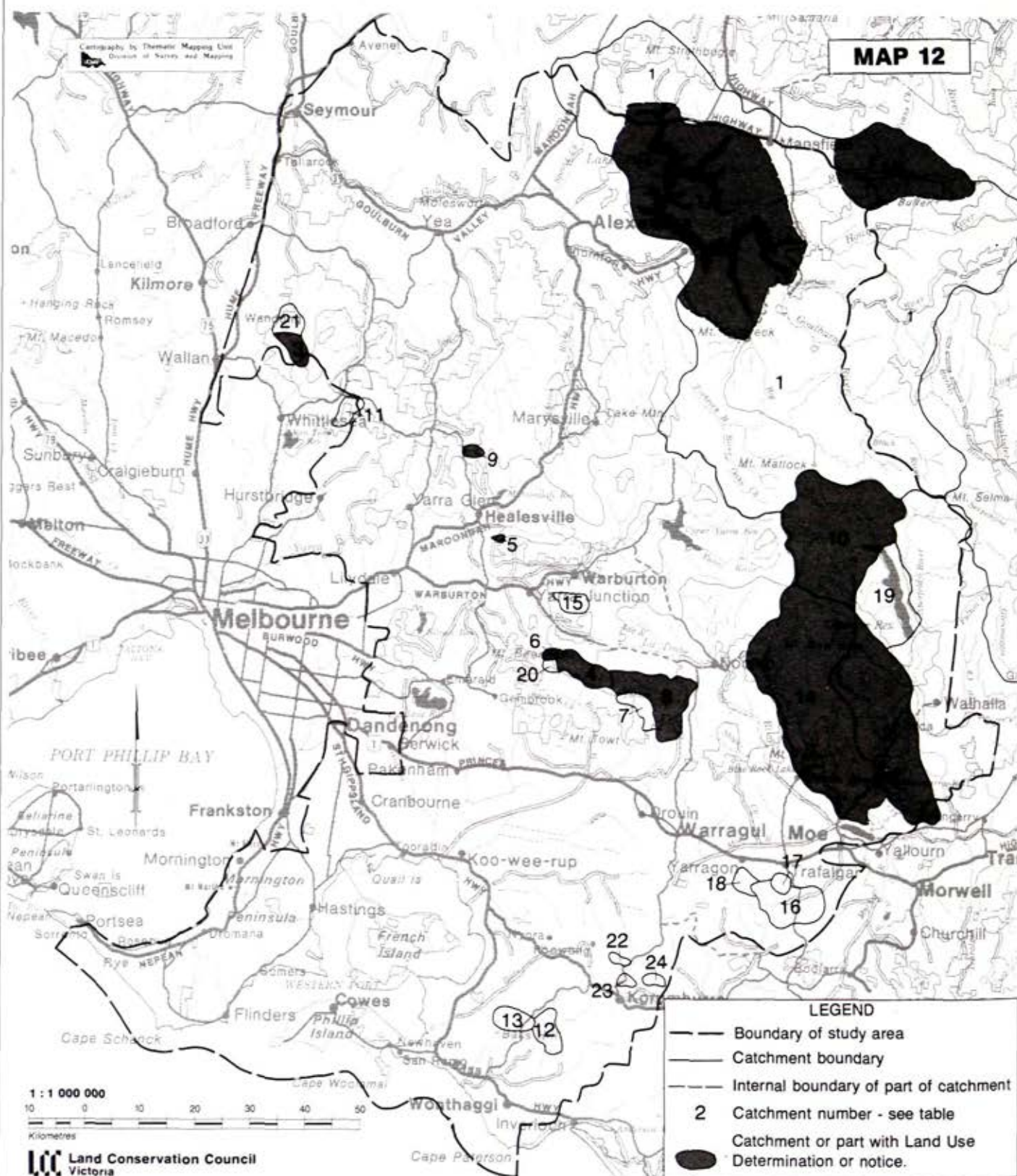
Local water authorities

Alexandra Shire Council
Broadford Water Board
Dandenong-Springvale Water Board
Emerald District Water Board
Kilmore Shire Council
Korumburra Water Board
Lang Lang Water Board
Leongatha Water Board
Mansfield and District Water Board
Marysville Water Board
Mirboo Water Board
Pakenham Water Board
Pyalong Water Board
Seymour Water Board
South Gippsland Water Board
Tarago Water Board
Tarwin Valley Water Board
Wonthaggi-Inverloch Water Board
Western Port Water Board
Yea Water Board

River management authorities

Mid-Goulburn River Management Board
Shire of Yea River Improvement Trust
Shire of Alexandra River Improvement Trust
Shire of Korumburra River Improvement Trust
Dandenong Valley and Western Port Authority
Tarwin River Management Board

WATER SUPPLY CATCHMENTS



NO.	NAME OF CATCHMENT	CATCHMENT STATUS	DATE OF GAZETAL OR APPROVAL (A)	AREA SQ. KM.	NO.	NAME OF CATCHMENT	CATCHMENT STATUS	DATE OF GAZETAL OR APPROVAL (A)	AREA SQ. KM.
1	UPPER GOULBURN	P	19.01.57	3535	13	TENNANT CREEK (CANDOWNIE RES.)	P	13.06.79	20
1A	LAKE EILDON ENVIRONS	L.U.D.	29.08.84 *	868	14	TANJIL	L.U.D.	16.04.85(A)	509
1B	UPPER DELATITE (MANSFIELD)	L.U.D.	01.03.85(A)	240	15	BRITANNIA CREEK	P	04.06.80	18
2	TYERS RIVER	L.U.D.	07.05.75	317	16	NARRACAN CREEK	P	07.01.81	82
3	KILMORE	L.U.D.	02.06.65	5	17	SUNNY CREEK	P	10.12.80	5
4	BUNYIP RIVER	L.U.D.	07.08.68	39	18	ROLLO CREEK	P	06.06.81	6
5	HEALSVILLE	L.U.D.	02.03.66	3	19	THOMSON RIVER (STAGE 3)	P	09.02.83 *	158
6	MCCRAES CREEK	L.U.D.	21.09.66	5	20	TOMAKAWK CREEK (GEMBROOK)	P	20.06.84 *	3
7	DROUIN	P	09.03.66	14	21	SUNDAY CREEK (BROADFORD-KILMORE)	P	20.06.84 *	20
8	TARAGO RIVER	L.U.D.	16.05.73	114	22	LITTLE BASS RIVER (POOWONG-LOCH NYORA)	P	18.11.87	7
9	MICKS CREEK	L.U.D.	25.07.73	5	23	BELLVIEW & NESS CREEKS (KORUMBURRA)	P	18.11.87	6
10	THOMSON RIVER (STAGES 1,1A,2)	L.U.D.	03.10.73 *	332	24	RUBY CREEK (LEONGATHA)	P	18.11.87	9
11	RUNNING CREEK (HURSTBRIDGE)	P	11.05.77	20					
12	LANCE CREEK	P	13.06.79	20					

P - Proclaimed water supply catchment

L.U.N. - Land Use Notice

L.U.D. - Land Use Determination

* - Land Use Determination Investigation in progress

land. Catchment tenure has implications for the controls applied to such areas. As nearly all water supplies within the study area are drawn from surface resources, catchment controls form an important means of protecting those water resources.

Such proclamation is a formal process of identification under the *Soil Conservation and Land Utilisation Act 1958*, which defines a catchment's boundaries, publicises its existence, and allows the Department of Conservation and Environment to prepare a land use determination.

A land use determination (LUD) is an assessment of a proclaimed catchment's land capability under a variety of land uses. The assessment evaluates the potential for soil erosion, as erosion is a major factor in water turbidity and suspended solids levels and in the export of other contaminants associated with soil particles. As each LUD is a statutory document, its application on any public land is mandatory. Land use determinations are frequently used in the local government planning schemes.

Not all catchments used to supply urban water are proclaimed, although it is intended that all eventually be protected, and not all those with proclamations have LUDS. Table 61 shows the present status of the proclaimed water supply catchments in the study area, some 17 of which await the preparation of a land use determinations. These areas are shown on Map 12. Currently 23 (revise) surface water catchments are not proclaimed, and three groundwater borefields.

A priority list for 150 supply catchments across Victoria was prepared and published in the Land Conservation Council's 1988 'State-wide Assessment of Public Land Use'. The catchment investigations planned for 1988/90 included three within the study area: Tennent Creek (Candowie No.2); Deep Creek; and Loch River.

Board of Works-controlled catchments

Melbourne's water is obtained principally from a series of forested upland catchments in the Upper Yarra River Basin and Thomson

Table 61

PROCLAIMED WATER SUPPLY CATCHMENTS

Basin	Catchment *	Status	Date of gazettal or approval	Area (sq. km)
Goulburn	Upper Goulburn	P	1/2/57	3535
	Kilmore	LUD		
	Lake Eildon Environment	LUD	2/3/77	868
	Sunday Creek (Broadford-Kilmore)	P	20/6/84	20
	Upper Delatite (Mansfield)	LUD	1/3/85	240
	Tomahawk Creek	P	20/6/84	3
Thomson	Thomson River (Stages 1, 1a, & 2)	LUD	3/10/73	332
	Thomson River (Stage 3)	P	9/12/83	158
La Trobe	Mirboo North	LUD	4/12/74	8
	Tyers River	LUD	7/5/75	317
	Sunny Creek	P	10/12/80	5
	Narracan Creek	P	7/1/81	82
	Rollo Creek	P	6/5/81	6
	Walkley Creek	P	3/6/82	8
	Tanjil River	LUD	16/4/85	509
South Gippsland	Lance Creek	P	13/6/79	20
	Tennent Creek (Candowie Reservoir)	P	13/6/79	20
	Little Bass River (Poowong-Loch-Nyora)	P	18/11/87	7
	Bellview and Ness Creek (Korumburra)	P	18/11/87	6
	Ruby Creek (Leongatha)	P	18/11/87	9
Bunyip	Drouin	P	9/3/66	14
	Bunyip River	LUD	7/8/68	39
	Tarago River	LUD	16/5/73	114
Yarra	Kilmore	LUD	2/6/65	5
	Healesville	LUD	2/3/66	3
	McCrae Creek	LUD	21/9/66	5
	Micks Creek	LUD	25/7/73	5
	Running Creek (Hurstbridge)	P	11/5/77	20
	Britannia Creek	P	4/6/80	18
	Tomahawk Creek (Gembrook)	P	20/6/84	3

Note:

1. P - Proclaimed, LUD - Land Use Determination

River Basin, which account for 90% of average annual supply. Sugarloaf Reservoir, on the lower Yarra River, provides 10% of supply, which is fully treated. Ash timber species, with mountain ash the dominant ones, cover 50% of the catchments, and contribute 80% of the total catchment yield. Much of the ash forest (80%) is regrowth from the 1939 bushfires, with some 20% being at least 150 years old.

These water supply catchments are shown on Map 13 and listed in Table 62.

Melbourne's first water storage was Yan Yean Reservoir, constructed in 1857; following continued delivery of poor-quality water, a restricted catchment was imposed in 1879. Expansion of the metropolitan supply system saw Maroondah (1872), Upper Yarra (1888), and O'Shannassy and Armstrong (both 1889) become supply catchments. In 1890 the Melbourne and Metropolitan Board of Works was formed, and under its Act was vested with Maroondah and Yan Yean catchments. O'Shannassy subsequently came

under the Board in 1910. Upper Yarra was not vested in the Board - despite the Board's request - but was transferred under lease.

From 1962 to 1967 a 'Public Works Inquiry into Melbourne's Future Water Supply' led to the addition of the minor catchments of the Yarra tributaries to water supply sources. This Inquiry also led to the construction of Cardinia, Greenvale, Sugarloaf, and Thomson Reservoirs. Cardinia, Greenvale, and Sugarloaf Reservoirs are off-river storages within the Yarra catchment system, and covered by waters drawn from the lower Yarra (in Sugarloaf) being fully treated. Thomson Reservoir does not have a restricted catchment, but the area is proclaimed and covered by a land use determination.

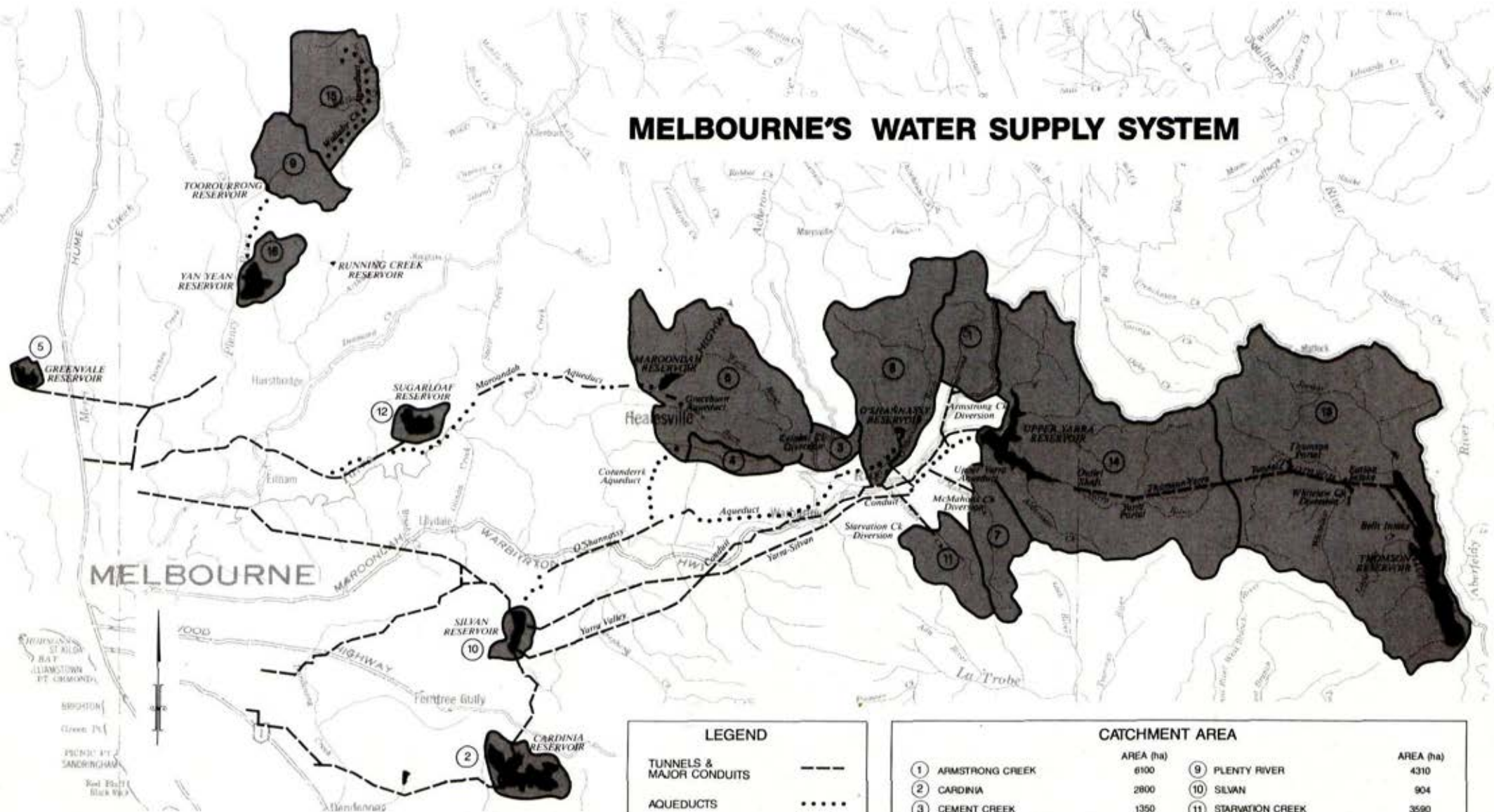
The Yarra catchments have high conservation values, and contain a number of popular recreation sites, and include large areas of ash forest. Issues relating to the values and use of the Board of Works-controlled catchments are discussed in Chapter 20.

Table 62

BOARD OF WORKS-CONTROLLED CATCHMENTS: LAND AND WATER RESOURCES

Catchment	Area of catchment (ha)	Area of buffer (ha)	Average stream flow (mm)	Land management and use
Wallaby Creek	9 100	3 050	200	- Board of Works' tenure - Strict catchment control - BofW supervised timber utilisation in buffer
Maroondah	16 540	1 290	630	- Board of Works' tenure - Strict catchment control (apart from a few legal walking tracks) - Experimental timber utilisation - Recreation in buffer area
O'Shannassy	12 720	490	790	- Board of Works' tenure - Strict catchment control
Upper Yarra	33 670	150	470	- State forest under permanent lease to Board of Works - Strict catchment control - Recreation in buffer
Yarra tributaries	14 830	80	430	- State forest under Board of Works' management - Seasonal logging in one catchment when water is not being utilised, limited public access
Thomson	48 700	-	490	- State forest and national park under Department of Conservation and Environment management

MELBOURNE'S WATER SUPPLY SYSTEM



LEGEND

TUNNELS & MAJOR CONDUITS



AQUEDUCTS



STORAGE RESERVOIRS



CATCHMENT AREAS



CATCHMENT AREA
BOUNDARY



CATCHMENT AREA

	AREA (ha)		AREA (ha)
1 ARMSTRONG CREEK	6100	9 PLenty RIVER	4310
2 CARDINIA	2800	10 SILVAN	904
3 CEMENT CREEK	1350	11 STARVATION CREEK	3590
4 CORANDERRK (BADGER) CREEK	1860	12 SUGARLOAF	906
5 GREENVALE	345	13 THOMSON	48700
6 MAROONDAH	14680	14 UPPER YARRA	33670
7 McMAHONS CREEK	4440	15 WALLABY CREEK (incl Silver Ck 2350)	4790
8 O'SHANNASSY	12720	16 YAN YEAN	2250

MAP 13

Cartography by Thematic Mapping Unit
Survey & Mapping Victoria

LCC Land Conservation Council
Victoria

Subsequent to Council's 1973 investigation, Thomson Reservoir has been constructed and begun operation. Although waters are transferred from this to the Upper Yarra Reservoir, its catchment is State forest and part of Baw Baw National Park. Timber-harvesting and recreation occur within the State forest area, and access is only restricted in the management zone, a 200-m buffer above the full supply of the reservoir.

Maroondah, O'Shannassy, and Wallaby Creek catchments are under the management and tenure of the Board of Works. Upper Yarra and the Yarra tributaries (comprising the separate catchment areas of Armstrong Creek, Armstrong Creek east, Cement Creek, Starvation Creek, and McMahon's Creek) are State forest areas leased to the Board of Works. All these Yarra catchments operate under a policy of restricted access by the Department of Conservation and Environment. Access is encouraged at a number of reservoir parks, approved scientific research is allowed, and the Board conduct tours through some areas; however, all other public access is prohibited. Table 62 summarises the area and tenure of each catchment.

Water Storage and Delivery

Surface waters can be harvested either from impoundments of watercourses, for storage or diversion, or from unimpounded ones. While diversion weirs and water extraction

can produce significant local environmental impacts, it is the effects of water storages - especially on-stream impoundments - that produce significant environmental effects.

It is not possible to list all water barriers and impoundments within the study area as no such inventory has been undertaken, and could involve several hundred structures. Table 63 lists all the larger water storages, although in differentiating between storages and service basins presents some difficulties. As can be gauged from the table, storage capacity varies considerably.

Several major storages have been completed since the Land Conservation Council's 1973 investigation - Sugarloaf (1980), Blue Rock (1984), and Thomson (1983) Reservoirs. Water harvested from Thomson Reservoir is apportioned on the following basis: Board of Works (60%), Mornington Peninsula and District Water Board (30%), and the Rural Water Commission (10%). Blue Rock Reservoir supplies the La Trobe Valley.

Thomson and Blue Rock storages impounded watercourses that previously had no major storage. As a consequence of the storage-construction programs, few large watercourses without a substantial impoundment remain within the study area. No further large storage projects have begun since the completion of Blue Rock Reservoir in 1984.

Table 63

MAJOR WATER STORAGES

Basin	Storage	Capacity (ML)	Primary purposes	Watercourse	Agency
Goulburn	Eildon	3 390 000	Irrigation	Goulburn River	Rural Water Commission
Thomson	Thomson	1 123 000	Urban	Thomson River	Board of Works
La Trobe	Blue Rock	200 000	Urban, Industrial	Tanjil River	LRWA
	Moondarra	30 300	Urban, Industrial	Tyers River	LRWA
	Yallourn	7 995	Industrial	La Trobe River	SECV
Sth Gippsland	Candowie	2 270	Urban	Tennent Creek	Western Port Water Board
	Lance Creek	1 900	Urban	Lance Creek	Wonthaggi--Inverloch Water Board
Bunyip	Cardinia	287 000	Urban	Off river	Board of Works
	Devilbend	14 600	Urban	Devilbend Creek	MPDWB
	Tarago	37 600	Urban	Tarago River	Tarago Water Board
Yarra	Maroondah	22 000	Urban	Watts River	Board of Works
	O'Shannassy	4 000	Urban	O'Shannassy River	Board of Works
	Silvan	40 000	Urban	Off river	Board of Works
	Sugarloaf	95 000	Urban	Off river	Board of Works
	Upper Yarra	200 000	Urban	Yarra River	Board of Works
	Yan Yean	30 000	Urban	Off river	Board of Works

Note:

1. Major storage: capacity exceeding 1000 ML

Sources: Board of Works (1988), DWR (1989), OCE (1989)



Moondarra Reservoir

The rapid expansion in total storage capacity from new storage constructions that characterised the water industry up to the early 1980s has not continued. As the industry enters its 'mature phase', the emphasis is on water management, which supersedes that sustained growth. Factors contributing to this new phase include the high construction costs of storages, the reduced number of sites available for large storages, and an awareness of the associated environmental costs. However, the issue of future water-harvesting for Melbourne is discussed below.

Despite a considerable body of overseas research on the environmental effects of storages, from which many general conclusions may be drawn, few specific, local studies have been conducted. As most of the local storages were constructed prior to a widespread environmental awareness, limited data are available on conditions before construction, except for research on the Thomson Reservoir.

Storages produce a range of in-stream environmental effects and associated floodplain and watercourse effects. In addition to the physical changes attributable to alterations to stream-flow patterns and yield, they produce a range of direct and indirect biological effects.

Storage construction, at least in the initial phase, lowers water quality by releasing sediment to the watercourse. Storages inundate large areas, and the impoundments act as barriers in the aquatic ecosystem. Retention or diversion of stream flow often curtails the high-flow events, resulting in

reduced floodplain and wetland inundation downstream of the storage. Stream-flow seasonality is reversed by storages operated to provide irrigation waters. This often results in changes to water temperatures, depth, current, and chemistry. Water in large impoundments can alter in both temperature and chemistry, and so released waters differ from those of natural conditions. Storages can substantially affect biological activities - such as migration, feeding, reproduction, and respiration - resulting in changes to species composition and population levels. Longer-term data from the Thomson Reservoir monitoring program should provide more detailed information on how the storage affects biota and measure the extent of biological recovery.



Thomson Reservoir

A good indication of the effect of storages on stream flow is provided by Eildon Reservoir, on the Goulburn River, operated primarily to provide irrigation waters. Under natural conditions, July to September stream flows account for 52% of the annual total, with January to March flows contributing only 5%. Operation of the Reservoir reduces July--September flows to 33% of the total and boosts the January--March component to 23%. Eildon Reservoir and Goulburn Weir (downstream of the study area) have reduced the annual stream flow of the Goulburn to less than half that of previously unregulated conditions.

Stream flow in the Yarra has been similarly reduced by water-harvesting; at Warrandyte it is now about half that of unregulated conditions (that is, without extractions).

Flooding frequency can also be reduced by impoundments. For example, prior to

construction of the Eildon Reservoir, the lower Goulburn River flooded in 30 out of every 39 years; in the 21 years following construction, flooding occurred in only 9 years.

Delivery

In large urban and irrigation supply systems, storage, distribution, and reticulation are highly complex. Multiple service basins and pumping stations, together with treatment plants, are a feature of the Melbourne and Mornington Peninsula systems. The Board of Works system contains more than 15 000 km of water supply lines. Part of this system comprises a number of open aqueducts. Many of the facilities associated with the of storage and delivery systems occupy public lands and require suitable land use recommendations. Small town supplies usually operate on a straightforward system comprising a single service basin, treatment plant, and reticulation.

All towns in the study area with more than 1000 persons receive a reticulated supply.

Water Quality and Treatment

Achieving and maintaining a level of quality for reticulated supplies within the limits established by recognised water-quality guidelines requires appropriate catchment management, storages, treatment, and distribution, with proper equipment and trained operators.

Untreated or 'raw' water is usually considered bacteriologically unsuitable for human consumption, especially if drawn from surface resources. Such water may also be unsuitable from a physico-chemical viewpoint, particularly with respect to turbidity. However, naturally forested catchments and storage in large impoundments over a long duration facilitates reduces turbidity, producing water that is relatively easy to disinfect and that may require relatively less chemical treatment to achieve clarification. Disinfection is required to protect against possible faecal contamination.

As described above, catchment protection is the first stage in protecting water quality. If raw water can be harvested at the highest possible quality, then the ensuing intensity of treatment (to ensure compliance with the

guidelines), and associated costs are lower than those for lesser quality raw water.

Examination of the water-treatment processes carried out by each water-supply authority provides a broad indication of the level of treatment, as shown in Table 64. Metropolitan Melbourne is not discussed here, as it lies outside the study area, although the issues of water supply catchment protection constitute a major land use issue and are linked to issues of Melbourne's drinking-water quality.

There is a general correlation between level of treatment and the resultant drinking-water quality. Water in which no disinfection occurs has a high likelihood of poor bacteriological quality. Supplies subject to filtration/sedimentation are more likely to have superior physico-chemical quality than those without.

Water quality is measured using microbiological, physical, and chemical parameters. Regular monitoring and analysis are undertaken by the State Water Laboratory (Rural Water Commission). Some water-supply authorities do not monitor their supplies for bacteriological quality at the recommended minimum frequency of once per month, while others do not have any monitoring program.

World Health Organisation (1984) guidelines form the basis for assessing water quality; the most recent results available are presented in the following section.

Sedimentation (which is usually preceded by chemical coagulation to aid flocculation) reduces suspended particles, improves colour and turbidity, and also allows more effective disinfection. Filtration removes suspended organic and inorganic particulate matter, and improves physico-chemical quality, thereby enhancing disinfection. Fluoridation is applied for dental health care. Chlorination is used for disinfection of the water.

Microbiological quality

Water-supply authorities are required to submit samples for analysis to the State Water Laboratory (SWL) at regular intervals, usually on a monthly basis. Results are forwarded to the authorities and published annually by the SWL.

Table 64

WATER SUPPLY SERVICE AND LEVEL OF TREATMENT

Authority	Town	Treatment	Source of supply		
GOULBURN BASIN					
Alexandra Shire	Alexandra	C	Goulburn River		
	Buxton	C	Steavenson River		
	Eildon	C	Eildon River		
	Thornton	-	Rubicon River		
Broadford WB	Broadford	C	Sunday Creek		
Kilmore Shire	Kilmore, Wandong	-	Hazel, Harpers, and Sunday Creeks		
Mansfield & District WB	Bonnie Doon	C	Eildon Reservoir		
	Mansfield	C	Delatite River		
	Woods Point	-	Brewery Creek		
Marysville WB	Marysville	C	Steavenson River		
Pyalong WB	Pyalong	SS F/C	Mollison Creek		
Seymour WB	Seymour	S/F/C	Goulburn River and Falls Creek		
	Tallarook and Avenel	S/C	Bulk supply from Seymour & Hughes Creeks		
Yea WB	Yea	S/C	Yea River		
LA TROBE BASIN					
Moe WB	Newborough	S/C	Tanjil River		
	Moe	S/C	Narracan Creek		
Narracan Shire	Erica	-	East Tyers River		
	Rawson	-	East Tyers River		
	Trafalgar	S/C	Sunny and Narracan Creeks groundwater		
	Thorpdale	C	Easterbrook Creek		
	Yallourn Nth	S/F/C	Bulk Supply SECV		
	Yarragon	S/F/C	Rollo Creek groundwater		
Tarago WB	Buln Buln, Rokeby	-	Tarago River		
	Nilma, Darnum	C	Tarago River		
	Noojee	C	Deep Creek, Loch River		
	Warragul	C	Tarago River		
SOUTH GIPPSLAND BASIN					
Korumburra WB	Korumburra	S/F/C	Bellview Creek, Coalition Creek		
	Loch, Poowong, Nyora	S/F/C	Little Bass River		
Leongatha WB	Leongatha	S/F/C	Ruby Creek		
Morwell WB	Mirboo North	S/C	Little Morwell River		
Sth Gippsland WB	Fish Creek	C	Battery Creek		
	Foster	S/F/C	Deep Creek		
	Toora	S/F/C	Agnes River		
	Welshpool, Port Welshpool, Port Franklin	S/F/C	Agnes River		
Tarwin Valley WB	Dumbalk	C	East Tarwin River		
	Meenyan	C	East and West Tarwin River		
Wonthaggi--Inverloch WB	Inverloch	C	Lance Creek		
	Wonthaggi, Cape Paterson	C	Lance Creek		
Western Port WB	Archies Creek, Bass, Coronet Bay, Corinella, Dalyston, Grantville, Kilcunda, Phillip Island, San Remo	C	Candowie Reservoir		
BUNYIP BASIN					
Board of Works	Dandenong, Springvale	C/FL	Board of Works		
Lang Lang WB	Lang Lang	C	Groundwater		
Mornington Peninsula and District WB	Mornington Peninsula Pakenham	C/FL	MP supply upstream		
Tarago WB	Drouin	S/C/FL	Labertouche Creek		
	Neerim South	C	Tarago Reservoir Tarago Reservoir		
YARRA BASIN					
Emerald District WB	Avonsleigh, Cockatoo, Emerald, Gembrook, North Avonsleigh	C	McCrae and Tomahawk Creeks		
Kilmore Shire	Kilmore, Wallan, Wandong		Hazel, Harpers, Sunday Creeks		
KEY:					
<i>Treatment</i>	S	-	Sedimentation		
C	-	Chlorination	SSF	-	Slow sand filtration
FL	-	Fluoridation	<i>Authority</i>		
F	-	Filtration	WB	-	Water board

Note:

1. Metropolitan Melbourne is outside the study area and not included above.
2. Moe Water Board was included in the Latrobe Region Water Authority on May 20, 1991.

Source: DWR

Microbiological quality of water is assessed by testing for the presence of organisms (faecal coliforms and total coliforms) that indicate that other pathogenic (disease-causing) organisms may also be present. World Health Organisation Guidelines require the complete absence of faecal coliforms in all samples and zero coliforms in 95% of samples. The remaining 5%, may contain up to three coliforms, but not in consecutive samples. Those results presented in Table 65 are expressed against a nominal WHO criteria (SWL), which simply requires zero *Escherichia coli* (faecal coliforms) and zero coliforms in 95% of samples.

Table 65 presents microbiological results (for samples taken both from within the distribution system and from material entering it) for the towns within the study area.

Water quality within the system indicates the quality received by consumers. The quality of material entering the distribution system gives some indication of catchment condition with respect to water quality. Where water quality diminishes between entry and distribution, contamination is occurring within the distribution system.

A failure to meet WHO guidelines implies a risk to human health. Examination of Table 65 reveals poor microbiological quality in many townships.

Poor drinking-water quality exposes a population to risk of water-borne disease, with the aged, infirm, and infants having the highest susceptibility. Fortunately, no major outbreaks of water-borne disease have been recorded in the study area in recent years.

Effective disinfection of drinking water can only be achieved if the water has low turbidity (<1 NTU). Chlorination of dirty water reduces the risk of conveying water-borne diseases, but may not be fully effective. Townships without chlorination, shown in Table 65, have poor water quality; in 1987/88 these were: Buln Buln, Erica, Kilmore, Newborough, Rawson, Rokeby, Wallan, and Wandong.

A number of townships supplied an insufficient number of samples and so were

inadequately assessed in 1987/88: Buln Buln, Darnum, Drouin, Lang Lang, Macclesfield, Neerim South, Nilma, Noojee, Rokeby, Warragul, and Yea.

Only Avonsleigh reaches the nominal WHO guidelines, but 36 360 people in 18 townships have water supplies that meet the guidelines on more 75% of occasions. Some 5480 people receive unchlorinated supplies; none had a zero *E. coli*/zero coliform result above 15% in 1987/88. Total population of townships inadequately assessed was 16 730.

Physico-chemical quality

Water's physico-chemical quality is also assessed against the World Health Organisation guidelines. Results of this monitoring for 1981 to 1986 are shown in Table 66, and are expressed as the percentage compliance against the guideline values. A number of parameters are regularly assessed - pH, electrical conductivity (EC), colour, and turbidity. These parameters influence aesthetic water quality.

As the results cover several years, a low level of compliance for any parameter indicates a persistent water quality problem. Turbidity compliance can be of concern, as high turbidity levels reduce the effectiveness of chlorination. Several systems have exhibited a turbidity compliance of 50% or less. Compliance for salinity (measured by electric conductivity) is at 100% for all systems except one. Although generally high, the pH compliance varies between 0 and 100% for different systems. Colour has a generally poor level of compliance; only one supply has a 100% compliance and over half the systems do not achieve a 50% compliance.

Urban Water Use

With the exception of Goulburn basin, water in the study area is predominantly for urban use, of which Melbourne's water demand is predominant.

Generally, the gross difference in total urban water use between different settlements is essentially a function of population size. Other factors can influence this, for example *per capita* household use, industrial water use, seasonal fluctuations in climate, and changes in population due to tourism.

Table 65

BACTERIOLOGICAL DRINKING-WATER QUALITY - 1987/88

Authority	Town	Population	Treatment	% samples ^a	% samples ^b
Alexandra Shire	Alexandra	2 300	C	58	85
	Eildon	900	C	27	73
	Thorton	150		10	0
Broadford WB	Broadford	1 580	C	28	46
Emerald District WB	Avonsleigh	1 000	C	100	80
	Clematis	1 000	C	64	80
	Cockatoo	770	C	91	80
	Emerald	2 860	C	82	80
	Gembrook	550	C	80	80
	Kallista	500	C	27	
	Macclesfield	900	C	75	80
	Menzies Creek	900	C	45	80
Kilmore Shire	Kilmore	2 500		15	0
	Wallan	1 600		11	
	Wandong	200		8	
Lang Lang WB	Lang Lang	800	C	50	
Leongatha WB	Leongatha	3 700	FSC	36	100
Marysville WB	Marysville	800	C	60	80
MPDWB	Bittern Basin	4 200	C	61	87
	Bittern Pipeline	9 200		10	83
	Cranbourne	23 300	C	26	84
	Dromana--Portsea	92 000	CN	71	59
	Frankston Pipeline	10 600	C	12	83
	Frankston Reservoir	91 200	C	41	79
	Garfield	3 400	C	29	92
	Koo-Wee-Rup	1 000	C	86	93
	Merricks--Shoreham	3 100	C	9	33
	Mornington--Mt Martha	25 000	C	38	87
	Mt Eliza	11 300	C	16	69
	Pakenham	5 700	C	20	78
	Somers Pipeline	4 400	C	28	74
	South Frankston	5 800	CN	34	79
	Tynong	1 800	C	36	96
	Upper Beaconsfield	1 000	C	66	96
	Westernport Basin	6 400	C	57	84
Moe WB	Moe	(20 000	FSC	74	71
	Newborough	(		50	71
Narracan Shire	Erica	300		0	
	Rawson	500		5	
	Thorpdale	350	C	74	
	Trafalgar	2 400	SCA	79	75
	Willow Grove	200	C	25	
	Yallourn North	2 000	FSC	13	
	Yarragon	980	C*	92	100
Seymour WB	Avenel	650	SC	64	
	Seymour	7 000	SC	71	
	Tallarook	220	SC	17	
Tarago WB	Buln Buln	150		0	
	Darnum	250	C	33	
	Drouin	3 800	SC	61	
	Neerim South	500	C	33	75
	Nilma	250	C	33	
	Noojee	400	C	88	75
	Rokeby	80		0	
	Warragul	8 500	C	7	
Tarwin Valley WB	Dumbalk	100	C	86	
	Meenyan	600	C	75	
Western Port WB	Bass	75	C	64	
	Corinella	225	C	73	
	Cowes	2 200	C	91	
	Kilcunda	100	C	60	
	Newhaven	400	C	82	
	Rhyll	300	C	73	
	San Remo	600	C	91	
	Ventnor	450	C	64	
	Woolamai Waters	250	C	55	
Wonthaggi-- Inverloch WB	Cape Paterson	450	C	63	
	Inverloch	2 000	C	48	70
	Wonthaggi	6 260	C	73	
Yea WB	Yea	1 100	SC	81	
Yea Shire	Molesworth	150	C	77	78

KEY: a - % samples with zero E.coli/Coliforms water within distribution systems

b - % samples with zero E.Coli/Coliforms water entering

A - Aeration

C - Chlorination (disinfection category)

C* - Occasionally chlorinated

CN - Chloramination (disinfection category)

F - Filtration

S - Sedimentation

Source: RWC

Table 66

PHYSICO-CHEMICAL QUALITY 1981-86 - PERCENTAGE COMPLIANCE

Authority	Reticulation	pH	EC	Colour	Turbidity	Fe
Alexandra Shire	Alexandra	44	100	25	50	
	Eildon	100	100	44	89	
	Thornton	71	100	0	57	
Broadford WB	Broadford	100	100	0	40	
Emerald District WB	Gembrook	100	100	0	83	100
	Cockatoo	0	100	0	100	
	Emerald	0	100	0	50	
Kilmore Shire	Kilmore	0	100	0	100	
	Wallan	73	100	0	100	
	Wandong	56	100	0	100	
Lang Lang WB	Lang Lang	100	100	20	60	100
Leongatha WB	Leongatha	100	100	82	100	
Mansfield District WB	Mansfield	100	100	14	14	
	Bonnie Doon	100	100	38	50	
	Woods Point	91	100	64	91	
Marysville WB	Marysville	100	100	0	91	
Mirboo WB	Mirboo North	87	100	80	80	
Moe WB	Moe	93	100	93	100	
Narracan Shire	Erica	100	33	?	?	
	Thorpdale	75	100	13	50	
	Trafalgar	77	100	62	69	
	Willow Grove	75	100	0	88	
	Yallourn North	100	100	75	100	
	Yarragon	100	100	88	100	
Seymour WB	Avenel	86	100	0	43	
	Seymour	93	100	100	100	
Tarago WB	Drouin	55	100	9	82	
	Neerim South	100	100	0	67	
	Noojee	29	100	0	43	
	Warragul	70	100	0	89	
Tarwin Valley WB	Dumbalk	83	100	0	33	
	Meenyan	100	100	0	17	
Westernport WB	Cowes	100	100	?	?	
	Rhyll	100	100	?	?	
	Corinella	100	100	?	?	
Wonthaggi--Inverloch WB	Wonthaggi	87	100	79	91	75
Yea WB	Yea	100	100	67	93	
Yea Shire	Molesworth	80	100	40	50	0
SYSTEMS						
MPDWB	Bunyip	75	100	0	67	31
	Koo Wee Rup	58	100	0	92	7
	Frankston (Res)	-	-	-	-	-
	Seaford	94	100	47	100	21
	Mornington					
	Mount Martha	100		50	100	15
	Dromana					
	Sorrento	92	100	50	100	39
	Tyabb					
	Flinders	90	100	70	100	86

Source: RWC (1988)

In Melbourne and the townships within the study area, domestic water use exceeds that for industrial, commercial, and public authorities; for example, Melbourne's domestic component accounts for 68% of total use. An exception is the Latrobe Region Water Authority, where catchments within the study area supply the high demands of industry and lesser demands of townships in the La Trobe Valley; for example, major towns there consumed only 13% of the total water use in 1988/89.

Understanding the characteristics of Melbourne's water use involves examining total use, use *per capita*, growth in consumption, and the end uses for the resource. This account will highlight a number of the significant developments that have taken place since the first Land Conservation Council investigation of the area.

Much of the discussion concentrates upon Melbourne, which dominates water-supply harvesting within the study area; it also offers

a greater amount of data and subsequent analysis for the Board of Works than for other water authorities.

Metropolitan Melbourne - with more than 2.5 million people - consumed a total of 438 000 ML in 1989. Each person thus averaged some 465 litres per day, which amounted to almost 170 000 litres annually.

Growth in Melbourne's water use was spectacular in the 1970-80 decade; however, it is necessary to examine the longer-term trend and recent developments to appreciate the broad changes in level of use. This rate of growth far exceeded the rate of population growth over the period. Total annual consumption increased from 305 000 ML to 446 000 ML between 1970 and 1980. This rapid rate of increase has not been sustained in the 1980s as a consequence of water restrictions and the Board of Works water conservation program. Demand-management measures have included revised water pricing, more efficient water-using appliances, and a public awareness and publicity campaign. Water consumption levels in Melbourne are currently 20% below the earlier projections of future demand.

Analysis by the Board of Works of Melbourne's domestic water use showed garden-watering to be the single largest use (40%), followed by toilet-flushing (20%), showers and bathing (17%), and kitchen uses (9%), while leaks accounted for 2%. No similar analyses are available for the water supply authorities in the study area.

A number of factors influence residential water use. Size of allotment and house, household income, cost of water, as well as type and size of garden all appear to influence the level of water use. Garden-watering in summer results in peak periods of consumption then. Towns with a high seasonal influx of tourists, such as those on the Mornington Peninsula and coastal towns, also experience high consumption levels in summer.

Industrial and commercial water use in Melbourne accounts for 24% of the total. Water planners have been less concerned with industrial water use, as its level has remained relatively steady over the last two decades, the time during which residential usage increased greatly.

Planning for Melbourne's future water needs

In order to help meet Melbourne's future needs, the government has established an independent review panel to examine a range of issues that include water pricing, water-efficient appliances, consumption patterns, community attitudes, and future supply options. A draft report by the panel will be released early in 1992 for public comment.



Yarra River at Warburton

As the demand for water in metropolitan Melbourne is increasing at approximately 12 000 ML per annum, a review panel has begun to examine its future water supply options through a comprehensive review of Melbourne's water resources. Issues relating to the efficient management of water demand play a prominent role in the Melbourne Water Resources Review. Augmentation options examined by the Board range from the non-traditional sources, such as the use of rain-water tanks to the more traditional options, such as harvesting from the Big or Black Rivers. Expected yield and the costs associated with each option considered are listed in 'Water for the Future' (Melbourne Water Resources Review 1981). Although diversion of water with a weir from the Big River is the most viable option, other factors, such as nature conservation and recreation values and land-use status, would play a significant role in determining the final decision.

Environmental flows

Restoring or maintaining environmental values in those watercourses where storages, or extraction of waters, influences stream

flow can be achieved by providing waters to specifically aid the aquatic environment. Such water allocations, known as 'environmental flows', are designed to overcome some of the effects of reduced or increased water supply, or changes to the normal variation. Environmental flows are discussed in Chapter 12.

Victorian Heritage Rivers

Council's Rivers and Streams Special Investigation assessed the Nature conservation, recreation, landscape, and cultural values of Victoria's watercourses. It identified 16 proposed 'Victorian heritage rivers', which are river corridors possessing natural, cultural, recreational and/or scenic values of outstanding significance. Those within the study area are the Big, Howqua, Thomson, and Yarra Rivers. Essentially natural catchments were also identified, of which the study area contains two: O'Shannassy River and Williams Creek (a tributary to the Goulburn River). Council has identified other river values and recommended measures to provide general protection. Council's final recommendations also include a wide-ranging set of management guidelines and policy recommendations which apply to all streams in the State.

Board of Works - Catchment Hydrology Research

In order to address the lack of knowledge of the relations between land use and water-harvesting in its catchments - revealed during controversies regarding timber utilisation in the catchments - the Board of Works has conducted detailed hydrological research in a series of experimental catchments.

This work began in 1948. In the mid 1960s, the Board established a set of specific aims to address the issue of the effects of forestry on water production. In 1967 it further refined a broad goal: to determine whether, and under what conditions, logging could be undertaken without loss of water quality or catchment yield. These investigations do not examine biological impacts of harvesting.

Council recommended (LCC 1977) that the Board of Works catchments form part of a Yarra Valley Multi-purpose Park. Council suggested that many forms of recreation did not affect water quality. However, the

government deferred any decisions on land use until the Board released research results from its catchment experiments.

The Board (MMBW 1980) presented a report to government, which directed that its catchments remain under strict management that prohibits commercial logging and unrestricted public access. O'Shaughnessy (1986) summarised that report, making the following points.



Big River

- * Provided both roading and timber-harvesting are well planned, and catchment protection prescriptions rigorously implemented at all times, limited road and timber-harvesting could be carried out in appropriate areas without detriment to conventional stream-flow quality parameters. However, the report warned that Melbourne's water-supply system is unfiltered and as such is sensitive to changes in stream-flow turbidity. Failure to maintain a high standard of planning, conduct, and supervision of roading and timber-

harvesting operations would necessitate water filtration at a very high capital cost.

- * Any roading in domestic water-supply catchments in an environment similar to that at Coranderrk must be of low intensity, with a minimum of stream crossings and close control exercised over the length and slope of roads draining towards the streams.
- * In terms of water yield, the report stated that the age and density of mountain ash forest, which are affected by both fire and timber-harvesting, have a major impact on stream flow: bushfires which convert old-growth forest to dense regrowth, cause large reductions in stream flow; and clear-felling and regeneration cause long-term reductions in flow compared with old-growth forest. The control of forest density was seen to have a potential, not yet experimentally verified, for increasing stream flows.

The research employed two major experimental catchments: Coranderrk - old-growth mountain ash forest; and North Maroondah - largely regrowth mountain ash. Some 17 small experimental catchments are established, ranging in size from 4 to 50 ha. An additional 120-ha catchment at Narbethong is subject to joint experimentation by the Board and the Department of Conservation and Environment.

Water quality results

Studies in Coranderrk examined the effects on water quality of roading, harvesting, and regeneration in clear-felling and selective-logging operations.

Chemical water quality changes were minor, from a water supply viewpoint. Physical water quality, in terms of suspended sediment and silt production, deteriorated and this persisted for about a year before a return to pre-treatment levels in the clear-felled catchment; persistence of deterioration lasted 9 years under selective logging. O'Shaughnessy (1986) attributes the difference in persistence to the more intensive road network in the selectively felled catchment.

Langford and O'Shaughnessy (1980) extrapolated these results to the 16 000-ha Maroondah catchment, in which it was assumed 5700 ha of ash type forest were suitable for clear-felling and regeneration. Even with careful attention to catchment protection, the authors concluded that the effects of road construction may cause long-term water quality deterioration, although small and difficult to detect.

Road sediment production continues to be examined. Recent results indicate that an unsurfaced road, with low traffic densities and well maintained, generates 30 000 kg per ha per annum. A high level of road usage increases this production rate to 35 000 kg; current levels in Maroondah Reservoir are about 300 kg of sediment per ha deposited annually.

Water yield

Bushfires that convert old-growth mountain ash into regrowth affect water yield. Kuczera (1985) found that average annual stream flows from ash areas fell by up to 50% following the 1939 fires. For every 1% of an ash-type catchment converted from old-growth to regrowth by fire, an average annual water-yield reduction of 6 mm can be expected in the following 20–30 years, with recovery to pre-fire levels taking about 150 years. Although only relatively limited results are available to date on the effects of clear-fell timber-harvesting, flows have declined after an initial increase following treatment, to significantly below pre-harvesting levels. Selective logging of old-growth mountain ash forests, which removed 30% of stand basal area, increased stream flow for 8 years, after which normal flows resumed. Other types of thinning have been undertaken in regrowth stands (uniform thinning, patch cutting, and strip thinning) and initial results indicate that stream flows have substantially increased following thinning; further monitoring will reveal the extent to which such increases persist.

Results of the research have been recognised in the Timber Industry Strategy and the Code of Forest Practice in relation to the management of water yield.

Various reports on the research program have been published, and are available from the Board of Works.

References

- Department of Water Resources (1989). 'Water Victoria: a resource Handbook.' (Victorian Government Printing Office: Melbourne.)
- Department of Water Resources (1990). 'Annual Report, 1988/89.' (Victorian Government Printing Office: Melbourne.)
- Duncan, H. (ed.) (1987). 'Monitoring Urban Water Demand: First Progress Report.' (Melbourne and Metropolitan Board of Works: Melbourne.)
- Kuczera, G. (1985). Prediction of water yield reduction following a bushfire in ash-- mixed species eucalypt forest. *Melbourne and Metropolitan Board of Works Report* No MMBW-W-0014.
- Land Conservation Council (1973). 'Report on the Melbourne Area.' (Victorian Government Printing Office: Melbourne.)
- Land Conservation Council (1977). 'Melbourne Area - Final Recommendations.' (Victorian Government Printing Office: Melbourne.)
- Land Conservation Council (1988). 'State-wide Assessment of Public Land Use.' (Victorian Government Printing Office: Melbourne.)
- Land Conservation Council (1989). 'Rivers and Streams Special Investigation.' (Victorian Government Printing Office: Melbourne.)
- Land Conservation Council (1991). 'Rivers and Streams Special Investigation - Final Recommendations.' (Land Conservation Council: Melbourne.)
- Langford, K.V., and O'Shaughnessy, P.J. (eds) (1980). A case study of Maroondah catchment. *Melbourne and Metropolitan Board of Works Report* No. MMBW-W-0011.
- LaTrobe Valley Water and Sewerage Board (1990). Annual report 1988/89. (LaTrobe Valley Water and Sewerage Board: Traralgon.)
- Melbourne and Metropolitan Board of Works (1980). Summary of technical conclusions to 1979. *Melbourne and Metropolitan Board of Works Report* No MMBW-W-0012.
- Melbourne and Metropolitan Board of Works (1987--89). *Annual Reports*.
- Melbourne Water Resources Review (1991). 'Water for the future: Issues paper'.
- Mercer, D., and Lloyd, D. (1986). Planning Melbourne's water supply system. *Australian Geographer* 17:51--64.
- Office of Commissioner for the Environment (1989). 'State of the Environment Report 1988: Victoria's Inland Waters.' (Victorian Government Printing Office: Melbourne.)
- O'Shaughnessy, P. (1986). Melbourne and Metropolitan Board of Works catchment management policies: A history and analysis of their development. *Australian National University Centre for Resource and Environmental Studies, Working Paper* 1986/28.
- O'Shaughnessy, P., and Jayasuriya, M.P.A. (1987). Managing the ash forests for water production in Victoria. *Proceedings, Institute of Foresters of Australia, Conference Perth*, pp.437--63.
- O'Shaughnessy, P.J., Jayasuriya, M.D.A., and Aney, S.G. (1989). A review of the catchment management policies of three major water supply authorities with special reference to recent Melbourne Board of Works forest hydrology research results. *Proceedings of the Thirteenth Biennial Conference of the Institute of Foresters of Australia, Leura, New South Wales*, pp.107--21.
- Rural Water Commission (1988). Physico-chemical quality of drinking water supplies 1981--86. *Rural Water Commission Report* No CE-1.
- Rural Water Commission (1989). Bacteriological water quality report for Victorian domestic water supplies (except the Melbourne metropolitan areas). *Rural Water Commission Report* No MB-6.
- World Health Organisation (1984). 'Guidelines for Drinking Water Quality; Vol 1 - Recommendations.' (WHO: Geneva.)

18. UTILITIES AND OTHER LAND USES

With such a large proportion of utilities and services vested in government agencies or statutory authorities, a large number of public land parcels and substantial land areas are involved.

Utilities and services discussed in this chapter include transport, energy, water, waste-disposal, communications, community services, and the armed forces. This chapter describes the most prominent activities, comments on the effects on some land uses, and refers to any substantial land parcels involved. It is not possible to address the full range of utilities and services, or discuss the scope of land use implications in detail.

Many major utilities and services - such as those associated with the provision and/or use of electricity, natural gas, roads, and railways - pass through the study area to reach metropolitan Melbourne. In addition, the study area contains 110 townships, all using a range of utilities and services.

Utilities and services involve structures and facilities in the landscape indicative of European settlement and, as such, feature prominently in local recorded historical sites.

Public institutions

Schools, public halls, shire offices and buildings, hospitals, prisons, cemeteries, and some areas of urban open space are publicly owned and controlled institutions, usually sited on small parcels of public land in townships, cities, and rural cities. Many such parcels were too small to be considered by the Land Conservation Council in its earlier investigation, and many occur in cities and rural cities that are outside the Land Conservation Council's jurisdiction. Public purpose reserves were nominated in the planning and surveying during European settlement, and the distribution of many public institutions has resulted from the early stages.

The features may be of considerable historical, cultural, and landscape value. Historical surveys, including one conducted for this review, highlighted the values of the public institution structures.

Community services

Services such as the Victoria Police, urban fire brigades and the Country Fire Authority, ambulance services, and emergency services operate from buildings which are often located on public lands. Relatively small parcels of public land are involved, usually in an urban or township setting; in many cases the structures occupy public purpose reserves.

Armed forces

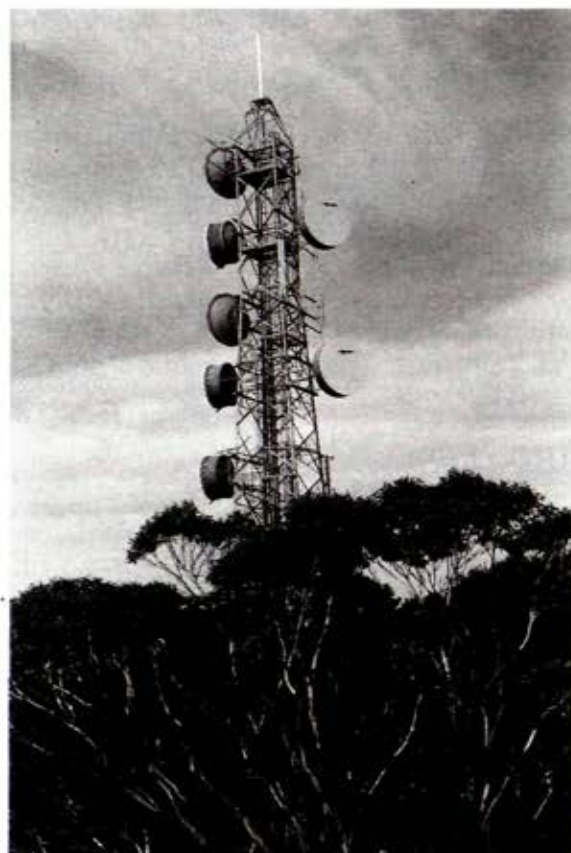
Commonwealth land is used by the Australian Army, Royal Australian Air Force, and Royal Australian Navy. High nature conservation values have been identified for some of these Commonwealth land areas, notably at Point Nepean and HMAS Cerberus at Crib Point. High conservation values exist over much of the Crib Point area, as described in Chapter 9.

The Australian Army conducts military training on public land in State forests in the Big River catchment and around Toolangi. Big River is used for 12-15 weeks annually by groups of 10-50 persons for 3- to 5-days spells. Toolangi is used for 20-25 weeks annually by groups of 20-80. Activities undertaken include adventure training, communications, and infantry exercises. Vehicular use involves three to five, 4-wheel-drive vehicles and two to three 2.5-or 5-tonne trucks.

Communications

Telephone lines and poles, radio masts, as well as satellite and microwave dishes are features of modern communication networks often located on public land. While communication structures often occupy quite a small area, they may have significant visual impact. The towers and masts atop Mount Dandenong comprise one frequently cited example.

Permanent survey marks and trigonometric stations erected on mountain tops and other prominent positions form part of Victoria's geodetic reference system. Survey beacons can be erected over the trig stations; most



Communication tower atop Arthurs Seat

have access roads. With precisely fixed positions and heights, trig stations provide the control system for all mapping, surveys, land information systems, and geographic data-bases. They are the responsibility of the State government agency dealing with these functions, currently the Department of Finance.

Navigation structures and trig stations are numerous and widespread. For example, the Port of Melbourne Authority listed more than 500 navigation aids in Western Port, which included beacons, buoys, and piles.

Transport

Roads and railway lines also occupy corridors of various widths (generally between 20 and 200 m) in public land reserves. Roads in Victoria have been calculated to cover 500 000 ha. No calculations have been undertaken to determine the total surface area they occupy in the Melbourne District 2, but it would amount to several thousand hectares. As the road network has been established for some

time, future works are likely to be re-alignments of existing roads, rather than construction of new ones. Most rail routes traverse the flatter, cleared parts of the study area.

In 1985, the State Forests and Lands Service, DCFL, calculated the density of roads for each Victorian municipality; this exceeded 16 km per 1000 ha, for the Mornington Peninsula and several local government areas (LGAs) adjacent to Melbourne, and 4 km per 1000 ha in nearly all the LGAs in the study area. Indicative of their density, roads provide great accessibility throughout the study area, as shown in two investigations of wilderness in Victoria (Preece and Leslie 1987; LCC 1990). Few areas were more than a few kilometres from the nearest road or track. Much of the network in uninhabited country can be attributed to the prevalence of formed roads, constructed for forestry purposes or fire management, that have remained open for public use. Recreation groups often oppose the closure of such roads, which were often intended for temporary use only.

Several road and rail reserves have high nature conservation values as they contain valuable patches of remnant vegetation. For example, the railway reserve between Beaconsfield and Pakenham contains the endangered orchid white diuris (*Diuris fragrantissima*). A system for assessing the conservation values of roadside vegetation in Victoria has been developed, although no assessment had been conducted for the study area. Some road and rail reserves, such as the Lilydale--Warburton railway reserve have been assessed as having high recreation values.

Railways played a major role in the economic and social development of the study area, as described in Chapter 3, but now only the high-usage lines remain open. V-line operates road transport services in place of several closed railways. Major passenger and freight trains operate between Melbourne and Sale (Gippsland line) and Melbourne and Albury. Sections of the latter route between Melbourne and Seymour cross to the west of the Hume Highway, so only portions of the line lie within District 2. Sections of the electrified metropolitan rail network extend into the study area along the Belgrave and Hurstbridge lines.

Table 67 lists the closed lines. A vigorous extension in the 1880s included many of these: the Great Southern Railway to Korumburra and Point Albert; Mornington; a branch line from Moe to Thorpdale; the Healesville line; Tallarook to Yea (and later to Mansfield); and Warragul to Noojee. Coal-carrying lines from Korumburra to Outtrim are now also closed. Other closed lines include Lilydale to Warburton and Nyora to Wonthaggi. Part of the closed Upper Ferntree Gully to Gembrook line is worked by 'Puffing Billy', a highly significant tourist attraction associated with the Dandenongs.



Trestle bridge on the closed Warragul to Noojee line

Public land carries the track easements and the railway stations, other buildings, and equipment sites. On the closed lines, many remnant features have significant historical and cultural value, exemplified in the National Trust Scenic Classification given to the Trawool Valley section of the Tallarook--Mansfield line. A section of the former Lilydale--Warburton line has been developed as the 'Centenary Trail' recreation pathway.

Table 67

RAILWAY LINES NOW CLOSED

Gippsland line (operating)
Branch : Moe--Thorpdale
Branch : Moe--Walhalla
Branch : Warragul--Noojee
Great Southern line
(Melbourne--Port Albert)
Branch : Korumburra--Outtrim
Branch : Wonthaggi--Nyora
Northern line (operating)
Branch : Tullarook--Mansfield
Frankston--Mornington
Frankston--Stony Point (operating)
Branch : Bittern--Red Hill South
Lilydale--Healesville
Lilydale--Warburton
Upper Ferntree Gully--Gembrook

A proposal for a Very Fast Train connecting Melbourne, Canberra, and Sydney is currently being assessed. The preferred route is north from Melbourne via Seymour to Albury. Examination of the route suggests that it is not likely to affect any large parcel of public land here.

Social, economic, and environmental effects of the Very Fast Train are correctly being assessed. Its environmental effects include clearing and disturbance, fire risk, creating an ecological barrier, elevated noise levels, and visual impacts. Numerous issues have arisen over the acquisition and ownership of the corridor for this private-sector project.

Coastal structures

Boat clubs, picnic areas, car parks, camping grounds, wharves, piers, and other facilities are of considerable interest in land-use planning, occupying sensitive coastal and foreshore environments often with considerable associated developments.

Table 68 lists wharves, piers, and boat ramps in the study area. None occurs on the open coasts of the mainland or Phillip Island, but many are found within Western Port, on French Island and the low energy northern shores of Phillip Island. Western Port contains about 1200 boat moorings, including 500 permanent moorings at Hastings Marina and 60 at Yaringa Marina; the remainder are mostly swing moorings.

Port facilities around Hastings are of particular interest, the location of an oil-terminal jetty at Crib Point, a liquids pier at Long Island Point, and Westhaven Marina. Pilot and other harbour services at Hastings serve deep-water commercial shipping.

More than 300 merchant ships (in excess of 2500 tonnes) use the Western Port harbour annually. In 1989, most of them carried liquid fuels - with 125 carrying Liquid Petroleum Gas and 82 carrying crude oil.

Several of the environmental effects of these developments are discussed in Chapter 9.

Table 68

WHARVES, PIERS, AND RELATED FEATURES

Feature(s)	Location
Mainland	
Pier, boat ramp (2)	Mornington
Pier	Dromana
Pier	Rosebud
Jetty, boat ramp	Blairgowrie
Pier, boat ramp	Sorrento
Pier	Portsea
Pier, boat ramp	Flinders
Slipway	Point Leo
Jetty	Balnarring
HMAS Cerberus	Crib Point
Pier, boat ramp	Stony Point
Oil terminal jetty	Crib Point
Boat harbour	Hastings
Pier, boat ramp	Hastings
Liquids pier	Long Island Point
Steel Industry wharf	Long Island
Pier, boat ramp	Warneet
Jetty	Rutherford Creek, Warneet
Pier, boat ramp	Blind Bight
Boat ramp	Tooradin North
Boat ramp	Tooradin South
Pier, boat ramp	Lang Lang
Boat ramp	Grantville
Boat ramp	Nr Grantville
Boat ramp	Coronet Bay
Pier	San Remo
Boat ramp	Corinella
Phillip Island	
Pier, boat ramp	Cowes
Ramp, boat ramp	Rhyll
Marina	Newhaven
Pier, boat ramp	Woody Point
French Island	
Pier	Freeman Point
Pier, boat ramp	Tankerton

Note:

Many smaller structures are not listed, notably small jetties in northern Western Port and southern Port Phillip Bay, and sand boat ramps.



Tooradin boat ramp

Port of Hastings

As one of Victoria's commercial ports, the Port of Hastings operates five berths for commercial shipping, which handled a total of 9 million tonnes in 1988/90. Trade was significantly higher in 1984/85 (15.6 million tonnes), but has declined due to falls in oil production from Bass Strait. Table 69 gives a description of major commodities handled and a break-up by industry sector.

Table 69

PORT OF HASTINGS: COMMODITIES AND CARGO: 1988/89

	(mass tonnes)
Major commodities handled	
Crude oil	6 920 000
Gas	1 153 000
Steel	900 000
Sectoral split of cargo	
Overseas imports	105 000
Overseas exports	1 891 000
Coastal imports	721 000
Coastal exports	6 256 000

Source: Port of Melbourne Authority

Of these five jetties, Crib Point has two, one for crude-oil tankers and the other designed for refined petroleum products. Long Island Point jetty handles crude oil and liquid petroleum gas. The BHP steel industry has two privately owned jetties, one for roll-on/roll-off cargo, the other for conventional cargo.

Sewerage and waste disposal

Collection and disposal of sewage from domestic and sewer industrial premises is the responsibility of water and sewerage authorities and selected local government authorities, so public lands carry many structures and associated facilities.

Table 70 summarises the waste-water services within the study area. Many of the larger urban centres on the Mornington Peninsula are now connected to the Board of Works system, as are the Dandenong and Springvale districts. The Latrobe Region Water Authority operates a large system in the La Trobe Valley, but Yallourn North is the only town connected in the study area. Elsewhere, the sewerage system is characterised by relatively small-scale and localised operations servicing rural towns and cities.

Public land requirements for these purposes are seldom extensive. As the activity is a noxious one, with pollution risks, the siting and location of treatment and disposal facilities require careful consideration if social and pollution problems are to be avoided.

Disposal of treated effluent occurs to land, to stream, or to both. All treatment within the study area is to secondary level, which involves biological reduction of the organic effluent, but treated effluent does raise the nutrient levels in any receiving waters. Secondary treatment is undertaken in tanks or open-air ponds, with treated effluent discharged to land and/or into watercourses. Effluent from Melbourne's south-eastern sewage-treatment plant is discharged to the ocean near Cape Schanck. Small towns are usually unsewered, with sewage collected and dispersed using on-site septic tanks and being the responsibility of individual land-owners. A trend to land discharge rather than discharging sewage effluent to watercourses has increased the areas of land managed by water boards and local government for this purpose.

A number of municipal garbage disposal facilities are located on public land throughout the study area. Greater attention to the location of sites has been necessary to reduce the environmental effects of inappropriate siting and the associated public nuisance.

A Parliamentary report on waste management in the greater Melbourne area noted several conditions that apply across the study area. Sanitary landfills (tips) will remain the major source of inoffensive waste disposal this century, but there is a need to improve waste collection, recycling, and disposal services (Victoria 1990). On average, each Victorian annually produces 800 kg of waste requiring disposal. Urban expansion in the study area is likely to be accompanied by:

- * increasing quantities of waste requiring disposal
- * rising costs of handling waste
- * problems associated with new and past landfill sites

Landfill sites suffer from a range of problems - groundwater pollution from leachates, large flocks of silver gulls, fire hazards, litter, visual offensiveness, and other nuisances.

Intractable wastes are currently being stockpiled, mostly within metropolitan Melbourne. A joint Commonwealth-New South Wales-Victoria proposal to develop high-temperature incineration facilities is underway, with the facility likely to be located in New South Wales.

Energy utilities

In Victoria, energy utilities comprise the State Electricity Commission and the Gas and Fuel Corporation. However, oil and other liquid fuels owned by private corporations are conveyed in pipelines across or beneath public lands. Linear corridors and easements carrying transmission lines and gas and oil pipelines have the most extensive impact on public lands. These corridors are commonly cleared of trees and shrubs in order to maintain access and reduce fire risks, which heightens their visual and environmental impact. They also cross private lands.

A number of major transmission lines (that is, 220 kV or more) pass through the study area, in easements varying from 40 to 160 m wide. Three major lines carry power from the La Trobe Valley to metropolitan Melbourne: Hazelwood-South Morang (500 kV); Hazelwood-Roweville (220 kV); and Hazelwood-Cranbourne (500 kV). Running north-east from Morang is the Eildon-Dandenong line, which splits into the

Table 70

WASTE-WATER SERVICES

Authority	Town	Discharge	Treatment
Alexandra Shire Council	Alexandra	Land and stream	Secondary
Broadford Water Board	Eildon	Land and stream	Secondary
Broadford Water Board	Broadford	Land and stream	Secondary
Dandenong--Springvale Water Board	Dandenong	Land and stream	Secondary
Kilmore Shire Council	Springvale	MMBW sewerage system	
	Kilmore	Stream	Secondary
	Wandong		
	Wallan	Land	Secondary
Korumburra Water Board	Korumburra	Land and stream	Secondary
Lang Lang Water Board	Lang Lang	Land and stream	Secondary
Mansfield & District Water Board	Bonnie Doon	Land	Secondary
	Mansfield	Land	Secondary
Moe Water Board	Moe	Stream	Secondary
Mornington Peninsula & District Water Board	Mornington Peninsula	MMBW sewerage system	Secondary
Narracan Water Board	Rawson	Stream	Secondary
	Trafalgar	Stream and land	Secondary
	Yallourn Nth	LaTrobe Valley outfall sewer	
	Yarragon	Stream and land	Secondary
Pakenham Water Board	Pakenham	Stream	Secondary
Seymour Water Board	Seymour	Land and stream	Secondary
South Gippsland Water Board	Foster	Ocean	Secondary
	Toora	Ocean	Secondary
Tarago Water Board	Drouin	Land and stream	Secondary
	Warragul	Stream	Secondary
Wonthaggi--Inverloch Water Board	Wonthaggi	Ocean	Secondary
Yea Water Board	Yea	Land and stream	Secondary

Source: DWR (1989)

Eildon--Templestowe/Mt Beauty--Eildon line (220 kV) and the Dederang--South Morang line (330 kV).

Terminal stations reduce the 220 kV and above to the lesser 22 and 66 kV for the metropolitan distribution system. South Morang station occupies 60 ha in the City of Whittlesea; those within the study area are located at Tyabb (9 ha) and at Thomastown (24 ha). Future terminal stations are planned, principally on the urban fringe of metropolitan Melbourne. Substations (22-and 66-kV) are more numerous and usually small, covering 1--3 hectares, and are located at Eltham, Epping, Hastings, Lilydale, Pakenham, Rosebud, and Warragul.

Hydro-electricity comes from: three hydro-electric power stations in the Rubicon River valley at Rubicon, Royston, and Rubicon falls; Eildon Power Station, situated at the Eildon Weir dam wall on the Goulburn River; and another hydro-electric power station recently installed on Thomson Reservoir. A current study underway is investigating opportunities for further hydro-electric developments, although it is likely that these will be limited to existing water storages of sufficient size. A study by the State Electricity Commission has identified potential hydro-electric stations.

Planning by the State Electricity Commission has identified power requirements in the near future and none involves thermal-power-station construction in the study area.

Power-station siting was considered in some detail in the Council's earlier investigation, which identified several potential sites: Tyabb, Red Bluff, and Penal Settlement (French Island), and the Corinella--San Remo--Cape Paterson region. Power station developments have not occurred in the study area, but have continued in the La Trobe Valley with the construction of Loy Yang Power Station, in Melbourne at Newport Power Station, and in Gippsland at the Jeeralang Gas Power Station. Large brown-coal stations in the La Trobe Valley will continue to provide the bulk of electrical energy for Victoria in the medium term, but energy conservation and renewable forms of energy will have an increasing role.

A government *Green Paper* on renewable energy describes several proposals for energy generation. Geothermal, wind, landfill gas, hydro-electric, and wave energy have been nominated as potential sources, each of which carries implications for public land use. Wind power stations and further hydro-electric schemes could be located in the study area. Compilation of a 'wind atlas' of the

Victorian coast is being undertaken to determine suitable locations for a 'wind farm' of wind-powered generations.

Underground natural gas and oil pipelines connecting the Bass Strait fields with Melbourne traverse the study area, as do those from Hastings to Melbourne. Depletion of Victoria's oil and gas reserves in Bass Strait in the long term may influence land uses by the energy utilities. Increased oil imports could be shipped to Western Port - a possibility described in Chapter 9. This would require additional port, handling, and storage facilities and further pipeline easements.

Changes in Victoria's longer-term energy use are inevitable, through the altered availability of different forms of energy and altered characteristics of energy use. It is highly uncertain how such altered circumstances will affect the study area in the short term.

Water supply

At present, 24 water supply authorities operate in the study area. Most have both harvesting facilities (that is, storages and

diversion weirs) and distribution systems (that is, service basins, pumping stations, water treatment, pipelines, and aqueducts). Others operate distribution systems only and purchase water from another authority.

Of the systems within the study area, the Board of Works and the Mornington Peninsula and District Water Boards are by far the largest. The MPDWB distributes water harvested outside its own district by the Board of Works, which sells it to the MPDWB. As shown in Map 13, the Board of Works operates a complex and lengthy system of aqueducts and pipelines.

Water supply catchments and major storages have been described in Chapter 17.

Approximately 170 gauging stations are listed in the study area, although many are no longer monitored. Water courses subject to harvesting carry the greatest concentrations of gauging stations.

River frontages, banks, and beds

River frontages are areas of public land associated with those water courses generally



The Goulburn River, near Thornton - fishing is popular here

within private land. These frontages, although varying considerably in width, usually measure 20 m. In nearly all cases, river banks and beds are public land. Frontages have nature conservation, recreation, landscape, geological, historical, and other cultural values. Management of river-frontage reserves is the responsibility of the Department of Conservation and Environment. This responsibility is shared with the Board of Works in parts of the Yarra River basin. A variety of agencies are responsible for bank and bed management, including river management boards, DCE, and the Board of Works. Although an administrative distinction is often made between frontage management and bank and bed management, values of these areas are interrelated and their protection requires co-ordinated management.

Water-frontage reserves have important environmental uses. Many contain remnant vegetation, and serve as wildlife refuges and corridors for their movement. Riparian and in-stream vegetation provides food, shelter, and habitat for a variety of aquatic and terrestrial fauna. In addition to stabilising stream-banks, vegetated frontages serve as buffers or filter strips to nutrients and sediments in catchment run-off.

Agricultural uses of frontages include grazing under licence and stock-watering. In some locations these activities have greatly reduced environmental values of river frontages, banks, and beds.

These areas have high recreation value, as water-based and water-enhanced activities are both numerous and popular. Riparian understorey vegetation is often disturbed at sites of high use, such as popular fishing spots along the Yarra and Goulburn Rivers, and this often represents a conflict in land uses.

References

- Department of Industry, Technology and Resources (1990). Renewable energy and energy conservation strategy. *Green Paper*.
- Department of Water Resources (1989). 'Water Victoria: a Resource Handbook.' (Victorian Government Printing Office: Melbourne.)
- Grieves, C., and Lloyd, D. (1984) Conservation of roadsides and roadside vegetation. *Arthur Rylah Institute, Technical Report No. 11*,
- Land Conservation Council (1973). 'Melbourne Study Area.' (Victorian Government Printing Office: Melbourne.)
- Land Conservation Council (1977). 'Melbourne Study Area - Final Recommendations.' (Victorian Government Printing Office: Melbourne.)
- Land Conservation Council (1988). 'Statewide Assessment of Public Land Use.' (Victorian Government Printing Office: Melbourne.)
- Land Conservation Council (1989). 'Rivers and Streams Special Investigation.' (Victorian Government Printing Office: Melbourne.)
- Land Conservation Council (1990). 'Wilderness: Special Investigation.' (Victorian Government Printing Office: Melbourne.)
- Preece, K., and Leslie, R. (1987). 'A Survey of Wilderness Quality in Victoria.' (Ministry for Planning and Environment, Victoria, and the Australian Heritage Commission: Canberra.)
- State Electricity Commission of Victoria (1989). *Annual Report 1988/89*.
- State Rivers and Water Supply Commission (1984). 'Victorian Surface Water Information to 1982.' Vols. 1, 2, and 3 (Victorian Government Printing Office: Melbourne.)
- Victoria, Parliament, Natural Resources and Environment Committee (1990). 'Waste Management in the Greater Melbourne Area.' (Victorian Government Printing Office: Melbourne.)

19. HAZARDS AND CONFLICTS

Hazards are those phenomena that reduce the identified values of physical and biological resources and conflict with the benefits derived from those resources. Principal hazards are fire, flood, soil deterioration, and introduced species. Major values reduced by such hazards include those of nature conservation, land productivity, recreation, water quality, and landscape.

Council's earlier consideration of 'hazards and conflicts' examined the effects of natural phenomena on human activities. Recent LCC investigations and reviews consider the effects of natural phenomena on the values derived from public lands, including the effects on environmental values.

Environmental conditions existing prior to European settlement provide the benchmark against which many hazards are evaluated. Although the Aboriginal people practised a system of land management, principally through the agency of fire, their land-use practises are believed to have formed part of a sustainable ecological system.

Subsequently, European land-use practises have substantially modified the landscape and the ecological systems. Manifestations of these practices include broad-scale removal of native vegetation, loss and extinction of native species, altered fire regimes, increased soil loss, changed catchment hydrology, and degradation of rivers and streams. As a result, a range of hazards affecting the natural environment have been created.

Characteristics of European occupation - such as extensive urban infrastructure or the occupation of floodplains and forests - make the land susceptible to natural events of flood and fire. Such natural phenomena are integral aspects of the Victorian ecosystem and have essential environmental functions. Victorians are acutely aware of the social and economic costs imposed by the severe forms of these hazards. Continued occupation of high-risk areas necessitates programs to control the incidence of extreme events and to manage their subsequent effects.

Land-use hazards can be linked to concepts of sustainability. Many current land uses are

not sustainable, and have promoted the rapid loss of environmental values and the generation or escalation of natural hazards. Many of the remedial or controlling measures put in place have the effect of creating more stable and sustainable systems.

Soil Deterioration

Soil deterioration can result from fertility loss, contamination, loss of structure, or various forms of erosion. Where soils are no longer protected by indigenous native vegetation, a potential for deterioration exists. Land use and land management are crucial determinants of soil condition.

Erosion - predominantly water erosion - is usually cited as the major form of soil deterioration in the study area. Wind erosion has caused dune blow-outs and loss of vegetation in places along the ocean coast.



Pedestrian and vehicle access can damage dune vegetation and result in erosion; this site is near Wonthaggi

Initiated by local vegetation loss, remedial plantings, usually of introduced marram grass, have been successful on the Mornington Peninsula.

Salinity is not a major problem in the study area, with only areas north of Seymour and the Western Port district affected.

Nutrient loss through leaching, soil structure changes from compaction, and changes to the composition of the soil microfauna are recognised soil deterioration features. Insufficient research is available to enable description of the extent of these problems in the study area, if in fact they are problems here.

Loams, clay loams, and sandy clays are liable to compaction. Compaction can occur on these soil types under agricultural production, where the effects of cultivation, vehicular movement, or stock trampling compress the upper soil layers.

Soils contain a large and diverse number of organisms, of which micro-organisms are primarily responsible for the release of minerals and carbon dioxide. Soil microfauna comprise fungi, bacteria, algae, viruses, and actinomycetes. These all significantly influence water infiltration, aeration, porosity, and soil structure, but, currently, relatively little is known about the effects of cultivation, fertilisation, and other land management practices on them. Fertilisers can be adversely affect some of them, as well as larger soil fauna such as earthworms. For example, superphosphate can have an immediate, but transitory, effect on nitrogen-fixing micro-organisms. Cultivation may stimulate some micro-organisms through the provision of additional food sources, while the associated temperature rises and soil drying may adversely affect others.

Water erosion

Whether in sheet, gully, or tunnel form, water erosion, has been a significant problem in parts of the study area. Exposure of the soil surface to water can result in the rapid and sustained removal of particles, leading to the creation of gullies, tunnels, and exposed lower soil horizons. Soil loss, an immediate product of water erosion, is described in Chapter 14.



Erosion control measures on Lake Mountain ski-trails

The erosion potential of land (the 'erosion hazard') is realised when an area is subject to inappropriate land management. Frequent causes of accelerated erosion include vegetation clearing, cultivation, construction works (roads and buildings), vehicular use, grazing, mining, and timber-harvesting.

Water erosion affects a range of values. Removal of the upper soil layers, which contain most nutrients, causes a loss of fertility, thereby lowering productivity. Sites of severe erosion become lasting landscape features, on which natural revegetation becomes unlikely. Large gullies on agricultural lands constitute a hazard to stock and machinery.

Waters receiving run-off from highly eroding catchments suffer from reduced quality, as turbidity and levels of suspended solids increase. The chemical quality of the water may also be affected. Siltation of streams resulting from accelerated erosion can harm aquatic biota and alter the hydraulic character of the water course and its associated floodplain.

Mapping of erosion hazards has not been completed for the study area, but available land-system mapping data can be compiled to form a composite image (see Map 9). High erosion hazard occurs in locations exhibiting such characteristics as high or intense rainfall, moderate to steep slopes, and shallow or skeletal soils.

Soil loss was often an immediate consequence of vegetation clearance last century and recognition of water erosion damage is recorded in the accounts of early settlers. Degraded catchment and riverine conditions combined with associated flood damage became acute in many parts of the State in the mid and late 1940s. In 1948 river improvement trusts were instituted and in 1950 the Soil Conservation Authority was formed. Working independently, the trusts undertook works in their own small districts, whereas the SCA was primarily an advisory body operating through a State-wide extension program. Following government restructuring, the functions of the SCA now reside in the Department of Conservation and Environment.

One major SCA soil conservation program in the study area involved the cleared catchments around Eildon's Reservoir. Catchment management - the integration of land and water planning and management - is a relatively recent achievement. Formation of catchment co-ordination groups and transforming river improvement trusts' outlook from local districts to the whole of the catchment are probably its most prominent expression. However, a range of land and water management agencies and private land managers have exhibited awareness of the catchment management concept in a variety of ways. Currently, one catchment co-ordinating group operates in the study area in the Goulburn catchment.

'LandCare', a government program, is designed to encourage community-based land management through projects on both public and private land. It provides technical and financial support to farmers and community groups for land protection and restoration projects, undertaken in conjunction with the Department of Conservation and Environment. Public land 'LandCare' projects can include revegetation of roadsides, coastal sites, and stream-banks, and protection of remnant vegetation.

Other groups are the farm tree groups (sponsored by the Victorian Farmers Federation and Garden State Committee) and the Land Protection Advisory Committee.

Fire

Fire and the study area

Eucalypt forests are extremely fire-prone and major bushfires are a feature of the Central Highlands. While these can be catastrophic to human life, property, and assets, fire also has an important role in forest ecology. Fire prevention and suppression are major management activities on public land, but may also have environmental effects.

Both Aboriginal and European cultures have made use of fire. Many authors and several historical accounts have described its manipulation by Aborigines to assist in mobility, food-gathering, and hunting, often referred to as 'firestick farming'. Such activities are believed to have influenced vegetation patterns. In contrast, Horton (1982) claims that Aborigines had little impact on native flora and fauna distribution with fire and, while they may have exploited an existing one, did not develop a new fire regime. 'Firestick farming' was possibly prevalent on plains and open woodlands (most of which are now private agricultural lands in the study area), but less so in mountain forests that the tribes only occupied periodically.

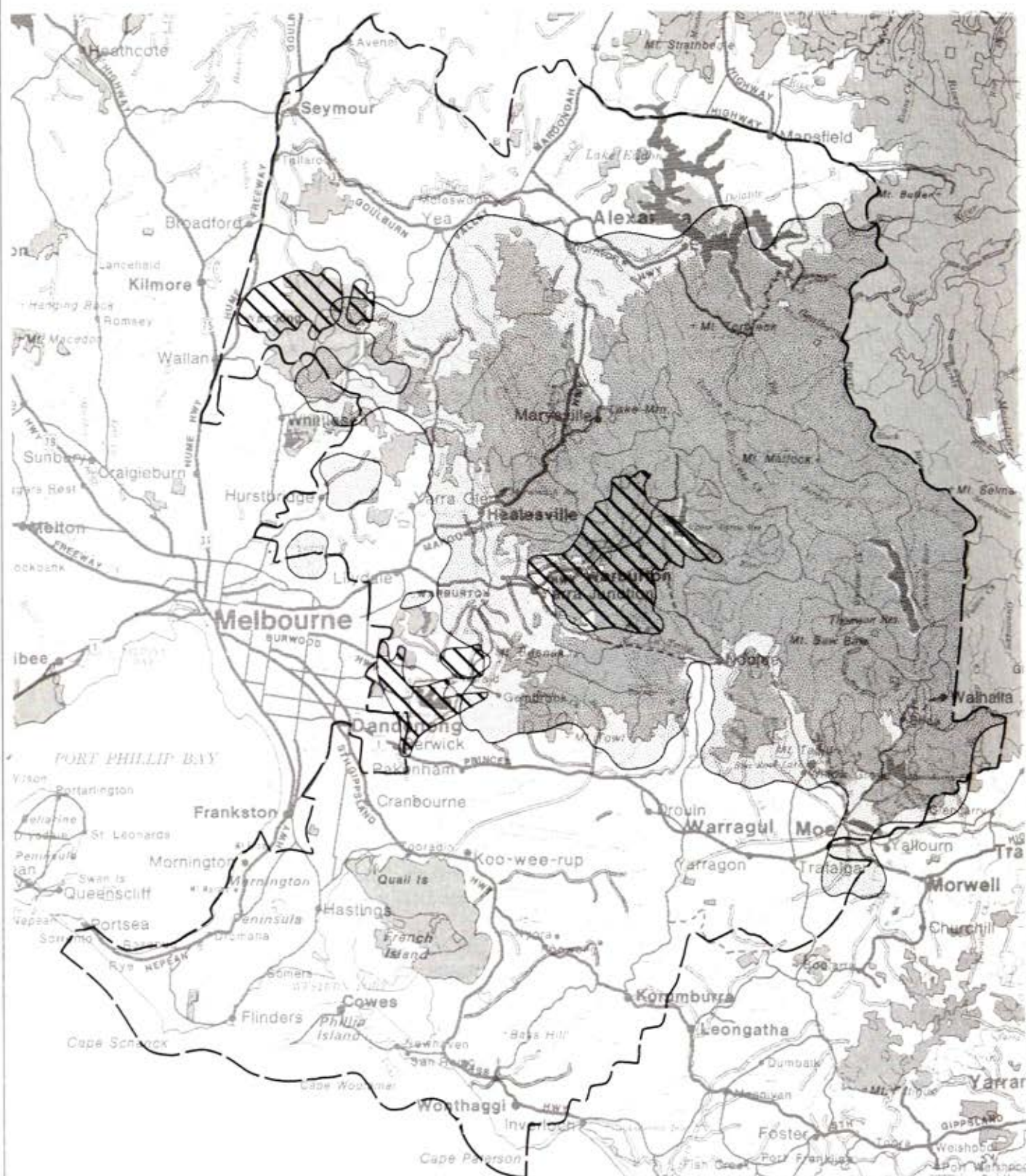
Early European settlers used fire as a primary means of forest and scrub clearing, and for pasture regeneration. Suppression and prevention of forest and grass wildfires are now features of European settlement, with a controlled use of fire for prevention and forest regeneration.

Losses from fire have been as great in the study area as anywhere in Victoria. As described in Chapter 3, fire has been a powerful and destructive agent in shaping our attitudes to, and use of, the Central Highland forests.

Ash Wednesday, 1983

Since the earlier LCC investigation, the Ash Wednesday Fires of 16 February, 1983, devastated parts of the study area. Three separate fires occurred: Belgrave

MAJOR BUSHFIRES



LEGEND

1938-39



1982-83



PUBLIC LAND



STUDY AREA BOUNDARY



1 : 1 000 000

10 0 10 20 30 40 50
Kilometres



Land Conservation Council
Victoria

Heights/Upper Beaconsfield; Cockatoo; and Warburton. In total, these burnt some 51 000 ha of public and private lands. Tragically, they caused 27 fatalities and destroyed 619 houses and other buildings. Nearly all of the 40 000 ha burnt in the Warburton fire was forested public land. The extent of the major 1939 and 1983 fires is shown on Map 14.

Forests and fires

Wet sclerophyll forests, with two or three layers of shade-tolerant trees, or a dense understorey of shrubs and ferns in more open situations, occur in higher-rainfall areas. The forests contain higher fuel quantities than dry sclerophyll forests, and may become extremely flammable during prolonged drought periods. Ash species are fire-sensitive, as described below. Rainforests are rarely flammable, except during severe droughts.

Dry sclerophyll forests possess a dominant tree layer with a well-developed shrub stratum. Although flammable in most seasons, most tree species are fire-resistant and survive even high-intensity fires.



Vegetation loss from fires this year at Warburton

Fire hazard

A number of factors contribute to the area's high fire hazard - fuel, climate, and fire conditions. Available fuel is a major determinant of fire intensity and rate of spread. Fuel accumulation can be expressed in terms of weight per unit area or height; forest fuel levels are usually measured as tonnes per hectare. Light fuel loads of 5 tonnes per ha consumed by a fire spreading at 2 m per minute produce a low-intensity fire (measured by energy output) of 266 kW per metre along the fire front. Forest fuel loads can reach 40 tonnes per ha, producing extreme fire intensities of 60 000 kW per m; grass fires can reach an extreme of 30 000 kW per m. Forest fires range in intensity from 1200 to 30 000 kW per m or more (Luke and McArthur 1978).

Fuel size (light to heavy), type (grassland, heathland, and low and tall forest), distribution, and moisture content all influence the fuel available for combustion. Light (or fine) fuels, such as bark, leaves and branchlets, provide a source of combustion for heavier ones, and therefore have particular importance. Fuel's arrangement can be more important in fire behaviour than its weight.

Fuel availability is critical once fuel becomes dry, as daily moisture absorption affects the moisture content and hence flammability. The condition of fuel has the greatest influence on fires developing. Weather is the major determinant of fire behaviour. Wind strength determines the rate of fire spread, and its source and direction. Temperature and humidity also affect behaviour.

Northerly and westerly winds, bringing hot dry air from the interior, increase the fire danger in the study area. Conditions become especially hazardous when air masses become stationary for several days and cause a cumulative heating effect in the summer fire season. Low rainfall preceding that season produces a low moisture content in the accumulated fuels.

Information on fire causes is available for Department of Conservation and Environment regions. This information cannot be consolidated for the study area; however, it can form the basis for the following generalisations. Lightning is the most

common natural cause. Human activities causing fires are numerous, most prominent being deliberate lightings, escaped campfires and barbeques, burning off, matches and cigarettes, and waste disposal sites.

Effects of fire

European settlement has altered the pre-existing fire regime, through changes to wildfire intensity, duration, extent, seasonality, and frequency. While our understanding of that earlier regime is limited, it appears that the probability of wildfires has increased since European settlement, and their number has increased three and a half times. These fire regime changes, in association with other environmental changes, have altered the composition and structure of ecosystems.

Fire is critical to forest composition and age within the study area. Ash forests, particularly mountain ash, are killed by intense fires - that is, from 15 000 to 30 000 kW per m. Such severe fires cause resultant regeneration comprising even-aged stands, although ash classes can also exhibit mixed-age stands resulting from the 'patchiness' of earlier fires. Mixed-species forests, however, can survive moderate to severe fires and the older trees remain. Trees in these forests display a mixture of ages.

Most eucalypts, apart from the ash species, can withstand the effects of high temperature, drought, and fire. In fact, most of the plant communities have specific characteristics indicative of the role of fire in the ecosystem. Dormant epicormic and basal buds that produce coppice stems, seed capsules that open after fire, and soil-stored seeds that germinate after fire and in the absence of competition, are examples of these characteristics. Bark is a good heat-insulator, enabling the cambial layer to be protected from high temperatures for short periods. Only a few eucalypts do not coppice after the above-ground portion is damaged or killed.

Low-intensity fires (up to 500 kW per m) produce a low scorch, with temporary or permanent removal of the shrub layer. Those from 500 to 1000 kW per m may damage older and taller trees. Ground vegetation suffers more and damage to trees extends further up the trunk when fire intensities exceed



Regrowth forest from the 1983 Ash Wednesday fires - Noojee State Forest

2000 kW per m. Fires from 15 000 to 30 000 kW per m cause significant damage. The trees may recover by coppicing and regeneration of fire-killed species.

The composition and structure of most shrub and ground vegetation in forests and woodlands are related to the frequency and intensity of past fires. Some species are fire-dependent: germination of some *Acacia* spp. depends on fire, so an absence of fire for 25 years can eliminate them.

Fire can affect soil and surface water quality. Complete removal of ground litter exposes surfaces to erosive forces, and loss of soil is common in such circumstances. Post-fire weather conditions and soil type influence soil loss. Increased erosion within a catchment causes elevated turbidity in watercourses. Nutrients can be transported to watercourses, but many are quickly leached rather than being available for uptake.

Fires can greatly influence catchment yield. Loss of forest cover causes increased run-off and, in the immediate post-fire period,

increases catchment yield accordingly. Following vegetation regeneration, yields tend to return to the pre-fire levels and may fall lower for a considerable period. Because of the range of variables involved the issue is highly complex; the comprehensive research program the Board of Works has conducted on the topic is described in the Chapter 20.

Few studies are available on how fire affects wildlife. It appears that most native species survive low- to moderate- intensity fires. Severe wildfire can kill large numbers, but sufficient numbers of survivors can maintain viable populations. Habitat changes result from the resultant alterations to vegetation communities, but re-colonisation may occur months or years later as forest structure becomes re-established. Frequent fires may adversely affect invertebrate populations.

Where natural habitat has been lost through land-use changes or where species' ranges have become highly restricted, fire could affect the survival of particular species. In the post-fire period, conditions are often severe for wildlife, as some species suffer food depletion or increased exposure to predators.

As a natural feature of Australian ecosystems, fire has influenced vegetation distribution and extent. Some animals are adapted to the early fire-successional stages. However, the great majority of mammals are adapted to unburnt habitats or late successional stages.

Fire suppression

The Department of Conservation and Environment has responsibility for fire prevention and suppression on public land. Its responsibility extends 1.5 km into private lands adjoining State forest, national park, and protected public land, unless specifically excluded. Control of wildfire and the provision of an environmentally sensitive fire-protection program are the central elements of the DCE fire protection policy.

Fire prevention includes public education, supervision of fire legislation, and fuel modification. Maintaining and constructing fire-fighting facilities and maintaining human resources form the means of fire suppression.

Fuel modification is the key element of fire protection. Fuel-reduction burning - a cost-

effective means of reducing fuel loads and altering vegetation structure so as to reduce fire intensity - is discussed in detail below. Prescribed burning, mechanical slashing, and grazing have all been used to create firebreaks. Firebreaks (strips of land with complete removal of fuel) are used to protect townships, softwood plantations, and other important assets.

Fire manipulation can be used to produce particular vegetation communities or achieve a particular successional condition. Creating a mosaic of vegetative conditions can stimulate biological diversity.

Fire protection plans

Each DCE region produces a fire-protection plan, outlining its protection goals and prevention, pre-suppression, and suppression strategies. Regions are divided into zones of priority for prescribed burning. Setting priorities involves consideration of: the assets requiring protection; risk of uncontrolled wildfire; land tenure; suitability of vegetation for burning; and environmental constraints. Each of the four priority zones used has a specific fuel-reduction program.

Priority One zones are designated to protect life, property (usually in townships), and assets, such as ash forests, multiple-use forests, forest plantations, and water-supply catchments. Typically, fuel-reduction burning is planned for every 3-5 years in such areas, when fire fuel quantities exceed 8 tonnes per ha. In Priority Two zones, fuel loads are kept below 12 tonnes per ha, with a burning frequency typically between 5 and 8 years. They are established to form a strategic barrier against the spread of wildfire, and reduce its intensity and damage. Priority Three zones aim at broad-area protection, complementing the higher-priority zones, and at protecting natural and cultural values. Fuel loads are kept to 12 tonnes per ha, but the burning frequency is longer, being 8-12 years. Priority Four zones also seek to complement higher-priority ones, to protect natural and cultural values and to achieve other management and biological goals.

Fuel-reduction burning

Prescription or fuel-reduction burning is designed to reduce the rate of fire spread,

lower fire intensity, and increase the likelihood of successful fire suppression. It reduces fuel accumulations by the deliberate application of fire. The DCE usually conducts this planned and controlled activity in spring and autumn, when the temperatures are below 25° and winds less than 15 km per hour. It employs both aerial and ground ignition techniques.

Aerial treatment can cover 5000–6000 ha, whereas from the ground a coverage of only 400–500 ha is possible. In some places, such as much of Dandenong Region, burns cover only small individual areas at a time because of extensive urban developments adjacent to the forests. Prescription burning is based on a large number of individual fires. Success is assessed as the total area satisfactorily treated. Victoria treats an average of about 225 000 ha annually in this way.

Fire intensity in a successful fuel-reduction burn is low, between 20 and 350 kW per m. For special purposes more intense fires may be used, but these should not exceed 3500 kW per m, otherwise the fires may develop in the tree crowns and become uncontrollable.

Fuel-reduction burning may alter natural values. Characterised by its regularity, frequency, and low intensity, it can reduce the range of natural fire regimes. And, as most natural fires occur in summer, the spring and autumn timing of fuel-reduction burning may alter natural vegetation associations. Some species may not survive or regenerate successfully under such a changed regime. This can result in loss of species from an area where frequent fires prevent maturation and successful regeneration, especially if the seed in the soil becomes exhausted.

Fire can promote exotic plant species in some ecosystems. Artificial burning regimes can favour 'fire weeds', such as silvertop, shrubby legumes, or bracken.

While most animal species can recover from fire, some may suffer from the effects of its increased frequency under a fuel-reduction burning program. Some exotic animals - such as the introduced house mouse in sclerophyll forests - recover more quickly than native ones immediately following fire.

Fuel-reduction burning decreases fire intensity, but the efficacy of the burning programs has been questioned. A 1985 review by the DCF&L stated that they had made it easier to control wildfires passing over treated areas. Currently, few studies are available, so there is little available evidence that the number, extent, or severity of wildfires had been reduced by fuel-reduction burning. One study suggested that it reduced fire intensity for the following 3 years, but did not produce a clear effect after that time.

Wildfire incidence is believed to have increased in Victoria since the 1920s, notwithstanding that lightning-caused fires went unreported prior to 1939, as did many others. In this period also, fire prevention and suppression have increased and fuel-reduction burning has been instituted. This association should not be interpreted as a casual one. However, with so many fires the result of human activity, possibly the increases in the fire-track network, which give greater access to the forests, together with a higher population and increased mobility, could contribute to increases in forest fires.

Floods

Flooding occurs when stream flow exceeds the 'bankful' capacity of a water course and spills over onto the adjacent floodplain. Although this is a natural and regular phenomenon, only the largest floods attract wide public attention when they threaten life and property. However, flooding is an ecological feature of floodplains.

Inundation of floodplains has an important ecological role. Its patterns greatly influence the distribution of many floral species such as river red gums. Aquatic species may depend on flooding, for example the breeding cycle of several fish species. Most wetlands are the product of flood-water inundation.

Land on riverine floodplains has often attracted settlement and agricultural development, and structures have been sited adjacent to water courses. Consequently and inevitably, flooding causes damage to these structures and agricultural losses on the flood-prone farms.

Extensive catchment clearing has significantly altered catchment hydrology across much of the study area. Forest and woodland removal

results in increased run-off and receiving water courses carry greater volumes of stream flow as a result. Stream flow responds more rapidly to rainfall events in cleared catchments than in forested ones, and catchment modifications of this type tend to increase the frequency and intensity of flooding.

Flooding can cause:

- * damage to agricultural productivity
- * loss of private property and public utilities (such as bridges and roads)
- * loss of agricultural and industrial stock and assets
- * danger to human life and health
- * socio-economic disadvantage to communities and individuals

Nature conservation values may also be lost through flooding. However, many floral species on floodplains are resistant to temporary inundation and, as noted above, many others depend on it.

Areas most susceptible to flooding lie on the lower riverine reaches, where elevation and relief are both relatively low. Water courses identified by the Rural Water Commission as being flood-prone are:

- * Goulburn River - Eildon Reservoir to Seymour
- * Yea River - lower reaches
- * Bunyip River - lower reaches
- * Cardinia Creek - lower reaches
- * Lang Lang River - lower reaches

Responses to floods are categorised as active (such as physical structures) or passive, which covers land-use planning. For example, extensive flooding continually jeopardised the ambitions for closer settlement across the Koo-Wee-Rup Swamp earlier this Century. When the artificial drainage capacity was finally sufficient to carry the increased run-off from the cleared catchments, the incidence of severe flooding fell dramatically.

Introduced Species

Introduced species occupy a conspicuous place in the environment of the study area. Extensive urban and rural land uses have resulted in high levels of introduced plant and animal species. Public lands in close

proximity to urban and rural lands generally suffer greater infestations than remote locations. Introduced species require considerable resource use and expenditure for amelioration of their effects and for programs undertaken for their control. They can diminish a range of public land values. It is now a widely held belief that the presence of any of them in natural environments will lower environmental values. They can cause significant losses to recreation values.

Of concern on public land are those introduced species that have had profound and extensive effects on native flora and fauna. Scientific knowledge of their effects is very limited, although some particular pest species have been more thoroughly studied.

Cleared lands are the major source of invasions into forested public lands, but pest plants and animals can emanate from public lands into private lands and create problems for the land manager.

Flora

Introduced flora

European settlement has greatly altered Victoria's flora composition. Of the State's approximately 2750 species of indigenous flora, some 850 species are introduced (27.5% of the total), of which an estimated 400 pose serious threats to indigenous vegetation communities. Some authors believe that this is one of Australia's greatest conservation problems. Since European settlement, the number of introduced species has continually increased; nation-wide, some four to six species are added annually.

Definitions vary, but environmental weeds are usually considered as plants that have spread beyond their natural range and are therefore invasive of natural environments. They can include even native species, when introduced outside their 'natural' range (that is, pre-European settlement). Weeds threaten environmental values, as distinct from the traditional perception of weeds as only those species that reduce human uses of natural resources, principally agriculture. Environmental weeds embrace all life forms and cover a broad taxonomic spectrum.

Some 93 species in this State are proclaimed noxious weeds (outside the Metropolitan

area) under the *Vermin and Noxious Weeds Act* 1958.

As Parsons (1976) observes, no 'weeds' occur in natural plant communities, where all plants co-exist in a natural balance. However, comparatively few natural plant communities remain. Pest plants exist because of disturbances to the native flora environment by clearance or other land uses and by introduction of a range of alien species. In native forest, weed infestation is low until disturbance due to, say, road construction, vehicle traffic, high fire frequency, or clearing for firebreaks.

Most weeds in Victoria are introduced species. Often of little significance in their country of origin, these species thrive in disturbed Australian habitats. Although controlled in their native lands by associated vegetation, predators, agriculture, or climate and soil, they have no such inhibiting factors in an Australian setting.

While the causes for the establishment of pest plants vary considerably, they usually include two distinct factors: a constant disturbing agent and a vector for distributing plant propagules. For some introduced species, establishment and spread can follow only minimal disturbance to the natural community - boneseed, blackberry, and English ivy are prominent examples.

Successful weeds have certain characteristics of growth, development, and reproduction. They use four types of strategy: gap grabbers (through early and rapid germination) include many thistles, Patersons curse, and cape-weed; competitors, like boneseed, usually out-extend competing native species; survivors such as blackberry are long-lived and resistant to most causes of mortality; and swamplers, through mass germination of seedlings rapidly fills available space.

Effects on values

In addition to their effects on conservation values, environmental weeds also affect recreation and landscape values and may harbour diseases, as well as pest insects and animals.

On agricultural lands, they have a variety of harmful effects - such as competing with useful plants, poisoning stock, tainting or

contaminating produce, or interfering with operations - but those effects are not relevant to most public land. Weeds affect conservation values in a variety of ways. Invasive weeds alter the structure of vegetation communities and alter fauna habitat accordingly. They may completely replace, and even cause the loss of, native flora.

Areas affected/severity

Native vegetation most affected by weeds tends to be in areas with an understorey dominated by grasses and herbs. Land subject to stock-grazing tends to have high levels of weeds infestation, which also trouble riverine and coastal communities.

Native vegetation suffers least where human access is difficult, the soils nutrient-poor, and the vegetation of little economic importance. Such areas include rainforests, sclerophyll woodlands, salt-marsh, dry forests, wetlands, and heathlands. Infestation is greatest in the Dandenong Ranges, Mornington Peninsula, Western Port hinterlands, West Gippsland, the Stzrelecki Ranges, and around Kinglake.

Major weeds in study area

Noxious weeds, for which the best records are available, most prevalent in the study area include: angled onion, Bathurst burr, blackberry, boneseed, boxthorn, Californian thistle, cape broom, Chinese scrub, English broom, fennel, flax-leaved broom, furze, great mullein, hawthorn, hemlock, Patersons curse, ragwort, St Johns wort, slender thistle, soursob, spear thistle, stinkwort, sweet briar, tutsan, and variegated thistle. Table 71 lists the environmental weeds identified in the DCE Dandenong Region, in addition to declared noxious weeds:

Two noxious weeds of particular interest are blackberry and boneseed. Blackberry severely affects some regions: the Dandenong Ranges, Mornington Peninsula, and numerous watercourses. Capable of covering large areas quickly if unchecked, it has a dense canopy that excludes light from the soil surface and excludes other species. Blackberries can harbour rabbits and other pest animals. They rarely invade undisturbed land, but commonly infest cleared areas, roadsides, and stream-banks.

Table 71

ENVIRONMENTAL WEEDS, DANDENONG REGION

<i>Trees</i>		
	cedar wattle	Monterey pine
	cherry laurel	sycamore maple
	Cootamundra wattle	sweet pittosporum
	early black wattle	tree lucerne
	holly	willow
	karamu	willow hakea
<i>Shrubs</i>		
	cape wattle	sallow wattle
	cotoneaster	Spanish heath
	gorse	
<i>Climbers and creepers</i>		
	asparagus fern	English ivy
	banana passionfruit	Japanese honeysuckle
	blue periwinkle	smilax
	cape ivy	wandering Jew
<i>Grasses and ferns</i>		
	bubil watsonia	pampas grass
	creeping buttercup	quaking grass
	montbretia	

Source: DCE

Boneseed, a perennial shrub, has become well established around the Mornington Peninsula, around Western Port, the Upper Yarra area, and at Kinglake. An ability to become established in native vegetation makes the plant a risk to undisturbed habitats. Through competition, boneseed can eliminate smaller native vegetation and trees.

Weed control

On public land, the Department of Conservation and Environment is responsible for weed control (except where licensed to private interests). Private landholders have responsibility for control of declared noxious weeds within their property (a responsibility which extends halfway across any adjacent roads).

The Department conducts an eradication program on prohibited and priority noxious weeds, and control programs on restricted noxious weeds and other problem plants. Biological-control research forms part of the State's response to weeds, including such means for eradicating ragwort and boneseed. Research into chemical treatment has covered blackberry, erect prickly pear, furze, and skeleton weed.

Community groups have also had local successes in weed control, notably in the Dandenong Ranges.

Fauna

Some 13 mammal and 12 bird species, at least 11 fish, and numerous invertebrates have been successfully introduced into the study area. However, not all introduced species have become declared vermin. Table 72 lists vermin declared under the *Vermin and Noxious Weeds Act 1958*, while feral cats, deer, bellbirds, and blackbirds are others considered to be pests in the study area.

Effects on values

For many introduced species, the environmental impacts of their presence can be subtle and interactive and thus remain unknown.

Certainly, introduced species degraded conservation values. In the case of rabbits, feral cats and dogs, foxes, and other species, indigenous flora and fauna have suffered severe local or widespread effects. Feral pigs and rabbits cause ground disturbance leading



Foxes are declared vermin

to environmental weed invasions. Foxes and introduced birds such as blackbirds and Indian mynahs, which consume the fruit of species like blackberry, boneseed, ivy, and sweet pittosporum, spread these seeds into public land areas.

Aggressive and territorial introduced birds (for example, starlings, blackbirds, and Indian mynahs) displace all but the larger and more aggressive native birds. Such introduced birds can exclude the native bird predators of the *psyllids* insect (a major cause of eucalypt dieback), whereupon *psyllid* numbers and hence the incidence of disease can increase.

Recreation values can be associated with introduced animals, for example, deer-hunting. By contrast, introduced predators have lowered recreational values through heavy predation of native fauna that formed part of an area's attractiveness to visitors. Rabbit infestation can alter landscape values as a result of floristic changes. Production outputs from agricultural activities have clearly been lowered by pest animals.

Zones affected

Some species have become widely dispersed throughout the study area, while others have remained confined to particular regions.

Severity of infestation by pest animals (mammals and birds) usually correlates with the extent to which natural conditions are disturbed. Public lands with greatest pest animal problems are those adjacent to urban

areas or cleared agricultural lands. Management of the Dandenong Ranges and Kinglake National Parks requires considerable effort for pest animal control, a legacy of extensive urban land uses along the parks' boundaries.

In general, those areas with least access and lowest level of human activity have the lowest records of introduced species.

Pest animals

Table 72 lists declared vermin recorded in the study area, of which the most significant are described below.

Rabbits have caused major impacts in parts. High rabbit populations have damaged or removed native grasses and herbs, seedlings, and shrubs; moreover, and prevented regeneration or re-establishment of many native flora, leaving areas vulnerable to weed invasion. Native fauna can suffer from loss of food sources and habitat removal as a consequence of rabbit infestation. Erosion can accelerate where they have removed ground cover.

Table 72

DECLARED VERMIN

Common name	Scientific name
Rabbit	<i>Oryctolagus cuniculus</i>
Hare	<i>Lepus capensis</i>
Fox	<i>Vulpes vulpes</i>
Dingo	<i>Canis familiaris</i> , <i>dingo</i>
Feral dog	<i>Canis familiaris</i>
Pig	<i>Sus scrofa</i>
Sparrow	<i>Passer domesticus</i> , <i>P. montanus</i>
Starling	<i>Sturnus vulgaris</i>

Note:

1. The dingo currently has an unusual status, as it is declared vermin, but also a protected species.

Foxes, feral dogs, and cats are widespread and common, especially close to settled areas and agricultural lands. Rabbits make up a substantial portion of their diet, but, importantly, they also prey on native species including mammals, birds, reptiles, and invertebrates. A reported sustained decline

in lyrebird populations in the Dandenong Ranges has been attributed to predation by these pests (and roaming domestic pets add to dog and cat numbers). Generally, however, the effects of predation on native wildlife populations remain largely unknown.

Introduced fish

Victoria has 12 introduced species, of which nine occur in the study area, as shown in Appendix VIII. Introduced fish lower the environmental values of a water body, but their environmental effects are often difficult to isolate from major catchment and waterway changes. Limited information is available about their effects on native fish. Some introduced species compete with natives for food sources, and some predation occurs. For example, the trout might have contributed to a reduced range of galaxiids in the Upper Yarra. Areas may become infested with introduced species, such as mosquito fish, and native species become excluded.

Several species are regarded as serious pests, especially the carp, but also the mosquito fish, both of which are declared noxious fish.

Nearly all the major watercourses in the study area contain introduced fish. Due to the unevenness of survey coverage and differences in the studies undertaken, generalisations about the distribution and severity of infestations are difficult to form. An assessment of available fish survey data by the DWR (1989) revealed that the following larger watercourses in the study area contain introduced species: Aberfeldy, Acheron, Bass, and Big Rivers, Cardinia Creek; Delatite, Howqua, Jamieson, Lang Lang, and La Trobe Rivers; Narracan Creek; and Plenty, Rubicon, Tanjil, Tarago, Thomson, and Yarra Rivers.

Insects

Beekeeping began with early European settlement, and the introduced honey bee (*Apis mellifera*) has established widespread feral populations. Modern commercial operators carefully control swarming, to prevent further additions of feral bee colonies; hobbyists may not exercise similar care. A number of potentially detrimental environmental effects of introduced bees have been identified; key issues are summarised in

Chapter 14. Reference areas (and effectively wilderness areas) currently exclude bee-keeping.

European wasps (*Vespula germanica*) are relatively recent arrivals - currently occupying mostly urban areas, but their expansion into forests and recreation areas could occur in the future. Wasp stings cause painful and potentially dangerous injuries, so food and drink consumed outdoors should be carefully examined.

Sirex woodwasp (*Sirex noctilio* F) attacks coniferous trees and carries a fungus that can kill radiata pine (*Pinus radiata*). As radiata pine comprises nearly all Victoria's softwood plantations, sirex wasp is a pest of economic significance. Greatest damage occurs in sites facing higher stress - poor-quality or crowded sites, or windbreaks. Between early January and late March the woodwasp emerges and is attracted to trees that are semi-dormant, damaged, or suppressed. Control is achieved by maintaining tree growth and reducing water stress. Biological control - through other parasitic wasps such as *Ibalia* and *Megorhyssa* spp. that attack sirex-larvae or nematodes which cause sterility in sirex has effectively restricted the spread of infestation.

Eucalypt forests are vulnerable to insect pests that can cause substantial damage and dieback. Of these, the most important is probably the spur-legged phasmatid (*Didymuria violescens*), which has severely defoliated several thousand hectares of forest in the last two decades. For example, 2631 ha of the Yarra forests have suffered severe defoliation of ash-type forests in the last 25 years. In response, the DCE has aerially sprayed nearly 20 000 ha over this period and no severe attacks have occurred in the last 15 years. Most at risk are regrowth stands of high density reaching an intermediate age.

Psyllid insects (lerps) attack the foliage of woodlands and forests in sudden and recurring periods of high populations, damaging large areas and causing dieback. DCE has reported dieback of 780 ha in the Yarra forests in the late 1970s and early 1980s, with several thousand hectares damaged in mountainous areas since 1984. The effects of lerp damage could include reduced seed production and a thinning of regrowth through premature death.

Other insects - such as ambrosia beetle, dampwood termite, and seed-harvesting ants - can cause considerable loss of wood resource or seed supplies in timber-producing forests.

Cinnamon fungus

The microscopic, soil-inhabiting cinnamon fungus (*Phytophthora cinnamomi*) is found in association with root-rot diseases in all continents. Capable of killing large numbers of trees, it causes collar rot or destroys root material.

Although restricted to a particular environmental range by temperature and moisture, it can spread through undisturbed areas by spores that swim over or through wet soil. It may also exist as mycelium (vegetative, thread-like growths) and resting spores. Spores can be transported into unaffected areas by earthmoving equipment, vehicles, or footwear.

High-elevation forests are protected from its effects by low temperatures and well-drained soils. However, it has been suggested that trees completely free of the disease are rare; large areas of forest may be vulnerable to endemic disease if climatic factors become conducive to spread of the pathogens.

Disease symptoms are most pronounced, and spread most rapidly, in poorly drained soils of low fertility and little organic matter (particularly areas receiving run-off from hill slope or road drainage). Symptoms first appear in the understorey as a mosaic of yellowing and dying plants. Strict hygiene measures are necessary to prevent accidental spread of the fungus into previously uninfected areas, especially during timber-harvesting operations. However, birds and other animals may spread the inoculum by transporting infected soils.

Native species naturalised outside their native range

Naturalisation of native plant species outside their normal geographic range has the potential to cause serious disruption. Not only can these species become successful environmental weeds in indigenous communities, but distribution boundaries between native species can be obscured and hybridisation may occur.

Naturalisation has occurred in situations ranging from native communities to largely introduced ones, and in populations ranging from a few individuals to the structural dominant in a community. Most species are likely to persist and reproduce, and exponential population growth is possible. At least 22 species can invade native communities and become serious environmental weeds. Further naturalisation of more species seems likely.

It has been stated that at least 64 species and hybrids (25 genera, 13 families) of horticulturally utilised flora have become naturalised in Victoria, outside their natural range. Most are woody taxa - shrubs (31), trees (28), lianes (2) and herbs (3) - while the genera include *Acacia*, *Eucalyptus*, *Melaleuca*, *Grevillea*, and *Hakea* (Groves and Burton 1986).

Benefits of introduced species

Public lands with high nature conservation values have two recreational benefits from introduced species: deer-hunting where it is permitted - principally of sambar deer; and angling for trout (brown and rainbow), which form a major recreational resource.

Introduced species have been used as agents of biological pest control, but inappropriate introductions can create an additional pest



Sambar deer

species. For example, the cane toad in Queensland has become a significant pest in its own right.

References

- Australia, Parliament of (1984). 'Bushfires and the Australian Environment. Report by the House of Representatives Standing Committee on Environment and Conservation.' (AGPS: Canberra.)
- Cadwallader, P.L., and Backhouse, G.N. (1983). 'A Guide to the Freshwater Fish of Victoria.' (Victorian Government Printing Office: Melbourne.)
- Department of Conservation, Forests and Lands (1986). 'Policy on Fuel Reduction Burning.' (Victorian Government Printing Office: Melbourne.)
- Department of Water Resources (1989). 'Water Victoria: an Environmental Handbook.' (Victorian Government Printing Office: Melbourne.)
- Ealey, E.H.M. (ed.) (1984). Fighting fire with fire. *Proceedings of symposium on Fuel Reduction Burning, Monash University*, September 17-18, 1983.
- Gill, A.M., Groves, R.H., and Noble, I.R. (eds.) (1981). 'Fire and the Australian Biota.' (Australian Academy of Science: Canberra.)
- Groves, R.H., and Burdon, J.J. (eds), (1986). 'Ecology of Biological Invasions: an Australian Perspective.' (Australian Academy of Science: Canberra.)
- Horton, D.R. (1982). The burning question: Aborigines, fire and Australian ecosystems. *Mankind* 13(3):237-51.
- Luke, R.M., & McArthur, A.G. (1978). 'Bushfires in Australia.' (AGPS: Canberra.)
- Marks, G.E., Fuhrer, B.A., and Walters, N.E.M. (1982). 'Tree Diseases in Victoria.' (Forests Commission: Melbourne.)
- Office of the Commissioner for the Environment (1989). 'Victoria's Inland Waters: State of the Environment Report 1988.' (Victorian Government Printing Office: Melbourne.)
- Parsons, W.T. (1976). 'Noxious Weeds of Victoria.' (Inkata Press: Melbourne.)
- Rawson, R., Billing, P., and Rees, B. (1985). Effectiveness of fuel-reduction burning. *Department Conservation Forests and Lands Fire Protection Branch Report No 25*.
- Stretton, L.E.B., Mr Justice (1939). 'Report of the Royal Commission to Inquire into the Causes and Measures Taken to Prevent the Bush Fires of January, 1939 and to Protect Life and Property and the Measures to be Taken to Prevent Bush Fires in Victoria and to Protect Life and Property in the Event of Future Bush Fires.' (Government Printer: Melbourne.)
- Weed Science Society of Victoria (1988). Weeds on public land - an action plan for today. *Proceedings of a Symposium Presented by the W.S.S.V. and the School of Environmental Science, Monash University, May 19 and 20, 1988*.

20. ISSUES

In the course of preparing this report, a number of key issues of particular public interest have been identified and these are described below.

Nature Conservation in Marine and Coastal Areas

Nature conservation in marine and coastal areas is complex. It involves a wide range of issues, and coastal areas are the focus for a range of activities, often with complicated management arrangements. However, many conservation measures have been undertaken, although the current lack of knowledge has often inhibited action over much of the marine environment.

Coastal waters and most of the foreshore are publicly owned. A variety of land-use recommendations and management activities protect nature conservation values, with the highest levels of protection occurring in Point Nepean National Park, French Island State Park, and a variety of flora and fauna reserves. Other land-use recommendations, such as coastal reserves, provide lesser levels of protection.

The use of coastal and marine areas for a wide variety of purposes has led to compromises between nature conservation and other uses. For this and other reasons, many conservation values have diminished or been lost. Management actions can, however, protect or restore some values. Protection of nature conservation values can be complicated when the causes of actual or potential losses lie outside the area being managed - in the catchment or in the marine environment.

A difficult issue in coastal management is to match the identified conservation values of an area with a suitable form of protection. The administrative and management arrangements for coastal and marine areas are among the most complex covering public land. As a result, it has been difficult to obtain a thorough and consistent approach to the protection of conservation values.

Marine and coastal environments have, in general, been significantly modified since

European settlement. Detrimental changes have included loss of marine and terrestrial habitat (including seagrass, salt-marsh, mangrove wetlands, and dune vegetation), coastal modification and reclamation, port and industrial development, waste discharges, coastal settlements and roads, the spread of introduced species, and a range of catchment activities that have affected the marine environment.

Major issues

Seagrass beds in Western Port form an extensive habitat for many species. For example, they support large numbers of epiphytes, provide habitat for young fish, are a food source for marine and water-bird species and have a role in the food chain within Western Port. They bind together sediments of the mudflats they occupy, thereby reducing erosion by wave and tidal action and assisting in the maintenance of



The seagrass-covered tidal flats in northern Western Port are of high conservation value.

water quality. Although subject to natural fluctuations in area, the beds appeared to be diminishing in the early 1970s, causing some concern. Research in 1973 identified some 250 sq.km of mudflats covered by seagrass, with an additional 38 sq.km thought to have supported it previously. Subsequent surveys confirmed the trend of diminishing coverage, and in 1984 only about 72 sq.km carried seagrass; this represented a 70% decline in area and an 80% decline in biomass since the 1973 survey (Bulthuis *et al.* 1984).

Information on the consequences of the losses is limited, but concerns over the Western Port fishery appear to have been realised. Records indicate a reduction in the commercial catches here that coincides with the period of major diminution of the beds. Examination of the records that apply to those species whose life cycle is closely associated with seagrass, such as the King George whiting, indicate an even more marked reduction in level of catches. Bird observers reported a reduction in swan populations and fish-eating birds.

While the causes of seagrass decline remain unproven, the most plausible explanation concerns the massive sediment input to Western Port since European settlement, the result of catchment clearance and the drainage of Koo-Wee-Rup Swamp. This has led to the death of seagrass through exposure of the leaves to air and their coverage by a fine layer of mud. Sediment input could have raised the mudflats sufficiently to expose the seagrass beds, as it appears to have first occurred adjacent to the larger watercourses entering northern Western Port. Increases in turbidity resulted from loss of the beds, which might have further contributed to the losses of seagrass in other areas. Recovery will depend on the return of favourable conditions on the mudflats for seagrass growth; control over further sediment input from the catchment is a necessary precondition to such a recovery.

Other habitat areas have also diminished. In addition to substantial wetland clearance and drainage, incremental losses to the mangroves and salt-marshes in Western Port have occurred since European settlement. Clearance, coastal engineering, wood-harvesting, and sedimentation are among the causes of destruction. Mangroves have an important ecological role in stabilising shorelines, as a food source for fauna, and as fish nursery areas. Salt-marshes form part of the bird habitat for resident and migratory species for breeding, feeding, and roosting. For example, the orange-bellied parrot feeds on salt-marsh vegetation. These areas have not always been protected; many have been subject to land reclamation, grazing, rubbish disposal, and other forms of degradation. Problems still occur, for example, south of Hastings, and south of Yaringa Boat Harbour, through rubbish-dumping and illegal vehicular access.

Western Port has been identified as an important area for fauna, particularly for water-birds. Chapters 8 and 9 give a brief description of the diversity and number of species, together with some comments on species of conservation significance. Several international treaties for conservation apply here: the Ramsar Convention (for water-bird habitat of international significance); JAMBA (Japan–Australia Migratory Bird Agreement), and CAMBA (China–Australia Migratory Bird Agreement).

Studies of sites of conservation significance and the records of bird observer organisations have identified areas within Western Port with high conservation values.

An earlier study of zoological significance (Andrew *et al.* 1984) identified sites of national and State significance in Western Port, several of which were based on, or significantly involved, bird habitat. Nationally significant sites were the primary foraging areas for waders, Yallock Creek mouth, Settlement Road–Lang Lang, Reef Island, and primary breeding areas on the north-western and southern coasts of Phillip Island. Sites of State significance were Yaringa, Tooradin, Bass River mouth, secondary foraging areas of waders throughout the bay, secondary breeding areas on Phillip Island–Swan Lake, and Rhyll Swamp.

Other sites of botanical, archaeological, and geomorphological and geological significance have been identified in marine and coastal areas, and these have been described in preceding chapters.

A number of threats to the local bird life have also been identified, including disturbance of habitat, predators, shooting, rubbish, and water pollution.

Disturbance to habitat is of great concern. Boats, jet skis, and hovercraft have all disturbed breeding, feeding, and roosting areas. Sites currently at risk include Barrallier Island, Reef Island, Observation Point on Phillip Island, Rams Head, and Tortoise Head on French Island. Boats can also cause physical damage to mudflats.

Further port development at Hastings or development of new facilities at Tyabb North have been suggested as options for an

expansion of Victoria's port facilities. Chapter 9 describes risks associated with port and industrial development, such as oil spills. Proposals for a marina at San Remo will not proceed because of the environmental values of the site, and alternative marina locations may be investigated. One marine community and two invertebrate species at the San Remo site have been proposed for listing under the Flora and Fauna Guarantee. Earlier proposals for marinas at Sorrento and Safety Beach did not proceed; plans for one at Mornington harbour are continuing through the assessment process.

Increasing population will lead to be an increasing number of development proposals in marine and coastal areas, which will necessitate careful planning to prevent the loss of significant environmental values. In addition to the control of future development, the restoration of degraded coastal areas will require greater consideration.

Rainforest Conservation

The conservation of rainforest has become an international issue in recent decades. While most attention has focused on tropical rainforests, the conservation of temperate rainforests in Australia has also been the subject of intense debate.

Occurrence

In Victoria, three vegetation communities are considered to be rainforest: warm temperate rainforest and dry rainforest, which are restricted to East Gippsland, and cool temperate rainforest, which occurs in the Otway Ranges, the Central Highlands, and East Gippsland.

Within the study area, stands of cool temperate rainforest occur in gully heads, along streams, and on protected slopes, generally in association with wet sclerophyll forest and montane wet forest.

Definition

The Rainforest Technical Committee was established by the Department of Conservation, Forests and Lands in 1985 as a result of recommendations of the Timber Industry Inquiry. In 1986 the Committee, in accordance with the national consensus view of Australian ecologists expressed through the

Ecological Society of Australia, proposed the following definition for rainforest in Victoria:

'Rainforest is defined ecologically as closed (>70% projectile foliage cover) broad-leaved forest vegetation with a continuous rainforest tree canopy of variable height, and with a characteristic diversity of species and life-forms. Rainforest includes closed transitional and seral communities, with emergent eucalypts, that are of similar botanical composition to mature rainforests in which eucalypts are absent.

Rainforest canopy species are defined as shade-tolerant tree species which are able to establish below an undisturbed canopy, or in small canopy gaps resulting from locally recurring minor disturbances, such as isolated windthrow or lightning strike, which are part of the rainforest ecosystem. Such species are not dependent on fire for their regeneration.'

The Victorian State Conservation Strategy specifies that the government will 'protect all areas of rainforest (as defined by the Government Rainforest Technical Committee) from logging and other disturbances'. In 1987, the then Department of Conservation, Forests and Lands released 'Victoria's rainforests: An overview', which included a definition of rainforest identical to that of the Rainforest Technical Committee except for the deletion of the closed transitional and seral communities with emergent eucalypts.

Given concern about the adequacy of a definition which properly reflects the ecological processes of rainforest and its practical field application, the Department established a Rainforest Project Team in 1990 to clarify the definition, occurrence, and management of rainforest in Victoria.

Rainforest conservation was addressed by Council in its East Gippsland review and will also be covered in this review, and that of Corangamite study area (which includes the Otway Ranges).

Rainforest in the study area

The following discussion deals only with cool temperate rainforest which is the only type to occur in the study area.

Myrtle beech (*Nothofagus cunninghamii*) and southern sassafras (*Atherosperma moschatum*)

dominate cool temperate rainforest in the Central Highlands. Blackwood (*Acacia melanoxylon*) may also be present, although possibly as a result of past disturbance. The vegetation beneath the canopy includes tree-, ground-, and epiphytic ferns. Remnant emergent eucalypts may be present, indicating the link with vegetation communities previously occupying the site. The degree of canopy closure is a key element in the ecosystem. It plays a major role in determining the unique understorey conditions that favour the regeneration of rainforest species rather than those of the surrounding sclerophyll forest.

The critical ecological features of cool temperate rainforest include its sensitivity to fire and the ability of the dominant species to regenerate in the absence of fire. Although some of the dominants do resprout to some degree following fire, they are usually outcompeted by the more highly fire-adapted species of the surrounding sclerophyll forests. Fires may eliminate or encroach substantially into rainforest stands. This most certainly happened to a large extent during the 1939 fires, and to a lesser extent in 1983. The rainforest is restricted to sites in which high-intensity fire is rare because of high rainfall/moisture levels and effective topographic protection (for example in the headwaters of the Yarra River and adjacent areas).

Conservation planning for cool temperate rainforest is unusual for a vegetation

community in that it has to date been pursued through a set of prescriptions applying to the whole community, rather than through representation in conservation reserves (for example, some 13% within the study area is protected in reserves, with another 30% in the Board of Works catchments - see Table 73). The prescriptions require that cool temperate rainforest is not harvested or deliberately burned, and that buffer areas are maintained around stands. These buffer areas are currently 20 m around more or less linear stands, and 40 m around broader occurrences.

Clearly, such prescriptions are intended to protect the stands from immediate physical damage, but their adequacy in a broader ecological context is less certain. Since the occurrence of cool temperate rainforest is intimately linked with the long-term absence of fire, the management of adjacent stands of sclerophyll forest is an important consideration, particularly if it increases the likelihood of high-intensity fire entering the rainforest stands and if logging in the adjacent forest damages or puts at risk rainforest protection. It should be noted that there is debate over the relative fire risks and fire characteristics in regrowth and mature forests. Another consideration is the possibility that the disease, myrtle wilt, may be spread by forestry activities.

The most important stands of rainforest in Victoria have been indicated by the delineation of Sites of Biological Significance

Table 73

**STATEMENT OF COOL TEMPERATE RAINFOREST AREAS
CENTRAL HIGHLANDS REGION**

Locality	Dominant overstorey species	Area (ha)	Tenure and conservation status
Watts River/Deep Creek	<i>N. cunninghamii</i>	110	Protected by reserve
Donna Buang	<i>N. cunninghamii</i>	90	Protected by reserve
Warburton	<i>N. cunninghamii</i>	30	Protected by reserve
O'Shannassy/Watts	<i>N. cunninghamii</i>	610	Protected in Board of Works catchment
Marysville/Warburton	<i>N. cunninghamii</i>	30	Timber Production Zone - protected by reserve
Central Highlands	<i>N. cunninghamii</i>	1130	Timber Production Zone - protected by prescription
Powelltown	<i>N. cunninghamii</i>	30	Private property

Note:

1. Terms describing land tenure are those of the source document; these are not identical with those used by the Land Conservation Council.

Source: Rainforest Technical Committee

for Rainforest as part of the studies currently being undertaken within the Department of Conservation and Environment. These proposed sites are catchments containing areas of significant rainforest and have been listed in a memorandum subsequently made available to public-interest groups - see Table 74. However, these assessments used the definition of the Rainforest Technical Committee and the Department of Conservation and Environment regards this information as a draft internal document.

Tall astelia lily conservation

Closely linked, both ecologically and in the public mind, is the conservation of cool temperate rainforest and conservation of the tall astelia (*Astelia australiana*). This large,

native lily occurs in fewer than 20 isolated populations on stream-sides and swampy flats around Powelltown, Beenak, and the Otways. It is confined to these areas, and is considered vulnerable.

Little is known of its biology, particularly its reproductive system, and no scientific research has been undertaken to determine its ecological requirements. Since its discovery in 1929, it has already disappeared from some sites that it was known to occupy, believed to be as a result of the 1939 fires.

Concern over the conservation of this species arose in 1989, when ash roading program roadworks on Kobiolke Road, south of Powelltown, resulted in significant damage to a population there.

Table 74

CATCHMENTS CONTAINING SIGNIFICANT RAINFOREST IN THE STUDY AREA

Site name	DCE region	Significance rating
Acheron	A	national
O'Shannassy	A,D	national
Upper Bunyip River	D	national
Watts River	D	regional
Ada	D	State
Badger Creek	D	State
Cement Creek	D	State
Cumberland	A,D	State
Donna Buang	D	State
Federation Range	A	State
(Torbreck River South Branch)		
Mount Disappointment	A	State
Mount St Leonard	D	State
Mount Useful	CG	State#
Myrtle Creek, Black Spur	D	State
Pioneer Creek	D	State
Taggerty River	A	State
Tarago	CG	State
Yea River	A	State
Bell Clear Creek	CG	regional
Big Creek	D	regional
Britannia Creek	D	regional
Eastern Tyers	CG	regional#
Federation Range (Mount Bullfight)	A	regional
Hermitage Creek	A	regional
Kalatha Creek	*A	regional
Little Boy Creek	CG	regional
McMahons Creek	D	regional#
Mount Toorongo	CG	regional
Myrthee	CG	regional
Royston River	A	regional
Sherbrooke Forest	D	regional
Spring Creek	CG	regional
South Cascade Creek	CG	regional#
Storm River	A	regional
Starvation Creek	D	regional#
Upper Thomson (Newlands)	CG	regional#
Upper Tyers	CG	regional#
Western Tyers	CG	regional

Notes:

1. * DCE regions:
A - Alexandra; D - Dandenong; CG - Central Gippsland
2. # Provisional ratings only - these sites require further investigation.

Source: Department of Conservation and Environment.

Tall astelia has been listed as a threatened species under the *Flora and Fauna Guarantee Act 1988* and the Department of Conservation and Environment is currently preparing an action statement for its management. The species has not been recorded in a conservation reserve.

Board of Works-controlled Catchments

Water supply catchments and reservoirs under the control of the Board of Works are the focus for a number of interrelated issues. Specific aspects of these catchments are described in earlier chapters. Chapter 17 summarises the Board of Works' catchment hydrology research, some of the implications of which are discussed below.

Council's 1977 final recommendations recommended a multi-purpose park (of 113 000 ha) for the Yarra Valley. Such a park was to be under unified management, and included the Yarra water supply catchments, although decisions on land use of the catchments were to await the result of the Board of Works' catchment hydrology research. Under these recommendations, a policy of restricted access to Maroondah, O'Shannassy, and Upper Yarra was continued. Within the 'Yarra tributaries', timber-harvesting and/or recreation were permitted when not in conflict with water-harvesting. Wallaby Creek catchment was uncommitted land to remain under the existing tenure and management (Board of Works).

Government did not accept Council's Yarra Valley multi-purpose park recommendation, but approved a Yarra Valley Park of 33 500 ha, from which the water supply catchments were excluded and remained as uncommitted lands under the control of the Board of Works. In the park the major land-use activities are recreation, education, nature conservation, water catchment protection, and hardwood production. Although approved by government, the park has not been implemented.

Conservation

Studies of conservation significance have recorded sites and areas of high value in the Board's catchment areas.

A 1988 study of nature conservation values of rivers and streams recorded Smith Creek and O'Shannassy River (above Deep Creek) as having essentially unmodified catchments. Another, in 1989, surveyed botanical sites for the Upper Yarra Valley and Dandenong Ranges Authority and assessed O'Shannassy catchment as having national botanical significance. Two 1979 studies reached a similar conclusion about O'Shannassy catchment and parts of the Armstrong catchment, and identified sites of significance in Cement Creek catchment, the Acheron River, and Cumberland Creek Scenic Reserve.

Four reference areas (Watts River, Deep Creek, Walsh Creek, and Mt Gregory) are within the Yarra catchments, three (Stony Creek, Disappointment, and Joey Creek) in the Wallaby Creek catchment, and another two (Yan Yean north, Yan Yean south) in Yan Yean catchment.

Council's final recommendations for its Rivers and Streams Special Investigation (LCC 1991) classified the O'Shannassy as an Essentially Natural Catchment, and recommended that its high values for nature conservation and water quality be recognised and protected, and that it continue to be available for water production.

High conservation values result from a low level of recent human disturbance - a direct outcome of the restricted access policy - and the presence of old-growth forests.

Chapters 7 and 8 give information on the species of conservation significance in the catchment areas.

Recreation

Recreational activities are generally restricted to reservoir parks outside the catchments. Passive recreational facilities, some with walking tracks, are available at Cardinia, Silvan, Maroondah, Yan Yean, Toorourrong, Donellys, Sawpit, Coranderrk, and Upper Yarra. An exception is Maroondah, which contains several day walking tracks and a park at Fernshaw. Sugarloaf is also an exception, as bank fishing is available on a trial basis and plans are underway to introduce small boat sailing. Apart from these areas, public access is generally restricted under current policy in the Yarra

catchments. However, major public roads that traverse the catchments carry a large proportion of tourist traffic. High-use routes for pleasure driving through them include: the Maroondah Highway, Acheron Way, Cumberland Road, Muddy Creek Road, and Reefton Spur Road.

In the Thomson catchment, further east, the situation is quite different, on the basis that it is an indirect supply catchment, with pre-existing uses (such as timber harvesting), with the harvested waters subject to two levels of storage in Thomson and Upper Yarra. Much of the catchment is reserved forest that allows a range of recreation activities, including deer-hunting, vehicle access, fishing, and horseriding on roads in certain defined areas and in some cases under seasonal restrictions. The water storage adjoins reserved forest where hunting with hounds is not permitted. A reservoir management zone extends 200 m from full supply level; public access is prohibited here. Formal picnic grounds are provided outside the catchment, below the dam wall.

Because of proximity to Melbourne, access roads traversing the areas, and the popularity of those areas available for recreation, the recreation potential of the Yarra catchments is assumed to be high, although no estimates of latent demand are available. Demand could increase due to population increase and greater awareness of the area.

Hydrological research

The board undertakes hydrological research in Maroondah catchment. Considerable resources have been committed to the current research program, which began in 1967, and the results are recognised internationally. Clearfelling, regeneration, and thinning have occurred in forest hydrology experiments in North Maroondah and Coranderrk.

Water supply

About 70% of Melbourne's water is drawn from the Yarra catchments (90% if the Thomson system is included). Catchment protection prevents activities with the potential to degrade water quality and is essential as chlorination and detention in storage is the only treatment for water from the upland catchments. The Board's policy of allowing only very limited access and its active fire

protection and suppression role also protects water yield, by maintaining the bulk of the vegetation in the older age classes.

Timber

With the exception of some tributary catchments, timber within the Yarra catchments is not available for harvesting. Under a lease agreement between the Board and the Department of Conservation and Environment, one of the McMahons, Cement, Starvation, or Armstrong Creek catchments can normally be used for timber production in summer. During this period, the waters flow directly to the Yarra River and are not diverted into the supply system.



Mature mountain ash within a protected catchment area

In the Thomson catchment, timber production is a permitted activity except within the Reservoir Management Zone and Baw Baw National Park.

Maroondah catchment was not logged after 1890, nor was O'Shannassy catchment after 1910. Logging ceased in Walshes Creek in 1957, and in the rest of the Upper Yarra catchment after 1939. Evidence suggests very little logging in most of Maroondah and O'Shannassy prior to vesting in the Board of Works.

Table 75 presents information the Board of Works supplied to Council (in 1991) on the (nominally) suitable areas and sawlog volumes in each of its protected catchments. The data allow for the exclusion of steep slopes, reference areas, landscape protection zones, and stream and reservoir buffers. Except for Maroondah, for which case-study data are available, the data provided are estimates that could be revised through more detailed study.

These catchments contain significant volumes of timber. The total net productive area (if available) of forest within the catchments of the Maroondah, O'Shannassy, Upper Yarra Rivers, and Wallaby Creek is 35 419 ha.

Catchment research: management implications

A number of management implications follow from the Board of Works' catchment

research. In general terms, timber-harvesting can result in reduced stream-water quality, principally through roading and other earthworks disturbance of the catchment and watercourses. Careful roading practice can, however, significantly reduce the deleterious effects. In addition to the possible environmental consequences of lowered water quality and increased sedimentation, water supply values can be affected. If raw water quality is lowered, chlorination is less efficient as turbidity increases, and water storages are subject to increased rates of sedimentation. These effects would add to the cost of operating the supply system.

Changes to water yield caused by broad-scale timber-harvesting or extensive wildfire are crucial to the future of Melbourne's water supply. Research has determined the relationship in the ash forests between forest stand age and water yield. For a uniformly

Table 75

FOREST TYPE, SUITABLE AREA, AND SAWLOG VOLUME BY CATCHMENT

Catchment	Catchment area (ha)	Forest type	Buffer area (ha)	Suitable area (ha)	Sawlog volume (cu.m/ha)	Total sawlog volume ('000cu.m)
Wallaby Creek	9 100	Mature and over-mature ash	3 050	892	161	144
		Regrowth ash		1 081	226	244
		Mature and over-mature mixed species		2 436	80	195
		Regrowth mixed species		444	128	57
		Subtotal		4 853	132	640
Maroondah	16 450	Mature and over-mature ash	1 290	1 143	225	509
		Regrowth ash		4 514	179	809
		Mature and over-mature mixed species		1 803	90	162
		Regrowth mixed species		457	136	62
		Subtotal		7 917	195	1 542
O'Shannassy	12 720	Mature and over-mature ash	490	5 134	238	1 222
		Regrowth ash		2 618	125	327
		Mature and over-mature mixed species		284	74	21
		Regrowth mixed species		18	111	2
		Subtotal		8 054	195	1 572
Upper Yarra	33 380	Mature and over-mature ash	150	378	288	90
		Regrowth ash		8 018	109	874
		Mature and over-mature mixed species		5 807	55	319
		Regrowth mixed species		392	227	89
		Subtotal		14 595	94	1 372
Grand total				35 419	145	5 126

Note:

The buffers are under the Board's control, but do not contribute to water supply. Suitable forest within the buffers contains the following sawlog volumes: Wallaby Creek (11 600 cu.m ash, 48 480 cu.m. mixed), Maroondah (800 cu.m ash, 480 cu.m mixed), O'Shannassy (1050 cu.m ash, 1725 cu.m mixed), and Upper Yarra (nil).

Source: Board of Works, 1991

aged stand, water yield varies between 6 and 12 ML per ha per annum, with the lowest yield occurring at age 30. On a rotation age basis the yields vary between 7 ML per ha per annum for 50 years and 9 ML per ha per annum for 150 years. A severe bushfire would convert the extensive ash forests to regrowth stands and substantially reduce catchment yields. For example, a major bushfire in the year 2020 could cause a yield reduction of 290 000 ML, which would persist for a number of years, taking about 130 years to recover to pre-fire levels.

As the Board research results have shown that limited, well-managed forest harvesting can be conducted without a detectable effect on the quality of water from large catchments (from a water supply system perspective), and that strip thinning has the potential to increase water yield, the harvesting of timber for water-yield enhancement remains an issue.

Management

Management of the catchments and the restricted access policy relate principally to the values of water supply. Results of the Board of Works' research support several of the management principles.

Protection of water quality is a major management goal. Water drawn from the catchments is subject to disinfection by chlorination, but not full treatment. Water-quality improvement is achieved through catchment protection, including strict attention to road drainage, and lengthy retention periods for stored water (other than the lower Yarra resource, which is stored in Sugarloaf Reservoir and fully treated). Restricted access limits the risk of contamination by disease organisms of purely human origin. Water from Thomson Reservoir, after subjection to extensive detention time, is not used for direct supply but transferred to the Upper Yarra Reservoir.

In 1984 the Australian Water Resources Council published a position paper on the recreational use of urban water storages and catchments. Recreation is widely believed to be acceptable in water supply catchments and reservoirs where supplies are treated to a level at or near full treatment.

Treatment plants to fully treat waters from the Board of Works-controlled catchments have been estimated to cost \$450 to \$550 million, with annual running costs of around \$50 million. Allocation of this cost to Melbourne's water consumers would cause a doubling of water rates.

Management practices and restricted catchment access also protects water yield. As the ash forests age, yield increases. O'Shaughnessy (1986) states that the (28 500-ha) regrowth ash forests will produce an additional 114 000 ML over the next 60 years (equivalent to about 30% of Melbourne's annual consumption). Extensive fire or timber-harvesting would greatly reduce future water yield, creating a serious and persistent problem of diminished water supplies.

Limiting public access and a relatively long period of preservation have resulted in highly effective protection of conservation values. The degree to which further limited public access could be allowed without jeopardising water values is an issue. Operation of the water storages, with impounded rivers and altered stream flows, has disrupted the aquatic ecosystem values. Facilities associated with water-harvesting within the catchments include a management road network, fire towers, and the buildings and structures associated with the storage and transport of water. In recent years, pest plant and animal control programs have been instituted and active management for conservation values is under way.

Reservoir and other parks adjacent to the catchments are maintained and operated by the Board of Works. It should be noted that the Board is responsible for a number of recreation areas in the metropolitan park system, many of which lie in metropolitan Melbourne.

Water production from the catchments is the responsibility of the Board. Water from the Yarra and Thomson catchments supplies the Mornington Peninsula and the La Trobe Valley, as well as Melbourne. The complex delivery, transfer, and control system is outlined in Chapter 17.

Timber-harvesting in the Thomson catchments occurs under special conditions. In summary, these are strictly summer

logging only, with the location of coupes and extent of coverage discussed between the Department of Conservation and Environment and Board of Works, in line with the Thomson Catchment Committee's recommendations of September 1985 and the land-use conditions under the land use determination (soon to be gazetted). Timber-harvesting occurs in the Yarra tributaries catchments, but under special conditions. Public access remains restricted, the harvesting season is shorter, and only one catchment is available for harvesting at a time - during which water is not harvested.

Fire has burnt parts of the catchments, as described in Chapter 19, but the Board follows a policy of rapid suppression of any outbreaks in the Yarra catchments. No fuel-reduction burning occurs there, but is practised in limited areas of adjoining State forest and catchment buffer areas

History of the debate over catchment uses

From the time when timber-cutting was prohibited in the catchment of the Yan Yean reservoir in 1879, through to the present day, the policy of not allowing the timber industry access to the timber resources in the catchments has been the subject of much controversy.

In 1890, the Board of Works was established and it inherited strict catchment controls. By the 1920s, the Board developed an interest in forest management (although it did not employ foresters until after the 1939 bushfires) and in 1921 was considering the possibility of allowing limited logging on land under its control - below and to the east of the Wallaby Creek aqueduct. Such was the public concern that the Board refused timber extraction from the area. However, the government showed increasing reluctance to vest land outright in the Board because of the timber resources that would come under its control, and in 1929 the Board struck the arrangement with the Forests Commission that resulted in the Upper Yarra catchment remaining under its management, but as State forest, with the Board financially compensating the then Forests Commission for some of the royalty revenue foregone.

The 1939 bushfires created a shortage of timber resources in Victoria, which again put pressure on the government to allow timber-

harvesting in the Board of Works catchments. In 1956, a deputation to the Premier - comprising parliamentarians and representatives of shires, the pulp and paper industries, and the Victorian Sawmillers Association - sought access to timber resources in these and Colac catchments. The matter was referred to the State Development Committee, and its final report in 1960 recommended that timber-harvesting be permitted in buffer areas to the catchments, and that 'controlled' timber-harvesting be permitted in the catchments. However, later that year, after much public debate, the government announced that existing policy would remain unchanged.

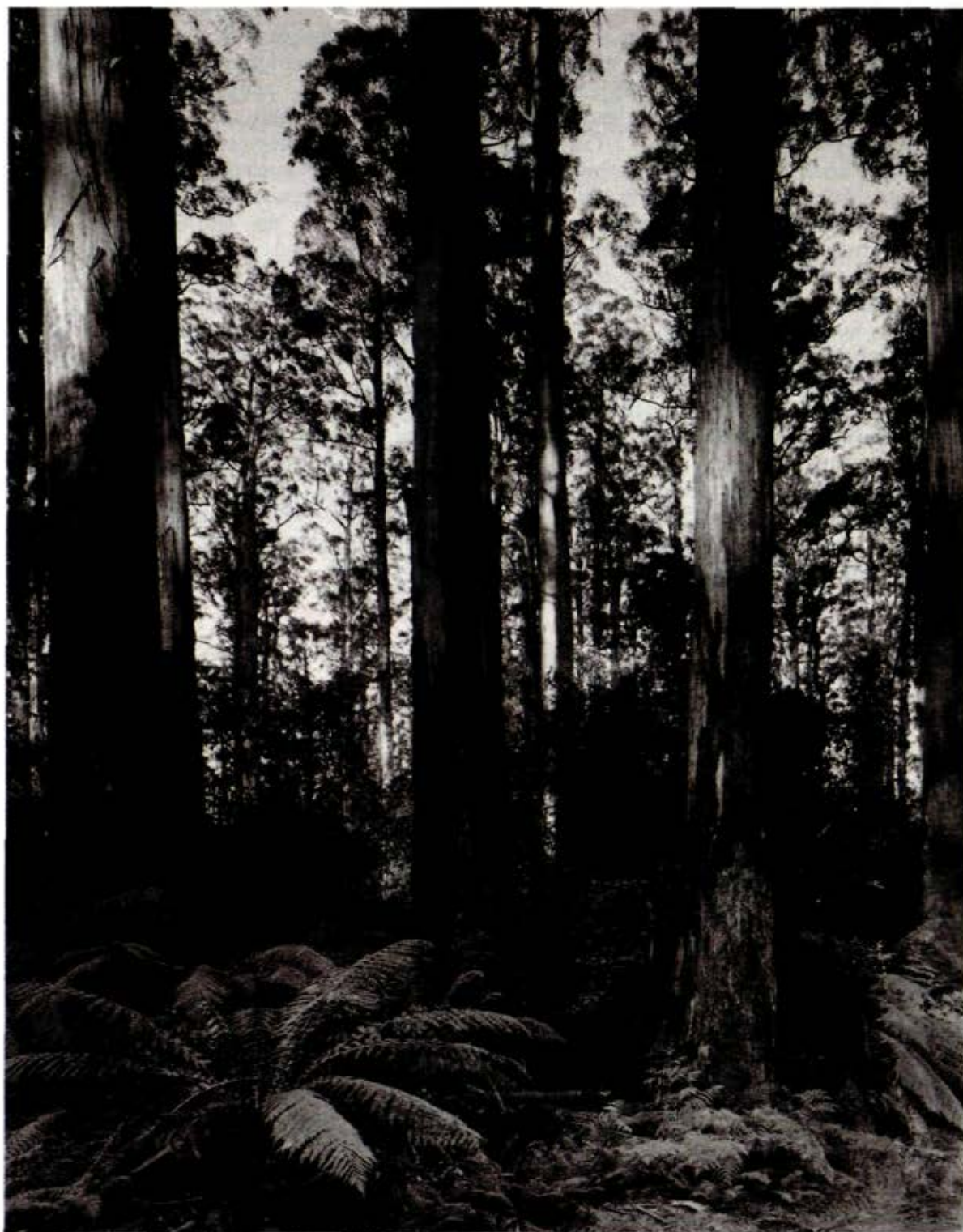
In 1962, the Board sought to have five other tributary catchments to the Yarra River vested in it, but in the final outcome these remained State forest, under lease. This lease expired in 1979 and a new lease has been negotiated between the Board and Department of Conservation and Environment.

In response to a government request in the 1960s, the Melbourne and Metropolitan Board of Works reactivated a research program into the effects of catchment conditions and land use on water resources. Timber-harvesting has been specifically examined and its effects on water yield and quality recorded.

As stated above, the government varied Council's 1977 recommendations and approved the creation of the Yarra Valley Multi-purpose Park. This park excluded the protected catchments and the government directed that the Board remain the managing authority for the catchments. Recent confirmation of the government's policy for these areas is the 1987 State Conservation Strategy which stated that timber harvesting would continue to be prohibited from the protected catchments.

Old-growth Forests

'Old-growth' and 'ecologically mature' are generic terms for classes of forests that are generally at advanced stages of their growth cycle and/or that generally show little evidence of major human-induced disturbance. These forests have high conservation values according to various criteria, and continue to be a major focus of



Old-growth mountain ash forest in O'Shannassy water supply catchment

the contemporary forest debate in Australia. They are perceived as being uncommon and diminishing, but no detailed inventory has yet been completed for Victoria. However, from existing inventory and survey data it is clear that the study area supports some of the State's most important stands, and some of

these have been identified as being of national significance.

Definition

The term 'old-growth' is most often applied to the best-developed eucalypt forests (for

example, wet sclerophyll, montane, and riparian forests), but can equally be applied to the full range of others (such as dry sclerophyll forest, damp sclerophyll forest, and foothill forest). Old-growth is a broad concept that is difficult to define simply; not only does it involve a number of characteristics but their application varies according to the forest community under consideration. In general, though, it has two key features:

- * vegetation dominated by relatively 'old' and 'large' individual plant specimens
- * vegetation featuring a high degree of 'naturalness' or 'ecological integrity' and relative lack of disturbance

Definitions have focused on either or both of these features, as the following examples show.

'Old-growth forests are those communities which are the older developmental stages of the forests, and characterised, at least in part, by the following: low growth rates for the trees in the tallest stratum, low to zero biomass production of trees in the tallest stratum, trees in the tallest stratum mature to senescent, very high biomass of individual trees in the highest stratum, trees in the tallest stratum usually more than 100 years old' (AHC 1990).

'Old-growth forest is forest that has not been, or has been minimally, affected by timber harvesting and other exploitative activities by Australia's European colonisers. The 'old-growth' refers to the fact that the current forest has not had a history of recent disturbance by human intervention, but has been regenerated and maintained by natural processes. Many of these forests are indeed old in age, and this is why the phrase 'old-growth' came to be used. A more appropriate term is *undisturbed forests* as they may indeed be naturally multi-aged or even young regrowth, providing the regrowth was initiated by a natural event.' (McIlroy 1990).

'Ecologically mature forest is forest in which the dominant tree species are

beyond the age of maximum growth rate, and in which the understorey has developed relatively free of disturbance. This is commonly over 100 years old, beyond the age regarded as optimal for wood production (usually about 80 years), and at or above the age at which hollows suitable for tree dwelling fauna begin to form' (Victoria 1987).

The conservation focus on old-growth forests is primarily for the natural heritage values associated with allowing the full expression of the forests' ecological cycles. The definition needs to encompass the dynamic nature of forest ecosystems and acknowledge that extant old-growth forests are the physical results of past ecological processes.

The Department of Conservation and Environment is currently developing a definition for use in East Gippsland forests which will be used to assess the extent of the resource in East Gippsland, and is intended to be applied to other areas of the State in the future. The process will largely involve assessing which criteria are most practical for delineation, and determining threshold values for these criteria for each type of forest community. The Department will then map the extent of each class.

Fauna

Old-growth forests are important for the conservation of a range of fauna, especially hollow-dependent species. Most arboreal mammals and bats within the study area require hollows for nesting or roosting, as do many bird species (for example, owls, parrots, and treecreepers). For some species (such as the sooty owl) old-growth ash forest is the principal habitat within the study area. Others (such as the greater glider), while also occurring in regeneration, are most abundant in old-growth forest.

The 1939 bushfires resulted in predominantly even-aged ash regeneration, with many of the fire-killed trees remaining as stags. As these remaining stags collapse over the next 50 years, the 1939 regeneration will become largely devoid of hollow-bearing trees. The remaining old-growth forest will then provide the main habitat for those species dependent on hollows. Even species that are currently more abundant in 1939 regeneration with

remnant stag trees (for example, Leadbeaters possum) depend on old-growth forest for their long-term conservation.

Multi-aged forest contains a high structural diversity, which provides a wide range of foraging substrates. The uneven canopy layer contains a variety of habitats suitable for invertebrates required by canopy-feeding insectivorous birds like the satin flycatcher and black-faced monarch. Such forests also provide a variety of hollow sizes, which are necessary to support a range of species.

Large logs and abundant litter on the forest floor are another characteristic. They are important in providing habitats for ground-dwelling fauna: valuable basking and foraging substrates for some reptiles such as the southern water skink (CTF), movement pathways for small and medium-sized mammals, shelter for ground-nesting birds, and a rich source of invertebrates for insectivorous species.

While most discussions on old-growth forest have focused on ash species, mixed-species old-growth forests are also very important for fauna conservation. The eucalypt species of these forests survive wildfires both by coppicing of adult trees and seedling regeneration, and this results in multi-aged forests (compared with the even-aged regeneration produced when an ash forest is burnt). Therefore, multi-aged mixed species forests are relatively more common than multi-aged ash forests.

Flora

Although discussion about the biological significance of old-growth forests tends to concentrate on the habitat value for particular faunal species, these forests also have significant flora values. For example, they include significant representatives of vegetation communities with a high degree of naturalness, maximum physical development, and scientific reference. Similarly, they often contain veteran individual plant specimens, not only of eucalypts but also of understorey (shrub) species.

Old-growth stands, particularly of the moister forest types, feature a greater diversity of specialised micro-environments that may provide optimal habitat for species of

epiphytic orchids and ferns, mosses, and lichens.

Qualitative values

In addition to quantitative or scientific values, old-growth forests 'have other highly significant values for the wider community, which may derive from direct experience of the forests or "in absentia". These values are generally the most 'intangible' values, and relate to such things as a sense of beauty or wonder, of spiritual uplifting. Such values may derive from the wilderness quality of large areas of old-growth forest, or the visual quality of mature, majestic old-growth trees which give rise to the forest being described as "cathedral-like" (AHC 1990).

An important part of these values is appreciation of the sense of scale provided by features of old-growth forest. Veteran trees well outlast a number of human lifespans and provide a living link with past historical eras - in the case of Australia, with pre-European settlement. Although less well-documented, or documented in a 'popular' rather than a scientific manner, these values are no less important than those with a scientific basis.

Timber production

Old-growth forests have a positive value as a timber resource through the standing volumes of timber they contain, although with increasing age the level of defect in the timber also increases (see Chapter 15).

On the other hand, particularly in wet forests, old-growth stands are considered to have a negative value inasmuch as they occupy high-quality sites that could produce wood more quickly if they were occupied by young, actively growing stands. This perception of old-growth stands in timber production rather than ecological terms is associated with descriptions such as 'over-mature'.

Water production

These forests are valued within water production catchments because the low level of soil disturbance and relatively low use of water by the trees lead to an optimisation of quantity and quality in relation to water production (as described earlier in this chapter).

Occurrence in the study area

The only definition applied in Victorian forest management so far is that in the draft Otways Forest Management Plan. The plan defined old-growth forests as mountain and eucalypt foothill forest where the majority of the basal area comprises mature trees which are pre-1890s in origin and nominally 150 years old or older. This definition may not apply to areas outside the Otway Ranges and no definition has been developed for the study area. The most useful set of information for the study area at present comes from the mapping of dominant age classes of eucalypts, particularly of ash forests, by the Department of Conservation and Environment.

This information shows, for example, that a significant proportion of the old-growth ash forests of the study area occur in the Board of Works protected catchments. The O'Shannassy catchment and the State forest surrounding its northern boundary are particularly important, as they form the largest and most intact continuous area here. Elsewhere, these forests are smaller and more fragmented (for example, south of Baw Baw National Park, Royston River area south of Rubicon, and New Turkey Spur area north-east of Powelltown).

Using such information as a means of indicating classes of old-growth forest has limitations and allowance must be made for the full range of age class histories. For example, old-growth forests may naturally contain trees of predominantly one age class (even-aged forest) or more than one (multi-aged forest). Also, they may exhibit different ages of understorey and overstorey within the same stand as the result of fire events of varying intensities.

The ash forests of the study area are notable in that, as a result of the extensive coverage of the 1939 wildfires, they are predominantly of one age class. Although only young, many of these stands retain a high degree of naturalness. The other obvious impact of this fire history is that old age ash forests cover an unusually small percentage of the study area - with 32 873 ha of 'mature/overmature' forests of alpine ash, mountain ash, and shining gum. Of these forests, 80% are not available for timber-harvesting (that is 20% is within net productive forest). In contrast,

the study area contains 353 769 ha of 'mature/overmature' mixed-species forest, of which 70% is not available for harvesting. Mature/overmature covers all forests over 80 years of age - that is, it includes some forest that would not normally be considered to be 'ecologically mature' or 'old-growth'.

Maintenance

Remnant stands of old-growth forest, particularly of ash species, are uncommon because the long period required to reach the culmination of any one forest ecosystem cycle makes it highly probable that a major disturbance will occur.

Most old-growth ash forest in the study area occurs in the Board of Works catchments where the probability of such disturbances is reduced. Land-use policy has restricted clearing and timber-harvesting, and the restricted access, protective topography, and high rainfall/moisture levels significantly reduce the incidence and severity of wildfires.

While the conservation value of existing veteran stands of old-growth forest is clear and strategies for their protection need to be developed, it is also important to recognise that these stands represent only one stage in the development cycle of the forest ecosystem. Consequently the conservation of current ecological processes becomes an essential aspect of maintaining the dynamic nature of old-growth forest over long time periods. Such an approach would make allowance for recruitment from existing young undisturbed stands, and for old-growth stands burnt by wildfire to retain their ecological integrity by avoiding additional disturbance and for the possibility of old-growth forest being replaced in some areas by 'mixed forest' and rainforest after a long period free of disturbance.

Lake Mountain

Lake Mountain has high conservation and recreational values, as described in Chapters 7, 8, and 13. It is the closest snow resort to Melbourne, and during last snow season (1990) received 217 000 visitors, attesting to its popularity and role in winter recreation. Most of the area is close to or above the Victorian winter snowline (that is, 1200-1350 m), and carries a mixture of montane

forest, alpine and subalpine woodland, and heath and bog communities on the plateau and ridge-tops, including species and communities of conservation value and botanical interest.

Although Council recommended in 1977 that Lake Mountain become a State park, and this was subsequently approved by government, the recommendation has not been implemented. Council recommended that the State park be used to provide for recreation, conservation, water supply, and education. Although not implemented, the area is managed by the Department of Conservation and Environment as a State park. The proposed park surrounded an existing alpine reserve, which the government declared as the Lake Mountain Alpine Resort in 1987. A portion of original park recommendation was added to it. This resort is the management responsibility of the Alpine Resorts Commission (ARC), and its 590 ha include the access road, several car parks, and the buildings and structures associated with the resort facilities at Gerratys. Importantly, the main recreational feature, some 25 km of cross-country ski trails, lies immediately north of Gerratys and within the proposed State park.

Several issues have arisen over the use and management of the area: Lake Mountain State Park is approved but not implemented, management responsibilities are divided between two agencies for the ski-trail areas, high conservation values at Echo Flat required protection in the recent development of a new ski trail in an adjacent area, and a draft proposal for a major development has been released.

Council's earlier Melbourne investigation identified a range of values within the area, with special recognition of conservation and recreation. Environmental surveys conducted since then have confirmed the ecological values. A number of species within the area are rare and/or restricted, and approximately one-third are at the western limits of their distribution. Faunal species have not yet been surveyed in detail, but Leadbeaters possum has been recorded.

Recreational values are very high during the snow season, which extends from June to September, when the primary activities are cross-country skiing and snow play.

Throughout the remainder of the year, recreational use is relatively low and consists of sightseeing, bushwalking, picnicking, and nature study.

Currently the ARC has responsibility for the resort, while the ski trail network is largely within reserved forest under the management of the Department of Conservation and Environment. Operation of the resort requires a range of management activities on the ski trails - such as track maintenance and skiing education - which is carried out by the ARC on lands under the responsibility of DCE. A co-operative management agreement operates between the two organisations.

Lake Mountain's winter popularity, notably over the 10-12 peak snow season weekends, has created crowded conditions at the resort, especially in car-parking and resort access at Gerratys.

Currently, it averages 450 snow-season visitors on weekdays, 4000 on Saturdays, and 5000 on Sundays, with peak Sundays exceeding 8000. About 90% of these visitors arrive from Melbourne, and 60% undertake cross-country skiing. Snow season visits, while fluctuating, are generally increasing, as the attendances since 1978, shown in Table 76 indicate.

The ARC and DCE (1990) have developed a draft proposal for a long-term plan which seeks to overcome existing problems and provide an optimal level of recreation in the resort and adjacent areas. This plan includes the development of new facilities and ski trails, and the redevelopment of the existing facilities. Features of the proposal include:

Table 76

LAKE MOUNTAIN SNOW SEASON VISITS

Year	Number	Year	Number
1978	62 000	1984	110 000
1979	45 000	1985	113 000
1980	87 000	1986	145 000
1981	124 000	1987	135 000
1982	70 000	1988	62 000
1983	90 000	1989	190 000
		1990	217 000

developing Lake Mountain summit area for snow play and summer activities, built facilities, and car-parking; enlarging Gerratys car-parking and upgrading facilities; extending the ski trails at Jubilee and Long Heath; establishing a new ski trails and biathlon facilities at Snowy Hill; and upgrading facilities at Cascades, Arnold Gap, and Snowy Hill.

Currently, the proposed development plan is being assessed and the future of the resort has yet to be decided. Issues raised by the LCC include the risk of loss of environmental values, the role of demand management, the possibility of climatic changes reducing the snow season, and the further development of facilities that are used for a comparatively short period each year, albeit by large numbers of visitors.

Leadbeaters Possum

Leadbeaters possum, one of Victoria's faunal emblems, is an endangered species endemic to the eastern Central Highlands within the study area (see Chapter 8). The species' habitat requirements, described below, are critical to its survival. Recently, a draft



Leadbeaters possum, one of Victoria's faunal emblems

management strategy (Macfarlane and Seebeck 1991) was publicly released, and an outline of its proposals to protect Leadbeaters possum is given below. While they form part of the public debate on this issue, views expressed in the summary do not necessarily represent those of Council.

Considerable research has been undertaken to define the habitat requirements of Leadbeaters possum. The montane ash forests it occupies are dominated by mountain ash, alpine ash, or shining gum, and it is categorised within the montane forest complex, wet sclerophyll forest, and damp sclerophyll forest communities. It requires the three main habitat components outlined below.

Availability of suitable nest trees

The number of hollow-bearing trees is a factor limiting the abundance of Leadbeaters possum. The possum constructs nests in hollows in either living or dead mature ash trees, preferring decayed, short, large-diameter trees that contain numerous hollows and have dense surrounding understorey vegetation. Mountain ash trees do not begin to form hollows until they are 120 years old and the large deep hollows preferred by Leadbeaters possum take 190–200 years to develop (Smith and Lindenmayer 1988) but may be considerably older. The large nests consist of shredded bark inside a cavity in the trunk of the tree. Colonies of up to eight individuals use these communal nests and defend a territory of 1–2 ha, with one colony using a number of nest trees.

Vegetation structure

A dense understorey of wattle and other shrubs is an important habitat component, as it provides a relatively continuous layer through which the animals can move.

Food availability

The diet of Leadbeaters possum includes arthropods (particularly tree crickets, beetles, moths, and spiders), plant exudates (wattle gum, nectar, and eucalypt manna), and insect exudates (psyllid honeydew). Wattle gum is particularly important in providing a source of carbohydrate. Invertebrates, especially wingless tree crickets that shelter in the loose bark hanging from living ash trees, appear to

be an important source of protein, and their availability may affect breeding success. The amount of available loose bark is an important habitat component affecting possum abundance.

Habitat location

The habitat requirements of Leadbeaters possum are best met by forest with a suitable density of nest trees (that is, those bearing hollows) and with suitable foraging areas of the necessary density of wattles and eucalypts. The mature trees killed by the 1939 fires (which burnt 79% of the Central Highlands ash forests) provide nesting sites, and the dense regenerating wattle provides a foraging substrate and allows movement between areas. However, this 1939 regrowth forest is becoming less suitable as the fire-killed nest trees collapse. The current annual rate of stag fall here has been measured at 3.6%. The rate of fall of the more-decayed stags, which are the preferred nest trees, is much higher. Lindenmayer *et al.* (1990) predict that all trees now classified as preferred nest sites will have decayed and fallen within 50 years, and that in 75 years all the currently dead hollow-bearing trees will have collapsed, leaving only the living mature trees to provide nest hollows. This will lead to a considerable reduction in abundance and distribution of Leadbeaters possum - probably more than a 90% reduction over the next 50 years (Lindenmayer 1989).

As the 1939 regrowth forest becomes less suitable, old-growth forest will assume a greater importance for the long-term conservation of the species. It will take at least 70–140 years from collapse of the 1939 stags to the development of new hollow-bearing trees in these regrowth forests. During this period it is likely that the distribution of Leadbeaters possum will contract to the old-growth forests. While population densities are presently lower here than in regeneration, old-growth forest will provide essential refuges from which animals may disperse when surrounding areas become more suitable.

Some ash trees survive wildfires. The resultant multi-aged forest is an important habitat for Leadbeaters possum as it may contain the necessary dense wattle layer in addition to living hollow-bearing

trees. Living trees, while not the preferred form of nest tree, are used and do provide nesting sites for a much longer time than stags.

Approximately 75% of the montane ash forest within the known distribution of Leadbeaters possum occurs in State forest where timber-harvesting is permitted. Harvesting is currently excluded from the remaining areas, with 20% in the Board of Works' restricted-access catchments and 5% in parks and reserves (see Appendix X). Clearfelling is currently used to harvest ash in State Forests. Prescriptions under the Code of Forest Practices allow clearfelling in coupes up to 40 ha, every 80–120 years. As ash trees do not begin to form hollows until they are 120 years old, these rotations will not provide the essential nesting sites for Leadbeaters possum.

Draft management strategy

The draft management strategy for Leadbeaters possum identifies threats to the species and proposes measures for its protection. The main threat to its continued survival is the loss and fragmentation of suitable habitat. This may result from:

- * a reduction in the abundance of available nest trees
- * natural progression of current favourable habitat to a structurally less-suitable successional stage
- * timber-harvesting in montane ash forests, particularly clearfelling on a rotation of less than 150 years

It is recognised that, regardless of the type of management carried out, populations of Leadbeaters possum will decline substantially during the next 50 years due to loss of nest hollows. The incremental effects of commercial hardwood-harvesting operations undertaken with current prescriptions may threaten the long-term survival of the species. To address these issues, various management strategies have been developed. These include habitat management in a range of land-use categories, including timber-production forests, and other options such as establishing reserves and providing nest boxes, as well as captive breeding and subsequent reintroduction into the wild.

The proposed management strategy for Leadbeaters possum categorises the timber-production areas into three zones, determined by the abundance of hollow-bearing trees.

Zone 1, with Leadbeaters possum conservation as the major priority, comprises all areas of mature ash forest (greater than 120 years old) and regrowth ash forest with 12 or more live or dead hollow-bearing trees per 3 ha. This zone is to be protected from all types of timber-harvesting, other than low-intensity selective logging specifically undertaken for habitat development.

Zone 2 has Leadbeaters possum conservation and timber production joint priorities. It consists of all regrowth ash forest with 6 to 11 hollow-bearing trees per 3 ha. All existing hollow-bearing trees are to be actively protected, and allowance made for their future replacement on the perimeter of logging coupes.

Zone 3 has timber production as a priority in the remaining forest, with the exception of areas excluded from harvesting for economic and environmental reasons, such as steep slopes, unmerchantable areas, streamside reserves, and wildlife corridors. However, steep slopes and streamside reserves are unlikely to be of great conservation value to Leadbeaters possum. Current management prescriptions apply, but with the protection of all living hollow-bearing trees.

The draft strategy states that DCE will establish a reserve system based on the presence of known optimal and potentially optimal habitat, plus sites of known occurrence. These areas will be linked to existing parks, reserves, and closed water catchments by wildlife corridors, streamside reserves, buffer strips, and areas of State forest not suitable or available for timber-harvesting.

Another possible management option is the provision of nest boxes in areas devoid of trees with hollows. However, the short life expectancy of the boxes (less than 10 years), the time for which they would be required (up to 140 years), as well as the logistics and the cost of providing them, greatly reduce the potential value of this strategy for the long-term conservation of Leadbeaters possum.

Successful management of the possum will depend on further research. A number of

aspects require urgent investigation. The distribution and density of hollow-bearing nest trees need to be mapped and areas classified into zones. The effectiveness of existing reserves needs to be investigated, and the shapes and sizes necessary to support viable populations require identification. The dispersal and recolonisation capability of the species needs to be determined, including the ability to utilise forests excluded from harvesting, such as wildlife corridors and streamside reserves. Alternative silvicultural systems need to be examined and their effect on both Leadbeaters possum conservation and timber-harvesting evaluated. Ways of manipulating the forest to provide suitable habitat require investigation, including methods to promote the development of hollows. To incorporate the results of this research, management strategies will need to be regularly updated.

Since Leadbeaters possum was rediscovered, considerable debate has centred on its preferred habitat, the effect of timber-harvesting, and the most effective conservation strategy for the species. While current silvicultural practices are incompatible with its conservation, modified methods of timber-harvesting may satisfy its habitat requirements. Some authors have suggested the establishment of a large reserve or series of linked reserves in the Central Highlands, to be managed specifically for Leadbeaters possum conservation. Some have noted that this possum was 'in an almost unique position to benefit from integrated conservation and development' (Smith *et al.* 1985). Others warned that its management is, the test case of integrated conservation and timber production in Victoria, but that failure is 'not likely to engender public confidence in the governments ability to protect other rare and endangered species.' (Gruen *et al.* 1989). A combination of the implementation of management strategies, further research, and close liaison between wildlife biologists and forest managers will be essential to ensure the long-term conservation of this endangered species.

Future of the Timber Industry

This section focuses on several key issues, especially those that have a direct impact on the future resource demand and the level of harvesting.

Resource security

Securing adequate future timber resources is of particular concern to the timber industry. The industry maintains that uncertainty over the continued supply stifles investment in new plant and equipment and leads to inefficiency.

Under the *Forests (Timber Harvesting) Act* 1990, the government has given the industry a commitment to provide a sustainable supply of (grade C+) sawlogs, based on the principle of a regional sustainable sawlog yield. Under this Act, it will provide a specified volume of sawlogs from each Forest Management Area, the volume being based on the estimated sustainable yield. As the calculation of regional sustainable yield forms the basis of this legislated commitment, establishing the figures is of critical importance. Variation of the volume of sawlogs made available each year (to account for industry-related or forest-management-related circumstances) is allowable, provided the specified total volume is made available over the 15-year period of the licence. An explanation of how this system applies to the study area is given in Chapter 15.

Under the Act, the sustainable yield rates must be reviewed every 5 years, or at a shorter interval if circumstances require or the Minister directs.

Although no obligations for value-adding are placed on licensees under this Act, the conditions of the each licence require sawlogs to be directed to their highest and best use, with licence assessments by the Department of Conservation and Environment every two years.

The other form of resource security - given under the *Forests (Wood Pulp Agreement) Act* 1961 - guarantees Australian Paper Mills a pulpwood supply from public land, partly within the study area. From 1989/90, this agreement provides for a minimum annual supply of 500 000 cu.m.

Factors that can alter the resource base

The timber resource base comprises both native forests and plantations of softwoods and hardwoods. Most prominent of the natural factors that can alter the resource base is fire. As described in Chapter 19,

catastrophic fire - such as occurred in 1939 - can devastate the timber resource of the Central Highlands. Previous chapters have described the interaction between fire and the ash species forests.

As public forests are managed for multiple uses, with timber production as one of many values, various prescriptions for timber-harvesting have been developed. Many of these relate to the need to successfully regenerate harvested areas, and also to ensure the economic and efficient use of the timber resource. Others deal with the protection of forest values such as nature conservation, recreation, and water production.

Changes in land-use recommendations can alter the areas available for timber-harvesting. Previous Council recommendations have made land available for timber production (State forest) and have also designated areas for uses that exclude timber-harvesting, such as parks and other conservation reserves.

Management factors that can alter the place availability of timber resources include the various forestry prescriptions, most of which are derived from the Code of Forest Practices. The protection of particular flora and fauna or their habitat may occur under *Flora and Fauna Guarantee Act* 1989, and may result in further reductions in timber resource availability.

It should be noted that changes to the resource only involve stands of productive forest. Confusion often arises from the erroneous assumption that all land unavailable for timber-harvesting contains productive forest. However, only a relatively small portion of parks and reserves contain ash species suitable for sawlog production.

Plantation timbers form the other major source of supply. Victoria has more than 200 000 ha of softwood plantations and just less than 20 000 ha of hardwood plantations. About half of them occupy public land; those in the study area are described in Chapter 15. Most of the private hardwood plantations are owned by Australian Paper Manufacturers.

Size of timber mills

A few large mills and a relatively large number of small ones characterise the study

area. A survey of the 44 mills that obtained timber from the study area conducted by the Timber Industry Council in 1989, revealed several facts. Smaller mills (that is, those with licences under 3000 cu.m) have low levels of investment and limited plans for future development, such as kiln drying facilities or new planing and moulding equipment. Most of them produce unseasoned structural timber and chipped residue. Larger mills have a greater investment in plant, buildings, and equipment and have more varied produce, with an emphasis on seasoned timbers. Of the five large mills drawing timber from the study area, four are State-wide organisations. While the largest firms have State and national markets, the small ones have markets either locally or in Melbourne.

One feature of hardwood logs that distinguishes them from softwoods is that they are less suited to mass-production techniques and automated equipment. It may be this factor that has resulted in the sawmilling industry being characterised by so many small mills, as each log requires an individual approach to achieve an optimal yield of sawn timber. Small and efficient mills can often be better suited to extracting the highest value from individual sawlogs through greater flexibility in sawing techniques, something that larger highly mechanised operations cannot achieve. Small mills can have a higher recovery rate from lower-grade logs, support more jobs per unit of timber, utilise resources that larger mills cannot, and conduct specialist work.

Small mills typically operate with low levels of capital investment, a high degree of owner participation, and local marketing, and usually a lower level of mechanisation than the larger ones. The Timber Industry Council suggested that the number of small mills in the study area may be in part due to the limited quantities of high-value timber available after the 1939 salvage operations, and the mills' subsequent production of green-sawn timber for construction and residue products (such as palings, boxes, and pallets).

With the government's commitment to ensuring that sawlogs are used for their highest-value use (under the Value Added Utilisation Scheme) may come pressure for further restructuring in the industry. Larger

mills are better able to make the required level of investment in further equipment, training, and market development. However, in recent years a State-wide trend towards a reduction in the number of mills has resulted in fewer small ones. A minimum volume of 'throughput' seems to be required to warrant investment in the predrying and reconditioning facilities involved in the high-value-added products. However, larger enterprises are more capital-intensive, and high levels of borrowings can make them more vulnerable to declines in the market.

The reduction in the number of small mills has seen a corresponding growth in the size of the few large ones, with a general industry trend of increasing mill efficiency and labour productivity. One factor here has been the acquisition of the sawlog licences held by the smaller mills, which results in the larger mill increasing its total licensed volume.

Future supply and demand

The future of the industry will be greatly influenced by the supply of forest resources and the demand for the industry's products. As noted by most writers in the field, predictions of the industry's future carry considerable uncertainty.

Hardwood sawlogs and pulp-logs are primarily taken from native forests. A feature of the study area is the extensive area of ash regrowth forests. As these approach an optimal age for harvesting, hardwood supplies in the study area will increase. Chapter 15 provides some data on the areas of forest and volumes of timber involved. Current supply levels can be derived from the sustainable yield information.

With the maturation of large areas of softwood plantations within and beyond the study area, the supply of softwood sawlogs and pulp-logs will increase significantly. In addition, overseas plantations - notably in New Zealand - now approaching harvestable age and much of the resultant timber is likely to be exported to Australia.

Imports of timber and timber products have a prominent role in the timber industry. Australia imports about one-third of sawn timber requirements, mainly as softwoods, and under the Closer Economic Relations agreement with New Zealand, would not

impose any trade barriers against any future large-scale imports from that country.

Imports of paper to Australia were worth over \$1000 million in 1988/89, and exports were worth about \$100 million in the same period.

Sawlog demand is primarily determined by activity in the housing and construction markets. Historically, only modest growth has occurred in total sawlog demand since 1950. In 1989, the Australian Bureau of Agricultural and Resource Economics predicted that the sawlog demand to the year 2030 would grow at a rate between 0.6 and 1.1% per annum. The current low level of new buildings being commenced means a relatively low demand for timber for construction purposes at present.

While some commentators are predicting declines in future sawlog demand, a contrary view is held by the Victorian Association of Forest Industries who have described the cyclic nature of housing demand, and predict growth to follow the current downturn. Furthermore, the association believes that the market need not be restricted to local areas and that opportunities exist for overseas sales in 'niche' markets, especially for value-added ash timbers from the study area.

Softwoods have displaced hardwoods in many applications, prominently in house construction, where hardwoods once had the greater market share. The construction field also shows a trend of non-wood materials substituting for traditional timber uses. This may, however, have other undesirable environmental implications. If these trends continue, only the 'appearance'-grade timbers will remain a market stronghold for hardwoods, but these currently account for only a small portion of the sawn timber market.

Value-added ash species products are of particular relevance to the study area as maturation of ash regrowth reaches optimal harvesting age and the government's strategy is to promote value-adding processing of sawn timber by the timber industry. Currently, the State imports about a third of its sawn-timber requirements (including rainforest timbers from South East Asia), and one of the benefits of increased value-adding of local timbers would be to replace a portion

of these imports. As stated above, the industry also believe that considerable export opportunities exist for products from the highest grades of timbers. For these reasons a number of mills have invested in capital equipment to enable them to undertake value-adding processing. Increasing softwood supplies could fill gaps in supply caused by higher value-adding of ash timbers.

Future demand for pulpwood is difficult to predict. Several factors contribute to this uncertainty - future demand for paper products, level of recycling, the products manufactured domestically, and the location of manufacturing plants. In addition, future pulpwood supplies are likely to be subject to competition from imports as increases in overseas supplies occur. The level of future paper recycling may be a major determinant in domestic demand. Currently, domestic manufacturers appear to have large opportunities for import-substitution. Some paper products of a specialist nature may always be imported. Establishing an export paper products capability is possible, but the international market is regarded as highly volatile and competitive. Australian firms have carried out feasibility studies into export potential, and the industry reports favourable prospects.

Other factors that will influence the timber industry include government policies, such as those covering the pricing of forest services and interaction between public and private interests in softwood production.

Plantations

Much current discussion concerns the present and possible future role of plantations in providing timber resources for industry. As described above, substantial areas of softwoods are already planted, and a continued program of expansion is under way.

Major issues have arisen in the debate over the possible impact of these plantations on the harvesting of native forests - including whether plantation timbers can substitute for native forest timbers, and the economy and productivity of hardwood plantations.

There is clear agreement that softwoods cannot substitute for the highest grades of timber, the appearance grades. However,

these only account for a relatively small portion of the total market. With recent advances in timber engineering and technology, it now appears likely that plantation timbers can meet the performance requirements for most structural purposes. An exception seems to be the long lengths of timber for construction, in which imported oregon currently has a major place in the market.

Growth rates, yield, and output per area planted all range across a wide spectrum. Economic analysis has shown that the returns from plantations are highly sensitive to growth rates and plantation yield. It follows that comparative economic analyses of hardwood plantation and native forests production are strongly influenced by the growth rates of plantation eucalypts. Other factors on which different economic analyses have varied include pulp-log royalties and the relative costs of production from native and plantation forests. Plantation timber being used for sawlogs clearly differs from that used for pulp-logs: hardwood plantation pulp-logs do appear to be competitive; however, opinion varies considerably on whether hardwood plantation sawlogs are competitive with those from native forests. The VAFI report that hardwood plantation sawlogs do not have a place in the market at present.

References

- Alpine Resorts Commission and Department of Conservation and Environment (1990). Lake Mountain: Management and Development Plan.
- Australian Bureau of Agricultural and Resource Economics (1990). 'Forestry and Conservation: an Examination of the Policy Alternatives. Submission to the Resource Assessment Commission.' (AGPS: Canberra.)
- Australian Heritage Commission (1990). Forests and the National estate. *A submission to the Resource Assessment Commission Inquiry into Australian Forest and Timber Resources.*
- Briggs, J.D., and Leigh, J.H. (1988). 'Rare or Threatened Australian Plants.' (CSIRO: Canberra.)
- Bulthuis, D.A., Axelrad, D.M., Bremner, A.J., Coleman, N., Holes, N.J., Krebs, C.T., Marchant, J.W., and Mickelson, M.J. (1984). Loss of seagrass in Western Port, progress report No 1, December 1983 to March 1984. *Marine Science Laboratories, Internal Report No 73.*
- Burton, J. (1984). Recreational use of urban water storages and catchments. *Australian Water Resources Council, Water Management Series No. 4.*
- Cameron, J., and Penna, I. (1988). 'The Wood and the Trees: A Preliminary Economic Analysis of a Conservation-Oriented Forest Industry Strategy.' (Australian Conservation Foundation: Melbourne.)
- Department of Conservation, Forests and Lands (n.d.). 'Victoria's Rainforests: An Overview.' (Released July 1987.)
- Fleming, M.R., Temby, I.D., and Thomson R.L.. (1979). Sites of zoological significance in the Upper Yarra region. *Ministry of Conservation, Environmental Studies Program Report No. 247.*
- Forestry and Forest Products Industry Council (1987). 'Forest Industries Growth Plan: a Submission to the Australian Government.' (FAFPIC: Melbourne.)
- Gruen, F., Leslie, A. and Smith A.P. (1989). 'Inquiry into the Proposed Trial of the Value-adding Utilization System in the Central and East Gippsland Forest Management Areas, under the Environmental Assessment Act.' (Ministry for Planning and Environment:, Melbourne.)
- Gullan, P.K., Parkes, D.M., Morton, A.G., and Bartley, M.J. (1979). Sites of botanical significance in the Upper Yarra region. *Ministry of Conservation Environmental Studies Program Report No 246.*
- Hossain, M., Sar, L., and Samuel, N. (1989). Long term consumption projections for forest products: implications for trade and sector development. *ABARE Discussion Paper No. 89.6.*
- Land Conservation Council (1973). 'Report on the Melbourne Study Area.' (Victorian Government Printing Office: Melbourne.)
- Land Conservation Council (1977). 'Final Recommendations - Melbourne Study Area.'

(Victorian Government Printing Office: Melbourne.)

Land Conservation Council (1991). 'Final Recommendations - Rivers and Streams Special Investigation' (Land Conservation Council: Melbourne.)

Lindenmayer, D.B. (1989). The ecology and habitat requirements of Leadbeaters Possum. *PhD Thesis, Australian National University, Canberra.*

Lindenmayer, D.B., Cunningham, R.B., Tauton, M.T., and Smith, A.P. (1990). The conservation of arboreal marsupials in the montane ash forests of the Central Highlands of Victoria, South-east Australia: II. The loss of trees with hollows and its implications for conservation of Leadbeaters possum *Gymnobelideus leadbeateri* McCoy (Marsupialia: Petauridae). *Biological Conservation* 54: 133-45.

Lindenmayer, D.M., Tauton, M.T., and Norton, T.W. (1990). Leadbeaters possum - a test case for integrated forestry. *Search* 21: 156-159.

Macfarlane, M.A., and Seebeck, J.H. (1991). Draft management strategies for the conservation of Leadbeaters possum *Gymnobelideus leadbeateri*, in Victoria. *Arthur Rylah Institute for Environmental Research Technical Report Series No. 111.*

McIlroy, D. (1990). 'The ecological future of Australia's forests'. (Australian Conservation Foundation: Melbourne.)

O'Shaughnessy, P.J. (1986). MMBW catchment management policies, a history and analysis of their development. *Centre for Resource and Environmental Studies Working Paper* 1986/26.

O'Shaughnessy, P.J., and Jayasuriya, M.D.A. (1987). Managing the ash type forests for water production in Victoria. *Forest Management in Australia Conference Proceedings, Institute of Forests of Australia Perth, 28 September-2 October, 1987*, pp.437-63.

Rainforest Technical Committee (1986). 'Rainforest conservation in Victoria'. (Department of Conservation, Forests, and Lands: Melbourne.)

Smith, A.P., Lindenmayer, D., and Suckling, G.C. (1985). The ecology and management of Leadbeaters possum. Research report to the World Wildlife Fund. University of New England, New South Wales.

Smith, A.P. and Lindenmayer, D. (1988). Tree hollow requirements of Leadbeaters possum and other possums and gliders in timber production ash forests of the Victorian Central Highlands. *Australian Wildlife Research* 15: 347-62.

Smith, A.P. (1984a). Demographic consequences of reproduction, dispersal and social interaction in a population of Leadbeaters possum (*Gymnobelideus leadbeateri*). In 'Possums and Gliders', (ed. A.P. Smith and I.D. Hume, pp. 359-73. (Surrey Beatty and Sons: Chipping Norton, New South Wales)

Smith, A.P. (1984b). Diet of Leadbeaters possum, *Gymnobelideus leadbeateri* (Marsupialia). *Australian Wildlife Research* 11: 265-73.

Victoria, Government (1987). 'Protecting the Environment: a Conservation Strategy for Victoria.' (Victorian Government Printing Office: Melbourne.)

APPENDICES

Appendix I

EXTRACT OF THE *LAND CONSERVATION ACT 1970*

Public Land

Section 2.

- (1) 'Public land' means -
- (a) land which is not within a city or rural city and is -
 - (i) unalienated land of the Crown including land permanently or temporarily reserved under section 4 of the *Crown Land (Reserves) Act 1978* and State forest and parks within the meaning of the *National Parks Act 1975*;
 - (ii) vested in any public authority (other than a municipal council or an authority under the *Water Act 1989* that has a sewerage district under that Act); or
 - (iii) vested in the Melbourne and Metropolitan Board of Works; and
 - (b) any other land which the Governor in Council declares under sub-section (2) to be public land for the purposes of this *Act*

'Reserved forest' and 'State forest' have the same meanings as in section 3 of the *Forests Act 1958*.

- (2) The Governor in Council may on the recommendation of the Minister made after consultation with -
- (a) any Minister of the Crown in whom any land is vested; or
 - (b) the Minister responsible for a public authority in which any land is vested -
- by proclamation published in the *Government Gazette* declare any such land to be public land for the purposes of this *Act*.

Functions of the Council

Section 5.

- (1) The Council shall -
- (a) carry out investigations and make recommendations to the Minister with respect to the use of public land in order to provide for the balanced use of land in Victoria;
 - (b) make recommendations to the Governor in Council as to the constitution and definition of water supply catchment areas under the *Soil Conservation and Land Utilization Act 1953*; and
 - (c) advise the Minister administering the Soil Conservation Authority concerning policy on the use of land (whether public land or any other land however vested) in any water supply catchment area.
- (2) In making any recommendation the Council shall have regard to the present and future needs of the people of Victoria in relation to -
- (a) the preservation of areas which are ecologically significant;
 - (b) the conservation of areas of natural interest beauty or of historical interest;
 - (c) the creation and preservation of areas of reserved forest;
 - (d) the creation and preservation of areas for national parks;

- (e) the creation and preservation of areas for leisure and recreation, and in particular of areas close to cities and towns for bushland recreation reserves;
 - (f) the creation and preservation of reserves for the conservation of fish and wildlife;
 - (g) the preservation of species of native plants; and
 - (h) land required by government departments and public authorities in order to carry out their functions.
- (2A) In making a recommendation as to land use the Council shall have regard to the social and economic implications relevant to the recommendation.
- (3) Where the Council recommends the alienation of any land the recommendation shall include the Council's opinion as to the best method of alienating the land to ensure the most satisfactory use and management of the land in the public interest.
- (4) Any person or body may make submissions to the Council as to how any public land can be better used to meet the needs of the people of Victoria and the Council shall consider any such submissions before making any recommendation under paragraph (a) of sub-section (1).

Section 8.

- (1) Where the Governor in Council is of the opinion that an investigation and recommendation of the Council in relation to any particular district or area of Victoria is necessary or expedient he may require the Council to make such investigation and recommendation within such time as is fixed by the Governor in Council.
- (2) The Governor in Council may extend the time fixed under sub-section (1) where in his opinion the investigation could not otherwise be properly carried out.

Investigations, Notices and Reports

Section 9.

- (1) The Council shall not make any recommendation under this *Act* in relation to any district or area without a prior investigation of the district or area.
- (2) Before commencing any investigation under paragraph (a) of sub-section (1) of section 5 the Council shall publish a notice in the *Government Gazette*, in a newspaper circulating throughout the State and in a newspaper circulating particularly in or in the vicinity of the area or district to be investigated stating that an investigation of that district or area described in the notice is to be carried out for the purposes of this *Act*.
- (3) On completing an investigation of a district or area under paragraph (a) of sub-section (1) of section 5 the Council shall -
 - (a) publish a report of the investigation;
 - (b) give notice in the *Government Gazette* of the publication of the report, the address where copies of the report may be obtained or inspected and stating that any submissions to the Council in relation to such report will be considered by the Council if they are made within 60 days of such notice; and
 - (c) publish notice in a newspaper circulating throughout the State and in a newspaper circulating particularly in or in the vicinity of the area or district investigated of the publication of the report, the address where copies of the report may be obtained or inspected and stating that submissions may be made to the Council and the date before which they should be made.
- (4) The Council shall consider any submissions in relation to such report made by any person or body within 60 days of notice being given under paragraph (b) of sub-section (3).

Notice to be given to public departments and authorities in certain cases.

Section 10.

- (1) Not earlier than 60 days after notice being given under paragraph (b) of sub-section (3) of section 9, the Council shall send a copy of its proposed recommendation to -
 - (a) the Council of any municipality in the municipal district of which any part of the area or district to which the recommendation relates is situated;
 - (b) any other public authority or government department that in the opinion of the Council has an interest in the area of the proposed recommendation; and
 - (c) any person or body who made a submission under section 9 -

and shall consider any submissions received within 60 days of the sending of such copy to the council, authority, department, person or body or in the case of a public authority or government department within such longer period as may be agreed upon between the Minister and the Minister administering that department or responsible for that authority.
- (2) Where any recommendation is made to the Minister under this *Act* it shall be accompanied by a copy of any submissions received from any person body department authority or council pursuant to the provisions of sub-section (4) of section 9 or sub-section (1) of this section.
- (3) Where the Council has made a recommendation to the Minister under paragraph (a) of sub-section (1) of section 5 the Minister may, after he has given not less than fourteen days notice of his intention so to do to the Minister administering a government department or responsible for a public authority recommend to the Governor in Council that notice of the recommendation or that part of the recommendation that affects the government department or public authority be given to the government department or public authority concerned and where notice of that recommendation or part is so given by the Governor in Council it shall be the duty of the government department or public authority to use all diligence and dispatch to give effect to such recommendation so far as it affects any land vested in or controlled by it.

Copy of every recommendation and of proposals to be tabled in Parliament.

Section 11.

A copy of every recommendation of the Council made under sub-section (1) of section 5 and of the proposals of the Council submitted to the Minister pursuant to section 7 shall be laid before both Houses of Parliament within fourteen days of the making thereof if Parliament is then sitting and if Parliament is not then sitting within fourteen days after the meeting of Parliament.

A copy of the *Land Conservation Act* 1970 can be obtained from the Information Victoria Centre, 318 Little Bourke Street, Melbourne, 3000.

Appendix II

HISTORIC SITES

Assessment of Significance

Key:

A	Important at the State level	S	Scientific
B	Important at the regional level	-	Further research required before significance of this site can be properly evaluated/
C	Important at the local level		

Code number	Site	Ranking
Tracks and settlement sites		
T1	Collins Settlement Site, Sorrento	A
T2	Corinella Settlement Site	A
T3	Dandenong Police Paddocks	A
T4	The Yarra Track	A
T5	Bullock Track, Uralla Reserve	C
T6	Geodetic cairns	A
T7	Matlock township	B/A
T8	Red Jacket Post Office	B
T9	Gaffney's Creek	A
T10	Tanjil Bren township	B
T11	Tin Hut (Rubicon) township and Post Office	B
T12	Coalville township	B
T13	Narracan township	?
Pastoral and agricultural sites		
P1	Churchill Island	A
P2	Gulf Station, Yarra Glen	A
P3	Torbreck pastoral station	-
P4	Gairdners cottage	A
P5	Bear's Castle, Yan Yean	A
P6	Bear's Well	C
P7	Sage's Cottage, Baxter	A
P8	Chicory kiln	A
P9	Berwick cheese factory	A
P10	Cashin Brothers Flour Mill ruin, Lilydale	B
P11	Coolart	A
P12	Stone fence, Eildon State Park	B
P13	Farm house sites, Jerusalem Creek	B
P14	Stone's outstation and stockyards	B/A
P15	Glen Hope/Benara homestead	B
P16	Bob Brier's Home Site and garden	C
P17	Sunnyslope Hut Site and Puzzle Range Spring	C/B
P18	Buildings, Mt Worth State Park	-
P19	McKenzie's Well, French Island	C/B
Mining sites		
M1	Walhalla Historic Area	A
M2	Enoch's Point mines	A
M3	Luck's All Mine	A
M4	Wallaby mines	A
M5	Webster's Spur and Gooley's Creek mines	A
M6	Standers Creek mines	A
M7	Leviathan Creek workings	A
M8	New Chum Mine, Dry Creek	A
M9	Lily Creek Mine	A

Appendix II (continued)

Code number	Site	Ranking
Mining sites (continued)		
M10	Wild Flower Mine	A
M11	White Star Mines - Number 1	A
M11	White Star Mines - Number 2	B
M12	Donnelly's Creek Mines	A
M13	Toombon mines and settlement	A
M14	Lady Vera Mine	B
M15	Mountain Maid Mine	B
M16	Victor's Quartz Mine	S
M17	United Gleason's Mining Area	B
M18	Working Miners Mine	C
M19	Jamieson alluvial workings	-
M20	Cooper's Creek copper mine, town and lime works	A
M21	Chinese oven, Chinaman's Point	A
M22	Pound Bend diversion tunnel and gold workings	A
M23	Jordan River diversion tunnel	B
M24	Thomson River diversion tunnel	B/A
M25	Big and Little Peninsula diversion tunnels	B
M26	Stockman's Reward dredging site	C
M27	Miner's Log Hut, Tonsil Spur	-
M28	Robb's Reward Mine, Eildon State Park	B
M29	Wilson's Creek mining area	B
M30	Black Creek mines, Eildon State Park	B
M31	O.K. Mine, Fraser National Park	B
M32	Solferino Mines, Fraser National Park	B
M33	Italian Gully Mines, Fraser National Park	B
M34	Golden Bower Mine	-
M35	Victorian Mount Morgan Mine	-
M36	Cumberland Falls Mine	C
M37	Snobs Creek Mine	C
M38	Contention Mine	B
M39	Damper Mine	C
M40	Chester and Lockes Mine	C
M41	Brown's Camp	C
M42	Great Britain Mine	C
M43	Peninsula Road goldfield	B
M44	Sovereign Mine, Reefton Spur	C
M45	Chalmers Ridge Gold Workings	C
M46	Antimony Mine, Kinglake	C
M47	Old Mount Slide and Mt Jerusalem mine shafts	C
M48	Wolfram Mine, Wilks Creek Track	B
M49	Mt Robertson mining battery	B
M50	Tonsil mine and mill, site	C
M51	Reedy Creek alluvial mining area	C
M52	Marble Quarry, Numbruk	B
M53	Cape Woolamai Granite Quarry	B
M54	State Coal Mine, Wonthaggi	A
M55	Kilcunda Coal Mines	B
M56	Tin Mine, Gembrook	C/B
Sawmilling sites		
1. Plenty Ranges		
S1	Comet Mill	A
S2	Regular Camp	B
S3	Reedy Creek sawmill, mine and tramway	C
S4	Mt Disappointment plateau sawmills and tramways	B
S5	Greens Mill	C
S6	Spraggs Road mill site	B
S7	Marginal Road sawdust heap (Byrne mill)	C

Appendix II (continued)

Code number	Site	Ranking
Sawmilling sites (continued)		
2. Murrindindi forest (continued)		
S8	Blowhard Road sawmill site (Knott)	C
S9	Bull Creek sawmill (Tratford)	C
S10	Dindi mill site	B
S11	Murrindindi wooden tramway	B
S12	Robbies Mill, Black Range	B
S13	Granton's sawmill	B
S14	Kalatha Forestry Camp	C
3. Gembrook		
S15	Russell's Tomahawk Creek Tramway, Beenak	B
S16	Russell's Mill, Bridge and Dugout	B
S17	Cloverdell mill site	C
S18	Unknown mill, Gembrook	C?
S19	Steel Rail Tramway, Gembrook	B
S20	Hogan and Kirkpatrick's mill site	C
S21	Mortimer and Dyer Park Picnic areas	C
4. Upper Yarra		
S22	Britannia Creek Wood Distillation Plant	A
S23	Yelland's No 2 mill site	B
S24	Yelland's No 3 mill site	B
S25	Yelland's No 4 mill site	C
S26	Yelland's kilns	B
S27	Blake's mill site	C
S28	Powelltown--yarra Junction Tramway	B
S29	Reid's Creek tramline and mill	B
S30	The Bump Tunnel	A
S31	Ada River make-up	B
S32	High Lead summit	B
S33	Little Ada River make-up	B
S34	State Mill site	A
S35	Boiler and sateam engine	C
S36	Ada No 2 mill	A
S37	Incline to the New Ada mill	B
S38	New Ada mill site	A
S39	New Federal mill site	A
S40	Ezard's mill site	C
S41	Starling's Gap mill site	B
S42	Worley's Tramway, gilderoy	B
S43	Bjorksten Creek tramline	B
S44	Winch and landing site, Big Creek Road	A
S45	Log and bogie display, Powelltown	C
5. Kinglake/Flowerdale area		
S46	Carman's mill site and tramway	C
S47	Wright's Tramway, Yea	-
S48	Kinglake--Whittlesea Tramway	B
S49	Flowerdale Nom 1 mill site	C
S50	Higg's sawmill site	B
S51	Regular camp mill site	B
6. Rubicon		
S52	Clark and Pearce No 1 mill site	A
S53	Clark and Pearce No 2 mill site	B
S54	Clark and Pearce old No 4 mill site	C
S55	Clark and Pearce No 4 mill site	A
S56	Tresle bridge, Rubicon	B
S57	SEC trestle bridges	B

Appendix II (continued)

Code number	Site	Ranking
Sawmilling sites (continued)		
6. Rubicon (continued)		
S58	Tin Hut (Rubicon) to Alexandra tramway	C
7. Mount Worth State Park		
S59	Clark and Pearce No 1 winch and boiler	B
S60	Gardiner's No 1 mill site	C
S61	Gardiner's No 2 mill site	C
S62	Trevorrow's mill site and tramway	C
S63	Seymour's mill site	C
S64	Maslin's mill site	C
8. Marysville		
S65	Cambarville Sawmilling Company	B
S66	Marysville Timber and Seasoning Co. mills etc.	B
S67	Vic Oak Sawmilling Company	B
S68	Drain, Cook mill site and tramway	C
S69	Buxton Sawmilling Company and Tramway	B
S70	J. and J. Feiglin's Mill	B
9. Erica area		
S71	Christensen and Saxton's Mill, Tyers Junction	B
S72	Growler's Creek winch	C
S73	Growler's Creek trestle bridge	B
S74	Ingram's mill site, Spurwheel Saddle	C
S75	Ingram's skyline	A
S76	Munro's mill (eastern), Eastern Tyers River	C
S77	Munro's mill (western), Eastern Tyers River	B
S78	Sharp's No 2 mill, Thomson Valley	C
S79	Stationary steam engine, Tyers Junction area	C
S80	Alstergren's sawmill	B/A
S81	Thomson valley Tramway and sawmills	B
S82	Tyers Valley Tramways	B
10. Tanjil Bren		
S83	Brown's Timboon sawmill site	C
S84	Kirchubel's Mill and Tramway	B
S85	Downey's sawmill	B
S86	Porta's sawmill	B
S87	Toorong Sawmills Nos 1 and 2 and settlement	B
S88	Stronch's Camp	C
S89	Myree sawmill	C?
Other forest sites		
F1	Cumberland Valley Scenic Reserve	A
F2	Acclimatisation Reserve/Gembrook Park	A
F3	Forestry camps 1 and 2	B
F4	Bullock troughs, Gembrook	B
F5	Kurth Kiln, Gembrook	A
F6	Whitelaw Mountain Grey Gum	A
F7	South Cascade Creek Rainforest	A
F8	Andrews Hill fire tower	-
F9	Redwood plantations in catchment areas	A
F10	Mountain Ash stands in catchment areas	A
F11	Furmston's Tree	A
F12	Big Tree, Upper Yarra catchment	A
F13	Thorpdale Tree memorial	C
F14	The Ada Tree	A

Appendix II (continued)

Code number	Site	Ranking
Water supply and hydro-electric sites		
W1	Yan Yean Reservoir	A
W2	Caretaker's cottage, Yan Yean	A
W3	Yan Yean bywash	A
W4	Plenty River flume	A
W5	Yan Yean Pipetrack Valve House	A
W6	Yan Yean Reservoir Valve House and Channel	A
W7	Yan Yean Boatshed	B
W8	The Cascades, Wallaby Creek Channel	A
W9	Jack's Creek Channel	A
W10	Big Tunnel, Silver Creek Aqueduct	A
W11	Wallaby Creek Weir	A
W12	Silver Creek Weir	A
W13	Nimmo Falls Quarry	B
W14	Clear Water Channel	A
W15	Toorourrong Reservoir	A
W16	Wallaby Creek Quarters	A
W17	Maroondah Reservoir	B
W18	Donnelly's Creek Weir	B
W19	The Maroondah Aqueduct	B
W20	Graceburn Weir and Aqueduct	B
W21	Fernshaw	B
W22	O'Shannassy Weir and Aqueduct	B
W23	O'Shannassy Reservoir	B
W24	O'Shannassy Quarters	B
W25	Thomson to Upper Yarra Aqueduct	C
W26	Upper yarra Dam	B
W27	Dandenong water supply aqueduct	C
W28	Sunday Creek Reservoir	C
W29	Wirilda pipeline (and kilns)	B
W30	Rubicon Falls Power Station and Dam	A
W31	Lower Rubicon Power Station	A
W32	Rubicon Power Station	A
W33	Royston Dam and Power Station	A
Recreation sites		
R1	Falls Creek Hut, Warburton--Walhalla Track	B
R2	Ferntree Gully Kiosk	B
R3	One Tree Hill Lookout Tower, Ferntree Gully	C
R4	Remains of Fauna Sanctuary and Aviary, Ferntree Gully	C
R5	Coppins Lookout, Sorrento	B
R6	Sorrento Pier	B
R7	Sorrento Park	C
R8	Kiosk and jerry, Sorrento	C
R9	Stream train terminus platform	B
R10	Lookout tower, Arthur's Seat	C
R11	Band Pavilion, Sorrento	B
R12	'Seawinds', Nepean State Park	B
R13	Mornington Pier	B
R14	Healesville Sanctuary	A
R15	Warrandyte Youth Hostel	B
Miscellaneous		
X1	Cape Schanck lighthouse	A
X2	Tan Pit, Jack's Beach	A
X3	Sutton Grange, Mornington	B
X4	Fairhaven Jetty, French Island	C
X5	Tankerton Jetty, French Island	C

Appendix II (continued)

Code number	Site	Ranking
Miscellaneous (continued)		
X6	Queens Ferry Road Jetty	B
X7	Bridge over Yarra at Woori Yallock	C
X8	Langwarrin Flora and Fauna Reserve	A
X9	McLeod prison complex	A
X10	Plane crash site, Shire of Narracan	C
Memorials		
	War Memorials	-
	Explorers' Memorials	-
	Other Memorials	-
Cemeteries and lone graves		-
Railway lines and stations		-
Schools		-
Court Houses and Police Buildings		-
Mechanics' Institutes		-

Note:

This inventory of historic sites in the study area is not, and could not be, definitive. Further research and fieldwork will identify additional sites and amend evaluations of known ones.

Appendix III

PLANT SPECIES IN THE STUDY AREA

The list below follows nomenclature approved by the National Herbarium of Victoria (Ross 1990), but includes some subsequent updates. Names in the genus *Caladenia* include some put forward by Carr (1991).

GYMNOSPERMS		<i>Doodia caudata</i>	Small rasp-fern
		<i>Doodia media</i>	Common rasp-fern
CUPRESSACEAE			
	<i>Callitris rhomboidea</i>	Oyster Bay cypress-pine	
	* <i>Cupressus macrocarpa</i>	Montrey cypress	
PINACEAE			
	* <i>Pinus nigra</i>	Black pine	
	* <i>Pinus pinaster</i>	Maritime pine	
	* <i>Pinus radiata</i>	Monterey pine	
PODOCARPACEAE			
	<i>Podocarpus lawrencei</i>	Mountain plum pine	
FERNS AND FERN ALLIES			
ADIANTACEAE			
	<i>Adiantum aethiopicum</i>	Common maidenhair	
e	<i>Adiantum capillus-veneris</i>	Dainty maidenhair	
e	<i>Adiantum diaphanum</i>	Filmy maidenhair	
	<i>Anogramma leptophyllum</i>	Annual fern	
	<i>Cheilanthes austrotenuifolia</i>	Green rock fern	
	<i>Cheilanthes distans</i>	Bristly cloak-fern	
	<i>Cheilanthes sieberi</i>	Narrow rock fern	
	<i>Pellaea falcata</i>	Sickle fern	
	<i>Pellaea falcata</i> var. <i>falcata</i>	Sickle fern	
r	<i>Pteris comans</i>	Netted brake	
	<i>Pteris tremula</i>	Tender brake	
ASPLENIACEAE			
	<i>Asplenium bulbiferum</i>	Mother spleenwort	
	<i>Asplenium flabellifolium</i>	Necklace fern	
	<i>Asplenium flaccidum</i>	Weeping spleenwort	
v	<i>Asplenium obtusatum</i>	Shore spleenwort	
r	<i>Asplenium trichomanes</i>	Common spleenwort	
	<i>Pleurosorus rutifolius</i>	Blanket fern	
ATHYRIACEAE			
	<i>Allantodia australis</i>	Austral lady-fern	
AZOLLACEAE			
	<i>Azolla filiculoides</i>	Pacific azolla	
	<i>Azolla pinnata</i>	Ferny azolla	
BLECHNACEAE			
	<i>Blechnum cartilagineum</i>	Gristle fern	
	<i>Blechnum chambersii</i>	Lance water-fern	
	<i>Blechnum fluviatile</i>	Ray water-fern	
	<i>Blechnum minus</i>	Soft water-fern	
	<i>Blechnum nudum</i>	Fishbone water-fern	
	<i>Blechnum patersonii</i>	Strap water-fern	
	<i>Blechnum penna-marina</i>	Alpine water-fern	
	<i>Blechnum wattsi</i>	Hard water-fern	
CYATHEACEAE			
r	<i>Cyathea X marcescens</i>		Skirted tree-fern
	<i>Cyathea australis</i>		Rough tree-fern
r	<i>Cyathea cunninghamii</i>		Slender tree-fern
DENNSTAEDTIACEAE			
	<i>Culcita dubia</i>		Common ground-fern
	<i>Histiopteris incisa</i>		Bat's wing Fern
	<i>Hypolepis amaurorachis</i>		Austral ground-fern
	<i>Hypolepis glandulifera</i>		Downy ground-fern
	<i>Hypolepis muelleri</i>		Marsh ground-fern
	<i>Hypolepis rugosula</i>		Ruddy ground-fern
	<i>Pteridium esculentum</i>		Austral bracken
DICKSONIACEAE			
	<i>Dicksonia antarctica</i>		Soft tree-fern
DRYOPTERIDACEAE			
	<i>Lastreopsis acuminata</i>		Shiny shield-fern
r	<i>Lastreopsis hispida</i>		Bristly shield-fern
	<i>Polystichum proliferum</i>		Mother shield-fern
	<i>Rumohra adiantiformis</i>		Leathery shield-fern
GLEICHENIACEAE			
	<i>Gleichenia dicarpa</i>		Pouched coral-fern
	<i>Gleichenia microphylla</i>		Scrambling coral-fern
	<i>Sticherus lobatus</i>		Spreading fan-fern
	<i>Sticherus tener</i>		Silky fan-fern
GRAMMITIDACEAE			
	<i>Ctenopteris heterophylla</i>		Gipsy fern
	<i>Grammitis billardieri</i>		Common finger-fern
HYMENOPHYLLACEAE			
	<i>Hymenophyllum australe</i>		Austral filmy fern
	<i>Hymenophyllum cupressiforme</i>		Common filmy fern
	<i>Hymenophyllum flabellatum</i>		Shiny filmy fern
	<i>Hymenophyllum peltatum</i>		Alpine filmy fern
	<i>Hymenophyllum rarum</i>		Narrow filmy fern
	<i>Macroglena caudata</i>		Jungle bristle-fern
	<i>Polyphlebium venosum</i>		Veined bristle-fern
ISOETACEAE			
	<i>Isoetes drummondii</i>		Plain quillwort
	<i>Isoetes muelleri</i>		Rock quillwort
LINDSAEACEAE			
	<i>Lindsaea linearis</i>		Screw fern
r	<i>Lindsaea microphylla</i>		Lacy wedge-fern
LYCOPODIACEAE			
r	<i>Lycopodium australianum</i>		Fir clubmoss
	<i>Lycopodium deuterodensum</i>		Bushy clubmoss

Appendix III (continued)

Lycopodium fastigiatum	Mountain clubmoss	Centrolepis strigosa	Hairy centrolepis
Lycopodium laterale	Slender clubmoss		
r Lycopodium scarosum	Spreading clubmoss	COMMELINACEAE	
r Lycopodium serpentinum	Bog clubmoss	*Tradescantia fluminensis	Wandering jew
v Lycopodium varium	Long clubmoss		
Phylloglossum drummondii	Pigmy clubmoss	CYMODOCEACEAE	
		Amphibolis antarctica	Sea nymph
MARSILEACEAE			
Marsilea drummondii	Common nardoo		
Marsilea hirsuta	Short-fruit nardoo	CYPERACEAE	
		Baumea acuta	Pale twig-sedge
OPHIOGLOSSACEAE		Baumea articulata	Jointed twig-sedge
v Botrychium australe	Austral moonwort	Baumea gunnii	Slender twig-sedge
Ophioglossum lusitanicum	Austral adder's-tongue	Baumea juncea	Bare twig-sedge
		Baumea rubiginosa	Soft twig-sedge
OSMUNDACEAE		Baumea tetragona	Square twig-sedge
Todea barbara	Austral king-fern	Bolboschoenus caldwellii	Sea club-sedge
		Bolboschoenus medianus	Marsh club-sedge
POLYPODIACEAE		r Carex alsophila	Forest sedge
Microsorium diversifolium	Kangaroo fern	Carex appressa	Tall sedge
Microsorium scandens	Fragrant fern	Carex bichenoviana	Sedge
Pyrrosia rupestris	Rock felt-fern	Carex blakei	Sedge
		Carex breviculmis	Short-stem sedge
PSILOTACEAE		Carex brownii	Sedge
Tmesipteris billardieri	Long fork-fern	Carex canescens	Short sedge
v Tmesipteris elongata	Elongate fork-fern	Carex chlorantha	Green-top sedge
r Tmesipteris ovata	Oval fork-fern	*Carex divisa	Divided sedge
Tmesipteris parva	Small fork-fern	*Carex divulsa	Sedge
		Carex fascicularis	Tassel sedge
SCHIZAEACEAE		Carex gaudichaudiana	Fen sedge
Schizaea asperula	Rough comb-fern	Carex gunniana	Mountain sedge
Schizaea bifida	Forked comb-fern	Carex hebes	Sedge
Schizaea fistulosa	Narrow comb-fern	Carex incomitata	Hillside sedge
		Carex inversa	Common sedge
SELAGINELLACEAE		Carex iynx	Sedge
Selaginella gracillima	Tiny selaginella	Carex jackiana	Sedge
*Selaginella kraussiana	Garden celaginella	Carex polyantha	Sedge
Selaginella uliginosa	Swamp selaginella	Carex pumila	Strand sedge
		v Carex tasmanica	Curly sedge
		Carex tereticaulis	Rush sedge
MONOCOTYLEDONS		Carpha alpina	Small flower-rush
		Carpha nivicola	Broad-leaf flower-rush
ALISMATACEAE		Caustis pentandra	Thick twist-rush
*Alisma lanceolata	Water plantain	Caustis restiacea	Slender twist-rush
Alisma plantago-aquatica	Water plantain	Chorizandra cymbaria	Heron bristle-sedge
Damasonium minus	Star fruit	Chorizandra enodis	Black bristle-sedge
		Cladium procerum	Leafy twig-sedge
APONOGETONACEAE		Cyperus brevifolius	Short-leaf flat-sedge
Aponogeton distachyon	Cape water-hawthorn	*Cyperus congestus	Dense flat-sedge
		*Cyperus eragrostis	Drain flat-sedge
ARACEAE		Cyperus exaltatus	Tall flat-sedge
*Zantedeschia aethiopica	White arum lily	Cyperus gunnii	Flecked flat-sedge
		Cyperus lhotskyanus	Flat-sedge
BURMANNIACEAE		Cyperus lucidus	Leafy flat-sedge
v Thismia rodwayi	Fairy Lanterns	Cyperus rotundus	Nut-sedge
		Cyperus sanguinolentus	Flat-sedge
CENTROLEPIDACEAE		Cyperus sphaeroides	Flat-sedge
Aphelia gracilis	Slender aphelia	*Cyperus tenellus	Tiny flat-sedge
Aphelia pumilio	Dwarf aphelia	Eleocharis acuta	Common spike-sedge
Centrolepis aristata	Pointed centrolepis	Eleocharis atricha	Tuber spike-sedge
Centrolepis fascicularis	Tufted centrolepis	Eleocharis gracilis	Slender spike-sedge
Centrolepis glabra	Smooth centrolepis	Eleocharis pusilla	Small spike-sedge
Centrolepis polygyna	Wiry centrolepis	Eleocharis sphacelata	Tall spike-sedge
		Gahnia clarkei	Tall saw-sedge

Appendix III (continued)

Gahnia filum	Chaffy saw-sedge	Tricostularia pauciflora	Needle bog-sedge
v Gahnia grandis	Brickmakers' saw-sedge	r Uncinia compacta	Compact hook-sedge
Gahnia microstachya	Slender saw-sedge	Uncinia flaccida	Weak hook-sedge
Gahnia radula	Thatch saw-sedge	Uncinia tenella	Delicate hook-sedge
Gahnia sieberiana	Red-fruit saw-sedge		
Gahnia trifida	Coast saw-sege	HYDATELLACEAE	
Gymnoschoenus	Button grass	Ottelia ovalifolia	Swamp lily
sphaerocephalus		Trithuria submersa	Trithuria
Isolepis aucklandica	New Zealand club-sedge		
Isolepis cernua	Nodding club-sedge	HYDROCHARITACEAE	
Isolepis crassiuscula	Mountain club-sedge	* Egeria densa	
Isolepis fluitans	Floating club-sedge	* Elodea canadensis	Canadian pondweed
Isolepis habra	Wispy club-sedge	Halophila australis	Oval sea-wrack
Isolepis hookeriana	Grassy club-sedge	Ottelia ovalifolia	Swamp lily
* Isolepis hystrix	awned club-sedge	Vallisneria spiralis	Eel-grass
Isolepis inundata	Swamp club-sedge		
Isolepis marginata	Little club-sedge	IRIDACEAE	
Isolepis nodosa	Knobby club-sedge	* Crocosmia X crocosmiflora	Golden copper-tip
Isolepis platycarpa	Flat-fruit club-sedge	Diplarrrena moraea	Butterfly flag
Isolepis producta	Nutty club-sedge	* Freesia leichtlinii	Freesia
Isolepis stellata	Star club-sedge	* Galaxia fugacissima	Galaxia
Isolepis subtilissima	Club-sedge	* Gladiolus tristis	Evening-flower gladiolus
Isolepis victoriensis	Victorian clug-sedge	* Gladiolus undulatus	Gladiolus
r Isolepis wakefieldiana	Tufted club-sedge	* Gynandris setifolia	Thread iris
Lepidosperma canescens	Hoary rapier-sedge	* Homeria flaccida	One-leaf cape tulip
Lepidosperma concavum	Sand-hill sword-sedge	* Iris germanica	German iris
Lepidosperma congestum	Clustered sword-sedge	* Ixia maculata	Yellow ixia
Lepidosperma elatius	Tall sword-sedge	* Ixia polystachya	Variable ixia
Lepidosperma elatius	Tall sword-sedge	Libertia pulchella	Pretty grass-flag
var. elatius		Patersonia fragilis	Short purple-flag
Lepidosperma elatius	Tall sword-sedge	Patersonia glabrata	Leafy purple-flag
var. ensiforme		Patersonia occidentalis	Long purple-flag
Lepidosperma filiforme	Common rapier-sedge	Patersonia sericea	Silky purple-flag
Lepidosperma forsythii	Large-flower rapier-sedge	* Romulea minutiflora	Small onion-grass
Lepidosperma gladiatum	Coast sword-sedge	* Romulea rosea	Common onion-grass
Lepidosperma laterale	Variable sword-sedge	* Sisyrinchium iridifolium	Striped tush-leaf
Lepidosperma l-sedgeaterale	Variable sword-sedge	* Sisyrinchium sp. A	Scour-weed
var. angustum		* Sparaxis bulbifera	Sparaxis
Lepidosperma laterale	Variable sword-sedge	* Sparaxis tricolor	Harlequin glower
var. laterale		* Tritonia lineata	Lined tritonia
Lepidosperma laterale	Variable sword-sedge	* Watsonia borbonica	Rosy watsonia
var. majus		* Watsonia meriana	Bulbil watsonia
Lepidosperma lineare	Little sword-sedge	JUNCACEAE	
Lepidosperma longitudinale	Pithy sword-sedge	* Juncus acutus	Sharp rush
Lepidosperma neesii	Stiff rapier-sedge	Juncus amabilis	Hollow rush
Lepidosperma semiteres	Wire rapier-sedge	* Juncus articulatus	Jointed rush
Lepidosperma tortuosum	Tortuous rapier-sedge	Juncus articulatus	Rush
Oreobolus distichus	Fan tuft-rush	X holoschoenus	
Oreobolus oxycarpus	Tuft-rush	Juncus australis	Austral rush
Oreobolus pumilio	Alpine tuft-rush	Juncus bufonius	Toad rush
Schoenoplectus validus	River club-sedge	* Juncus bulbosus	Bulbous rush
Schoenus apogon	Common bog-sedge	Juncus caespiticius	Grassy rush
Schoenus brevifolius	Zig-zag bog-sedge	* Juncus capitatus	Dwarf rush
Schoenus calyptratus	alpine bog-sedge	* Juncus effusus	Soft rush
r Schoenus carsei	Wiry bog-sedge	Juncus falcatus	Sickle-leaf rush
Schoenus fluitans	Floating bog-sedge	Juncus filicaulis	Thread rush
Schoenus latelaminatus	Medusa bog-sedge	Juncus flavidus	Yellow rush
Schoenus maschalinus	Leafy bog-sedge	Juncus gregiflorus	Green rush
Schoenus nitens	Shiny bog-sedge	Juncus holoschoenus	Joint-leaf rush
Schoenus tenuissimus	Slender bog-sedge	Juncus homalocaulis	Wiry rush
Schoenus tesquorum	Soft bog-sedge	Juncus ingens	Giant rush
Tetraria capillaris	Hair-sedge	Juncus kraussii	Sea rush

Appendix III (continued)

<i>Juncus microcephalus</i>	Tiny rush	<i>Bulbine semibarbata</i>	Leek lily
<i>Juncus pallidus</i>	Pale rush	<i>Burchardia umbellata</i>	Milkmaids
<i>Juncus pauciflorus</i>	Loose-flower rush	<i>Caesia calliantha</i>	Blue grass-lily
<i>Juncus planifolius</i>	Broad-leaf rush	<i>Caesia parviflora</i>	Pale grass-lily
<i>Juncus prismatocarpus</i>	Branching rush	<i>Caesia parviflora</i> var. <i>parviflora</i>	Pale grass-lily
<i>Juncus procerus</i>	Tall rush	<i>Chamaescilla corymbosa</i>	Blue squill
<i>Juncus radula</i>	Hoary rush	* <i>Chlorophytum comosum</i>	
<i>Juncus revolutus</i>	Creeping rush	<i>Dianella caerulea</i>	Paroo lily
<i>Juncus sandwithii</i>	Alpine joint-leaf rush	<i>Dianella longifolia</i>	Pale flax-lily
<i>Juncus sarophorus</i>	Rush	<i>Dianella longifolia</i> var. <i>grandis</i>	Pale flax-lily
<i>Juncus sp.(a) sensu</i> L. Johnson	Diffuse rush	<i>Dianella longifolia</i> var. <i>longifolia</i>	
<i>Juncus sp.(D1) sensu</i> L. Johnson	Rush	<i>Dianella revoluta</i>	Black-anther flax-lily
<i>Juncus sp.(F) sensu</i> L. Johnson	Rush	<i>Dianella revoluta</i> var. <i>brevicaulis</i>	Black-anther flax-lily
<i>Juncus sp.(O) sensu.</i> L. Johnson	Rush	<i>Dianella revoluta</i> var. <i>revoluta</i>	Black-anther flax-lily
<i>Juncus subsecundus</i>	Finger rush	<i>Dianella tasmanica</i>	Tasman flax-lily
* <i>Juncus tenuis</i>	Slender rush	<i>Dichopogon frimbriatus</i>	Nodding chocolate-lily
<i>Juncus usitatus</i>	Rush	<i>Dichopogon strictus</i>	Chocolate-lily
<i>Juncus vaginatus</i>	Clustered rush	<i>Drymophila cyanocarpa</i>	Turquoise berry
v <i>Luzula atrata</i>	Slender woodrush	<i>Herpolirion novae-zelandiae</i>	Sky lily
<i>Luzula meridionalis</i>	Common woodrush	<i>Hypoxis glabella</i>	Tiny star
<i>Luzula meridionalis</i> var. <i>densiflora</i>	Common woodrush	<i>Hypoxis glabella/vaginata</i>	Yellow star
<i>Luzula meridionalis</i> var. <i>flaccida</i>	Common woodrush	<i>Hypoxis hygrometrica</i>	Golden weather-glass
<i>Luzula meridionalis</i> var. <i>meridionalis</i>	Common woodrush	<i>Hypoxis hygrometrica</i> var. <i>villosisepala</i>	Golden weather-glass
<i>Luzula modesta</i>	Southern woodrush	<i>Laxmannia orientalis</i>	Dwarf wire-lily
<i>Luzula novae-cambriae</i>	Coarse woodrush	* <i>Myrsiphyllum asparagoides</i>	Smilax asparagus
<i>Luzula ovata</i>	Oval woodrush	* <i>Myrsiphyllum scandens</i>	Asparagus
		* <i>Nothoscordum gracile</i>	Fragrant false-garlic
		<i>Sowerbaea juncea</i>	Rush lily
		<i>Stypandra glauca</i>	Nodding blue-lily
		<i>Thelionema caespitosum</i>	Tufted lily
		<i>Thysanotus patersonii</i>	Twining fringe-lily
		<i>Thysanotus tuberosus</i>	Common fringe-lily
		<i>Tricoryne elatior</i>	Yellow rush-lily
		<i>Wurmbea dioica</i>	Common early Nancy
JUNCAGINACEAE			
* <i>Lilaea scilloides</i>	<i>Lilaea</i>		
<i>Triglochin centrocarpa</i>	Dwarf arrow-grass		
<i>Triglochin procera</i>	Water-ribbons		
<i>Triglochin striata</i>	Streaked arrow-grass		
LEMNACEAE			
<i>Lemna disperma</i>	Common duckweed		
* <i>Lemna minor</i>	European duckweed		
<i>Lemna trisulca</i>	Ivy-leaf duckweed		
<i>Spirodela oligorrhiza</i>	Thin duckweed		
r <i>Spirodela polyrrhiza</i>	Large duckweed		
<i>Spirodela punctata</i>	Spotted duckweed		
<i>Wolffia australiana</i>	Tiny duckweed		
LILIACEAE			
* <i>Allium ampeloprasum</i>	Wild leek		
* <i>Allium oleraceum</i>	Field garlic		
* <i>Allium neapolitanum</i>	Naples onion		
* <i>Allium scorodoprasum</i>	Sand leek		
* <i>Allium triquetrum</i>	Three-cornered garlic		
* <i>Allium vineale</i>	Crow garlic		
<i>Arthropodium milleflorum</i>	Pale vanilla-lily		
<i>Arthropodium minus</i>	Small vanilla-lily		
* <i>Asparagus officinalis</i>	Asparagus		
* <i>Asphodelus fistulosus</i>	Onion weed		
<i>Astelia alpina</i>	Silver astelia		
v <i>Astelia australiana</i>	Tall astelia		
<i>Bulbine bulbosa</i>	Yellow bulbine-lily		
		ORCHIDACEAE	
		<i>Acianthus caudatus</i>	Mayfly orchid
		<i>Acianthus exsertus</i>	Gnat orchid
		<i>Arthrochilus huntianus</i>	Elbow orchid
		r <i>Burnettia cuneata</i>	Burnettia
		<i>Caladenia aurantiaca</i>	Orange-tip caladenia
		<i>Caladenia caerulea</i>	Blue caladenia
		<i>Caladenia carnea</i>	Pink fingers caladenia
		<i>Caladenia catenata</i>	White caladenia
		<i>Caladenia clavigera</i>	Plain-lip spider-orchid
		v <i>Caladenia concolor</i>	Maroon spider-orchid
		<i>Caladenia congesta</i>	Black-tongue caladenia
		<i>Caladenia cucullata</i>	Hooded caladenia
		<i>Caladenia deformis</i>	Bluebeard caladenia
		<i>Caladenia dilatata</i>	Green-comb
		<i>Caladenia filamentosa</i>	spider-orchid
			Daddy long-legs
			spider-orchid
		r <i>Caladenia flavovirens</i>	Summer spider-orchid
		r <i>Caladenia fragrantissima</i>	Cream spider-orchid

Appendix III (continued)

v	<i>Caladenia fragrantissima</i> ssp. <i>orientalis</i>	Cream spider-orchid	<i>Prasophyllum affine</i>	Alpine leek-orchid
	<i>Caladenia gracilis</i>	Musky caladenia	<i>Prasophyllum alpinum</i>	Austral leek-orchid
	<i>Caladenia insularis</i>		<i>Prasophyllum australe</i>	Short-lip leek-orchid
	<i>Caladenia iridescens</i>	Bronze caladenia	<i>Prasophyllum brevibracte</i>	Tall leek-orchid
	<i>Caladenia latifolia</i>	Pink fairies caladenia	<i>Prasophyllum elatum</i>	Yellow leek-orchid
v	<i>Caladenia leptochila</i>	Narrow-lip spider-orchid	r <i>Prasophyllum frenchii</i>	Slaty leek-orchid
	<i>Caladenia lyallii</i>	Mountain caladenia	v <i>Prasophyllum lindleyanum</i>	Green leek-orchid
	<i>Caladenia menziesii</i>	Hare orchid	<i>Prasophyllum odoratum</i>	Sweet leek-orchid
r	<i>Caladenia flavovirens</i>	Summer spider-orchid	v <i>Prasophyllum parviflorum</i>	Slender leek-orchid
r	<i>Caladenia oenochila</i>	Foothills spider-orchid	<i>Prasophyllum suttonii</i>	Mauve leek-orchid
r	<i>Caladenia patersonii</i>	Common spider-orchid	<i>Pterostylis X ingens</i>	Sharp greenhood
	<i>Caladenia praecox</i>	Early caladenia	<i>Pterostylis alata</i>	Striped greenhood
	<i>Caladenia pusilla</i>	Tiny caladenia	<i>Pterostylis alpina</i>	Mountain greenhood
e	<i>Caladenia rosella</i>	Rosella spider-orchid	<i>Pterostylis concinna</i>	Trim greenhood
	<i>Caladenia tessellata</i>	Spider-orchid	v <i>Pterostylis cucullata</i>	Leafy greenhood
	<i>Caladenia testacea</i>	Honey caladenia	<i>Pterostylis curta</i>	Blunt greenhood
	<i>Caladenia valida</i>	Caladenia	<i>Pterostylis cynocephala</i>	Swan greenhood
	<i>Calceana major</i>	Large duck-orchid	<i>Pterostylis decurva</i>	Summer greenhood
	<i>Calceana minor</i>	Small duck-orchid	<i>Pterostylis dubia</i>	Doubtful greenhood
	<i>Calochilus campestris</i>	Copper beard-orchid	<i>Pterostylis excelsa</i>	Dryland greenhood
	<i>Calochilus imberbis</i>	Shaved beard-orchid	<i>Pterostylis foliata</i>	Slender greenhood
	<i>Calochilus paludosus</i>	Red beard-orchid	<i>Pterostylis furcata</i>	Forked greenhood
	<i>Calochilus robertsonii</i>	Purplish beard-orchid	r <i>Pterostylis grandiflora</i>	Cobra greenhood
	<i>Chiloglottis cornuta</i>	Green bird-orchid	<i>Pterostylis longifolia</i>	Tall greenhood
	<i>Chiloglottis gunnii</i>	Common bird-orchid	<i>Pterostylis mutica</i>	Midget greenhood
	<i>Chiloglottis reflexa</i>	Autumn bird-orchid	<i>Pterostylis nana</i>	Dwarf greenhood
	<i>Chiloglottis trapeziformis</i>	Dainty bird-orchid	<i>Pterostylis nutans</i>	Nodding greenhood
	<i>Corybas aconitiflorus</i>	Spurred helmet-orchid	<i>Pterostylis obtusa</i>	Blunt-tongue greenhood
r	<i>Corybas despectans</i>	Helmet-orchid	<i>Pterostylis parviflora</i>	Tiny greenhood
	<i>Corybas diemenicus</i>	Veined helmet-orchid	v <i>Pterostylis pedoglossa</i>	Prawn greenhood
	<i>Corybas incurvus</i>	Slaty helmet-orchid	<i>Pterostylis pedunculata</i>	Maroon-hood
	<i>Corybas unguiculatus</i>	Small helmet-orchid	<i>Pterostylis plumosa</i>	Bearded greenhood
	<i>Cryptostylis leptochila</i>	Small tongue-orchid	<i>Pterostylis revoluta</i>	Autumn greenhood
	<i>Cryptostylis subulata</i>	Large tongue-orchid	<i>Pterostylis robusta</i>	Robust greenhood
	<i>Cyrtostylis reniformis</i>	Mosquito orchid	<i>Pterostylis rufa</i>	Rusty-hood
	<i>Dipodium punctatum</i>	Hyacinth orchid	<i>Pterostylis vittata</i>	Banded greenhood
	<i>Diuris X palachila</i>	Diuris	<i>Sarcophilus australis</i>	Butterfly orchid
	<i>Diuris corymbosa</i>	Wallflower orchid	<i>Spiranthes sinensis</i>	Austral lady's tresses
	<i>Diuris lanceolata</i>	Golden moths	<i>Thelymitra X chasmogama</i>	Globe-hood sun-orchid
	<i>Diuris maculata</i>	Leopard orchid	<i>Thelymitra X irregularis</i>	Sun-orchid
v	<i>Diuris palustris</i>	Swamp diuris	<i>Thelymitra antennifera</i>	Rabbit-ears
	<i>Diuris pardina</i>	Panther orchid	<i>Thelymitra aristata</i>	Great sun-orchid
v	<i>Diuris punctata</i>	Purple diuris	r <i>Thelymitra benthamiana</i>	Blotched sun-orchid
	<i>Diuris sulphurea</i>	Tiger orchid	<i>Thelymitra carnea</i>	Salmon sun-orchid
	<i>Eriochilus cucullatus</i>	Parson's bands	v <i>Thelymitra circumsepta</i>	Bog sun-orchid
	<i>Gastrodia sesamoides</i>	Cinnamon bells	<i>Thelymitra cyanea</i>	Veined sun-orchid
	<i>Genoplesium archeri</i>	Variable midge-orchid	<i>Thelymitra flexuosa</i>	Twisted sun-orchid
	<i>Genoplesium despectans</i>	Sharp midge-orchid	<i>Thelymitra holmesii</i>	Blue-star sun-orchid
	<i>Genoplesium morrisii</i>	Bearded midge-orchid	<i>Thelymitra ixioides</i>	Dotted sun-orchid
r	<i>Genoplesium pumilum</i>	Green midge-orchid	<i>Thelymitra luteociliatum</i>	Fringed sun-orchid
	<i>Genoplesium rufum</i>	Dark midge-orchid	<i>Thelymitra media</i>	Tall sun-orchid
	<i>Glossodia major</i>	Wax-lip orchid	r <i>Thelymitra media</i> var. <i>carnolutea</i>	Tall sun-orchid
	<i>Leporella fimbriata</i>	Fringed hare-orchid	v <i>Thelymitra mucida</i>	Hoary sun-orchid
	<i>Lyperanthus nigricans</i>	Red-beaks	<i>Thelymitra nuda</i>	Plain sun-orchid
	<i>Lyperanthus suaveolens</i>	Brown-beaks	<i>Thelymitra pauciflora</i>	Slender sun-orchid
	<i>Microtis atrata</i>	Yellow onion-orchid	<i>Thelymitra rubra</i>	Salmon sun-orchid
	<i>Microtis oblonga</i>	Rare onion-orchid		
r	<i>Microtis orbicularis</i>	Swamp onion-orchid	POACEAE	
	<i>Microtis parviflora</i>	Slender onion-orchid	<i>Agrostis adamsonii</i>	Bent-grass
	<i>Microtis unifolia</i>	Common onion-orchid	<i>Agrostis aemula</i>	Blown-grass
	<i>Orthoceras strictum</i>	Horned orchid		

Appendix III (continued)

r	<i>Agrostis aemula</i> var. <i>aemula</i>	Blown-grass	* <i>Bromus sterilis</i>	Barren brome
	<i>Agrostis aemula</i> var. <i>setifolia</i>	Blown-grass	* <i>Bromus tectorum</i>	Drifting brome
	<i>Agrostis avenacea</i>	Common blown-grass	<i>Chionochloa pallida</i>	Silvertop wallaby-grass
	<i>Agrostis avenacea</i> var. <i>avenacea</i>	Common blown-grass	<i>Chloris truncata</i>	Windmill grass
	<i>Agrostis avenacea</i> var. <i>perennis</i>	Common blown-grass	* <i>Cortaderia selloana</i>	Pampas grass
	<i>Agrostis billardieri</i>	Coast blown-grass	* <i>Critiesion hystrix</i>	Mediterranean barley-grass
	<i>Agrostis billardieri</i> var. <i>billardieri</i>	Coast blown-grass	* <i>Critiesion maritimum</i>	Sea barley-grass
	<i>Agrostis capillaris</i>	Brown-top bent	* <i>Critiesion murinum</i>	Barley-grass
	<i>Agrostis capillaris</i> var. <i>aristata</i>	Brown-top bent	* <i>Critiesion murinum</i> ssp. <i>glaucum</i>	Blue barley-grass
	<i>Agrostis gigantea</i>	Red-top bent	* <i>Critiesion murinum</i> ssp. <i>leporinum</i>	Wall barley-grass
	<i>Agrostis hiemalis</i>	Fine-leaf bent	* <i>Cynodon dactylon</i>	Couch
	<i>Agrostis meionectes</i>	Alpine bent	* <i>Cynosurus cristatus</i>	Crested dog's-tail
	<i>Agrostis parviflora</i>	Small-flower bent	* <i>Cynosurus echinatus</i>	Rough dog's-tail
	<i>Agrostis rudis</i>	Ruddy bent	* <i>Dactylis glomerata</i>	Cocksfoot
	* <i>Agrostis stolonifera</i>	Creeping bent	<i>Danthonia auriculata</i>	Lobed wallaby-grass
	<i>Agrostis venusta</i>	Misty bent	<i>Danthonia caespitosa</i>	Common wallaby-grass
	* <i>Aira caryophylla</i>	Silvery hair-grass	<i>Danthonia carphoides</i>	Short wallaby-grass
	* <i>Aira cupaniana</i>	Hair-grass	<i>Danthonia duttoniana</i>	Brown-back wallaby-grass
	* <i>Aira elegantissima</i>	Hair-grass	<i>Danthonia eriantha</i>	Reddish wallaby-grass
	* <i>Aira praecox</i>	Early hair-grass	<i>Danthonia geniculata</i>	Kneed wallaby-grass
	* <i>Alopecurus geniculatus</i>	Marsh fox-tail	<i>Danthonia induta</i>	Shiny wallaby-grass
	* <i>Alopecurus pratensis</i>	Meadow fox-tail	<i>Danthonia laevis</i>	Smooth wallaby-grass
	* <i>Ammophila arenaria</i>	Marram grass	<i>Danthonia linkii</i>	Leafy wallaby-grass
	<i>Amphibromus archeri</i>	Pointed swamp wallaby-grass	<i>Danthonia longifolia</i>	Long-leaf wallaby-grass
	<i>Amphibromus fluitans</i>	River swamp wallaby-grass	<i>Danthonia monticola</i>	Hill wallaby-grass
	<i>Amphibromus neesii</i>	Southern swamp wallaby-grass	<i>Danthonia nivicola</i>	Snow wallaby-grass
	<i>Amphibromus nervosus</i>	Veined swamp wallaby-grass	<i>Danthonia nudiflora</i>	Alpine wallaby-grass
e	<i>Amphibromus pithogastrus</i>	Swollen swamp wallaby-grass	<i>Danthonia penicillata</i>	Slender wallaby-grass
	<i>Amphibromus recurvatus</i>	Dark swamp wallaby-grass	<i>Danthonia pilosa</i>	Velvet wallaby-grass
	<i>Amphipogon strictus</i>	Grey-beard grass	<i>Danthonia pilosa</i> var. <i>pilosa</i>	Velvet wallaby-grass
	<i>Anisopogon avenaceus</i>	Oat spear-grass	<i>Danthonia procera</i>	Tall wallaby-grass
	* <i>Anthoxanthum odoratum</i>	Sweet vernal-grass	<i>Danthonia racemosa</i>	Branched wallaby-grass
	* <i>Arrhenatherum elatius</i>	False oat-grass	<i>Danthonia semiannularis</i>	Heath wallaby-grass
	<i>Austrofestuca hookeriana</i>	Hooker fescue	<i>Danthonia setacea</i>	Bristly wallaby-grass
	<i>Austrofestuca littoralis</i>	Coast fescue	<i>Danthonia tenuior</i>	Long-leaf wallaby-grass
	* <i>Avellinia michelii</i>	Avellinia	* <i>Desmazeria marina</i>	Grass
	* <i>Avena barbata</i>	Bearded oat	* <i>Desmazeria rigida</i>	Fern grass
	* <i>Avena fatua</i>	Wild oat	<i>Deyeuxia brachyathera</i>	Short bent-grass
	* <i>Avena sativa</i>	Oat	<i>Deyeuxia carinata</i>	Keeled bent-grass
	* <i>Avena sterilis</i>	Sterile oat	<i>Deyeuxia contracta</i>	Compact bent-grass
	<i>Bothriochloa macra</i>	Red-leg grass	<i>Deyeuxia crassiuscula</i>	Thick bent-grass
	* <i>Brachypodium distachyon</i>	False brome	<i>Deyeuxia densa</i>	Heath bent-grass
	* <i>Brachypodium olistachyon</i>		<i>Deyeuxia frigida</i>	Forest bent-grass
	* <i>Brachypodium tectorum</i>		<i>Deyeuxia gunniana</i>	Montane bent-grass
	* <i>Briza maxima</i>	Large wuaking-grass	<i>Deyeuxia innominata</i>	Short bent-grass
	* <i>Briza minor</i>	Lesser wuaking-grass	<i>Deyeuxia minor</i>	Small bent-grass
	* <i>Bromus catharticus</i>	Prairie grass	<i>Deyeuxia monticola</i>	Mountain bent-grass
	* <i>Bromus diandrus</i>	Great brome	<i>Deyeuxia parviseta</i>	Fine bent-grass
	* <i>Bromus fonkii</i>	Chilean brome	<i>Deyeuxia quadriseta</i>	Reed bent-grass
	* <i>Bromus hordeaceus</i>	Soft brome	<i>Deyeuxia rodwayi</i>	Tasman bent-grass
	* <i>Bromus lanceolatus</i>	Mediterranean brome	<i>Deyeuxia scaberula</i>	Rough bent-grass
	* <i>Bromus madritensis</i>	Compact brome	<i>Dichelachne crinita</i>	Long-hair plume-grass
	* <i>Bromus rubens</i>	Red brome	<i>Dichelachne micrantha</i>	Short-hair plume-grass
			<i>Dichelachne sieberiana</i>	Plume-grass
			<i>Digitaria ischaemum</i>	Smooth summer-grass
			<i>Digitaria sanguinalis</i>	Summer-grass
			<i>Distichlis distichophylla</i>	Australian salt-grass
			<i>Dryopoa dives</i>	Giant mountain grass
			* <i>Echinochloa crus-galli</i>	Common barnyard grass

Appendix III (continued)

<i>Echinopogon cheelii</i>	Long-flower hedgehog-grass	* <i>Phalaris arundinacea</i>	Reed canary-grass
<i>Echinopogon ovatus</i>	Common hedgehog-grass	* <i>Phalaris canariensis</i>	Canary-grass
* <i>Ehrharta calycina</i>	Perennial veldt Grass	* <i>Phalaris minor</i>	Lesser canary-grass
* <i>Ehrharta erecta</i>	Panic veldt Grass	* <i>Phelum pratense</i>	Timothy grass
* <i>Ehrharta longiflora</i>	Annual veldt Grass	<i>Phragmites australis</i>	Common reed
* <i>Elusine tristachya</i>	American crow's-foot grass	* <i>Piptatherum miliaceum</i>	Rice millet
<i>Elymus multiflorus</i>	Many-flowered wheat-grass	* <i>Poa annua</i>	Annual meadow-grass
<i>Elymus scabrus</i>	Common wheat-grass	<i>Poa australis</i> spp. agg.	Tussock grass
* <i>Elytrigia repens</i>	English couch	<i>Poa clelandii</i>	Tussock-grass
<i>Enneapogon nigricans</i>	Nigger-heads	<i>Poa costiniana</i>	Prickly tussock-grass
<i>Entolasia marginata</i>	Bordered panic	<i>Poa ensiformis</i>	Sword tussock-grass
<i>Eragrostis brownii</i>	Common love-grass	<i>Poa fawcettiae</i>	Smooth blue tussock-grass
* <i>Eragrostis cilianensis</i>	Stink grass	<i>Poa halmaturina</i>	Salt tussock-grass
* <i>Eragrostis curvula</i>	African love-grass	<i>Poa helmsii</i>	Tall tussock-grass
<i>Eragrostis elongata</i>	Close-headed love-grass	<i>Poa hiemata</i>	Soft tussock-grass
* <i>Eragrostis leptostachya</i>	Narrow-head love-grass	<i>Poa hothamensis</i>	Hotham tussock-grass
* <i>Eragrostis mexicana</i>	Mexican love-grass	<i>Poa labillardieri</i>	Common tussock-grass
<i>Eragrostis parviflora</i>	Weeping love-grass	<i>Poa morrisii</i>	Soft tussock-grass
* <i>Festuca arundinacea</i>	Tall fescue	<i>Poa phillipsiana</i>	Lax tussock-grass
<i>Festuca asperula</i>	Graceful fescue	<i>Poa poiformis</i>	Blue tussock-grass
<i>Festuca hookeriana</i>	Hooker fescue	<i>Poa pratensis</i>	English meadow-grass
<i>Festuca muelleri</i>	Alpine fescue	<i>Poa sieberiana</i>	Grey tussock-grass
* <i>Festuca rubra</i>	Red fescue	<i>Poa sieberiana</i> var. <i>cyanophylla</i>	Grey tussock-grass
* <i>Gastridium phleoides</i>	Nut grass	<i>Poa sieberiana</i> var. <i>sieberiana</i>	Grey tussock-grass
<i>Glyceria australis</i>	Australian sweet-grass	<i>Poa</i> sp. aff. <i>rodwayi</i>	Tasmanian tussock-grass
* <i>Glyceria declinata</i>	Sweet-grass	<i>Poa tenera</i>	Slender tussock-grass
* <i>Glyceria maxima</i>	Red sweet-grass	* <i>Poa trivialis</i>	Rough poa
* <i>Hainardia cylindrica</i>	Common barb-grass	* <i>Polypogon monspeliensis</i>	Annual beard-grass
<i>Hemarthria uncinata</i>	Mat grass	* <i>Polypogon viridis</i>	Water-bent
<i>Hierochloa redolens</i>	Sweet holy grass	* <i>Puccinella fasciculata</i>	Borrer's saltmarsh-grass
* <i>Holcus lanatus</i>	Yorkshire fog grass	<i>Puccinellia stricta</i>	australian saltmarsh- grass
* <i>Holcus mollis</i>	Creeping fog grass	<i>Pseudoraphis spinescens</i>	Spiny mud-grass
* <i>Holcus setosus</i>	Annual fog grass	* <i>Rostraria cristata</i>	Annual cat's-tail
* <i>Hordeum vulgare</i>	Barley	* <i>Secale cereale</i>	Rye
<i>Imperata cylindrica</i>	Blady grass	* <i>Setaria gracilis</i>	Slender pigeon-grass
<i>Isachne globosa</i>	Swamp millet	* <i>Setaria italica</i>	Italian millet
* <i>Lagurus ovatus</i>	Hare's tail	* <i>Setaria pumila</i>	Pale pigeon-grass
* <i>Lamarckia aurea</i>	Golden-top	* <i>Setaria verticillata</i>	Whorled pigeon-grass
* <i>Leersia oryzoides</i>	Cut-grass	* <i>Setaria viridis</i>	Green pigeon-grass
* <i>Lolium loliaceum</i>	Stiff rye-grass	* <i>Sieglingia decumbens</i>	Heath grass
* <i>Lolium multiflorum</i>	Italian rye-grass	* <i>Spartina townsendii</i>	Townsend's cord-grass
* <i>Lolium perenne</i>	Perennial rye-grass	<i>Spinifex sericeus</i>	Hairy spinifex
* <i>Lolium rigidum</i>	Wimmera rye-grass	* <i>Sporobolus indicus</i>	Indian rat-tail Grass
* <i>Lolium perenne</i> X <i>rigidum</i>		* <i>Sporobolus indicus</i> var. <i>africanus</i>	Indian rat-tail Grass
* <i>Lolium temulentum</i>	Bearded rye-grass	<i>Sporobolus virginicus</i>	Salt couch
<i>Microlaena stipoides</i>	Weeping grass	* <i>Stenotaphrum secundatum</i>	Buffalo grass
* <i>Molinierella minuta</i>	Small hair-grass	<i>Stipa aristiglumis</i>	Plump spear-grass
* <i>Nassella neesiana</i>	Spear-grass	<i>Stipa bigeniculata</i>	Kneed spear-grass
* <i>Nassella trichotoma</i>	Serrated tussock	<i>Stipa blackii</i>	Crested spear-grass
* <i>Panicum capillare</i>	Witch-grass	<i>Stipa curtica</i>	Short-crown spear-grass
<i>Panicum effusum</i>	Hairy panic	<i>Stipa densiflora</i>	Dense spear-grass
* <i>Parapholis incurva</i>	Coast barb-grass	<i>Stipa elegantissima</i>	Feather spear-grass
* <i>Parapholis strigosa</i>	Slender barb-grass	<i>Stipa gibbosa</i>	Spurred spear-grass
* <i>Paspalum dilatatum</i>	<i>Paspalum</i>	<i>Stipa flavescens</i>	Coast spear-grass
* <i>Paspalum distichum</i>	Water couch	* <i>Stipa hyalina</i>	Fine spear-grass
* <i>Pennisetum alopecuroides</i>	Swamp foxtail-grass	* <i>Stipa leucotricha</i>	Pale spear-grass
* <i>Pennisetum clandestinum</i>	Kikuyu	<i>Stipa mollis</i>	Supple spear-grass
* <i>Pennisetum villosum</i>	Feathertop		
<i>Pentapogon quadrifidus</i>	Five-awned spear-grass		
* <i>Phalaris aquatica</i>	Toowoomba canary-grass		

Appendix III (continued)

<i>Stipa muelleri</i>	Wiry spear-grass	<i>Lomandra micrantha</i>	Small-flower mat-lily
<i>Stipa nodosa</i>	Knotty spear-grass	ssp. <i>micrantha</i>	
<i>Stipa oligostachya</i>	Fine-head spear-grass	<i>Lomandra micrantha</i>	Small-flower mat-lily
<i>Stipa pubinodis</i>	Tall spear-grass	ssp. <i>tuberculata</i>	
<i>Stipa rudis</i>	Veined spear-grass	<i>Lomandra multiflora</i>	Many-flowered mat-lily
<i>Stipa rudis</i> ssp. <i>nervosa</i>	Veined spear-grass	<i>Lomandra nana</i>	Dwarf mat-lily
<i>Stipa rudis</i> ssp. <i>rudis</i>	Veined spear-grass	<i>Xanthorrhoea australis</i>	Austral grass-tree
<i>Stipa scabra</i>	Rough spear-grass	<i>Xanthorrhoea minor</i>	Small grass-tree
<i>Stipa scabra</i> ssp. <i>falcata</i>	Rough spear-grass	<i>Xanthorrhoea resinosa</i>	Spear grass-tree
<i>Stipa semibarbata</i>	Fibrous spear-grass		
<i>Stipa stipoides</i>	Prickly spear-grass	XYRIDACEAE	
<i>Stipa stiposa</i>	Quizzical spear-grass	<i>Xyris gracilis</i>	Slender yellow-eye
<i>Tetrarrhena acuminata</i>	Pointed rice-grass	<i>Xyris operculata</i>	Tall yellow-eye
<i>Tetrarrhena distichophylla</i>	Hairy rice-grass		
<i>Tetrarrhena juncea</i>	Forest wire-grass	ZANNICHELLIACEAE	
<i>Tetrarrhena turfosa</i>	Peaty rice-grass	<i>Lepilaena bilocularis</i>	Small-fruited water-mat
<i>Themeda triandra</i>	Kangaroo grass	<i>Lepilaena cylindrocarpa</i>	Long-fruited water-mat
* <i>Thinopyrum junceum</i>	Sea wheat-grass	<i>Lepilaena preissii</i>	Slender water-mat
* <i>Tribolium acutiflorum</i>	Plagiochloa		
* <i>Triticum aestivum</i>	Wheat	ZOSTERACEAE	
* <i>Vulpia bromoides</i>	Squirrel-tail fescue	<i>Heterozostera tasmanica</i>	Tasman grass-wrack
* <i>Vulpia ciliata</i>	Fringed fescue	<i>Zostera muelleri</i>	Dwarf grass-wrack
* <i>Vulpia fasciculata</i>	Dune fescue		
* <i>Vulpia muralis</i>	Wall fescue		
* <i>Vulpia myuros</i>	Rat's-tail fescue	DICOTYLEDONS	
* <i>Vulpia myuros</i> forma <i>megalura</i>	Fox-tail fescue		
<i>Zoysia macrantha</i>	Prickly couch	ACERACEAE	
		* <i>Acer pseudoplatanus</i>	Sycamore maple
PONTEDERIACEAE			
* <i>Eichhornia crassipes</i>	Water hyacinth	AIZOACEAE	
POTAMOGETONACEAE		* <i>Aptenia cordifolia</i>	Heart-leaf ice-plant
<i>Potamogeton crispus</i>	Curly pondweed	* <i>Carpobrotus aequilaterus</i>	Angled pigface
<i>Potamogeton ochreateus</i>	Blunt pondweed	* <i>Carpobrotus edulis</i>	Hottentot
<i>Potamogeton pectinatus</i>	Fennel pondweed	<i>Carpobrotus modestus</i>	Inland pigface
<i>Potamogeton tricarlinatus</i>	Floating pondweed	<i>Carpobrotus rossii</i>	Karkalla
<i>Ruppia maritima</i>	Sea tassel	<i>Disphyma crassifolium</i>	Rounded noon-flower
RESTIONACEAE		* <i>Galenia pubescens</i>	Galenia
<i>Empodisma minus</i>	Spreading rope-rush	* <i>Lampranthus tegens</i>	Little noon-flower
<i>Hypolaena fastigiata</i>	Tassel rope-rush	* <i>Mesembryanthemum crystallinum</i>	Common ice-plant
<i>Leptocarpus brownii</i>	Coarse twine-rush	<i>Tetragonia implexicoma</i>	Bower spinach
<i>Leptocarpus tenax</i>	Slender twine-rush	<i>Tetragonia tetragonioides</i>	New Zealand spinach
<i>Lepyrodia muelleri</i>	Common scale-rush	AMARANTHACEAE	
<i>Restio tetraphyllus</i>	Tassel cord-rush	<i>Alternanthera denticulata</i>	Lesser joyweed
SPARGANIACEAE		* <i>Amaranthus albus</i>	Stiff tumbleweed
<i>Sparganium subglobosum</i>	Floating burr-reed	* <i>Amaranthus deflexus</i>	Spreading amaranth
		* <i>Amaranthus retroflexus</i>	Red-root amaranth
		<i>Ptilotus spathulatus</i>	Pussy-tails
TYPHACEAE		APIACEAE	
<i>Typha domingensis</i>	Cumbungi	* <i>Ammi majus</i>	Bishop's weed
* <i>Typha latifolia</i>	Great reedmace	<i>Apium annuum</i>	annual celery
<i>Typha orientalis</i>	Cumbungi	<i>Apium prostratum</i>	Sea celery
XANTHORRHOEACEAE		* <i>Berula erecta</i>	Water parsnip
<i>Lomandra filiformis</i>	Wattle mat-lily	<i>Centella cordifolia</i>	Centella
<i>Lomandra filiformis</i>	Wattle mat-lily	<i>Ciclospermum leptophyllum</i>	Narrow-leaf celery
ssp. <i>coriacea</i>		* <i>Conium maculatum</i>	Hemlock
<i>Lomandra filiformis</i>	Wattle mat-lily	* <i>Daucus carota</i>	Carrot
ssp. <i>filiformis</i>		<i>Daucus glochidiatus</i>	Austral carrot
<i>Lomandra longifolia</i>	Spiny-headed mat-lily	<i>Diplaspis hydrocotyle</i>	Stiff diplapsis
<i>Lomandra micrantha</i>	Small-flower mat-lily	<i>Eryngium ovium</i>	Blue devil

Appendix III (continued)

<i>Eryngium vesiculosum</i>	Prickfoot	v <i>Brachyscome debilis</i>	Weak daisy
* <i>Foeniculum vulgare</i>	Fennel	<i>Brachyscome decipiens</i>	Field daisy
<i>Hydrocotyle algida</i>	Mountain pennywort	<i>Brachyscome diversifolia</i>	Tall daisy
<i>Hydrocotyle callicarpa</i>	Small pennywort	<i>Brachyscome graminea</i>	Grass daisy
<i>Hydrocotyle capillaris</i>	Thread pennywort	<i>Brachyscome leptocarpa</i>	Downy daisy
<i>Hydrocotyle foveolata</i>	Yellow pennywort	<i>Brachyscome multifida</i>	Cut-leaf daisy
<i>Hydrocotyle geraniifolia</i>	Forest pennywort	<i>Brachyscome multifida</i>	Cut-leaf daisy
<i>Hydrocotyle hirta</i>	Hairy pennywort	var. <i>dilatata</i>	
<i>Hydrocotyle laxiflora</i>	Stinking pennywort	<i>Brachyscome nivalis</i>	Snow daisy
<i>Hydrocotyle medicaginoides</i>	Trefoil pennywort	r <i>Brachyscome obovata</i>	Baw Baw daisy
<i>Hydrocotyle muscosa</i>	Mossy pennywort	<i>Brachyscome parvula</i>	Coast daisy
<i>Hydrocotyle pterocarpa</i>	Wing pennywort	<i>Brachyscome parvula</i>	Coast daisy
<i>Hydrocotyle sibthorpioides</i>	Shining pennywort	var. <i>parvula</i>	
<i>Hydrocotyle tripartita</i>	Slender pennywort	<i>Brachyscome perpusilla</i>	Rayless daisy
<i>Hydrocotyle verticillata</i>	Shield pennywort	<i>Brachyscome perpusilla</i>	Rayless daisy
<i>Lilaeopsis polyantha</i>	Australian <i>lilaeopsis</i>	var. <i>perpusilla</i>	
<i>Oreomyrrhis ciliata</i>	Fringed caraway	<i>Brachyscome perpusilla</i>	Rayless daisy
<i>Oreomyrrhis eriopoda</i>	Australian caraway	var. <i>tenella</i>	
* <i>Pastinaca sativa</i>	Parsnip	<i>Brachyscome rigidula</i>	Leafy daisy
<i>Platysace heterophylla</i>	Slender platysace	<i>Brachyscome scapigera</i>	Tufted daisy
<i>Platysace lanceolata</i>	Shrubby platysace	<i>Brachyscome spathulata</i>	Spoon daisy
* <i>Pteroselinum crispum</i>	Parsley	<i>Brachyscome uliginosa</i>	Small swamp-daisy
* <i>Torilis nodosa</i>	Knotted parsley	* <i>Calendula arvensis</i>	Field marigold
<i>Trachymene anisocarpa</i>	Parsnip trachymene	<i>Calocephalus brownii</i>	Cushion bush
<i>Trachymene humilis</i>	alpine trachymene	<i>Calocephalus citreus</i>	Lemon beauty-heads
<i>Xanthosia dissecta</i>	Cut-leaf xanthosia	<i>Calocephalus lacteus</i>	Milky beauty-heads
<i>Xanthosia pilosa</i>	Woolly xanthosia	<i>Calotis cunefolia</i>	Blue burr-daisy
<i>Xanthosia pusilla</i>	Heath xanthosia	<i>Calotis scabiosifolia</i>	Rough burr-daisy
<i>Xanthosia tridentata</i>	Hill xanthosia	<i>Calotis scapigera</i>	Tufted burr-daisy
APOCYNACEAE		* <i>Carduus pycnocephalus</i>	Slender thistle
<i>Alyxia buxifolia</i>	Sea box	* <i>Carduus tenuiflorus</i>	Thistle
<i>Parsonia brownii</i>	Twining silkpod	* <i>Carthamus lanatus</i>	Saffron thistle
* <i>Vinca major</i>	Blue periwinkle	<i>Cassinia aculeata</i>	Common cassinia
AQUIFOLIACEAE		<i>Cassinia arcuata</i>	Drooping cassinia
* <i>Ilex aquifolium</i>	Holly	<i>Cassinia longifolia</i>	Shiny cassinia
ARALIACEAE		<i>Cassinia trinerva</i>	Three-nerved cassinia
<i>Astrotricha asperifolia</i>	Rough star-hair	<i>Celmisia asteliifolia</i>	Silver daisy
<i>Astrotricha ledifolia</i>	Common star-hair	* <i>Centaurea calcitrapa</i>	Star thistle
* <i>Hedera helix</i>	Ivy	* <i>Centaurea melitensis</i>	Malta thistle
<i>Polyscias sambucifolia</i>	Elderberry panax	<i>Centipeda cunninghamii</i>	Common sneezeweed
ASCLEPIADACEAE		<i>Centipeda minima</i>	Spreading sneezeweed
* <i>Asclepias fruticosa</i>	Swan plant	* <i>Chondrilla juncea</i>	Skeleton weed
* <i>Asclepias rotundifolia</i>	Broad-leaf cotton-bush	* <i>Chrysanthemoides monilifera</i>	Boneseed
ASTERACEAE		* <i>Cichorium intybus</i>	Chicory
<i>Actites megalocarpa</i>	Coast sow-thistle	* <i>Cirsium arvense</i>	Perennial thistle
<i>Angianthus preissianus</i>	Salt angianthus	* <i>Cirsium vulgare</i>	Spear thistle
<i>Apalochlamys spectabilis</i>	Showy apalochlamys	* <i>Conyza albida</i>	Fleabane
* <i>Arctotheca calendula</i>	Cape weed	* <i>Conyza bilbaoana</i>	Fleabane
* <i>Arctotheca prostrata</i>	Creeping cape Weed	* <i>Conyza bonariensis</i>	Tall fleabane
* <i>Arctotis venusta</i>	White arctotis	* <i>Conyza canadensis</i>	Canadian fleabane
* <i>Artemisia verlotiorum</i>	Chinese wormwood	* <i>Conyza scabiosifolia</i>	Rough conyza
* <i>Aster subulatus</i>	Aster-weed	<i>Cotula alpina</i>	alpine cotula
<i>Bedfordia arborescens</i>	Blanket-leaf	<i>Cotula australis</i>	Common cotula
* <i>Bellis perennis</i>	English daisy	* <i>Cotula coronopifolia</i>	Water buttons
<i>Brachyscome aculeata</i>	Branching daisy	<i>Cotula vulgaris</i>	Slender cotula
<i>Brachyscome angustifolia</i>	Grassland daisy	<i>Craspedia chrysantha</i>	Golden billy-buttons
<i>Brachyscome cardiocarpa</i>	Hinge-fruit daisy	<i>Craspedia glauca</i>	Common billy-buttons
<i>Brachyscome ciliaris</i>	Variable daisy	<i>Craspedia globosa</i>	Drumsticks
		<i>Craspedia</i> sp. D	Billy-buttons
		* <i>Crepis capillaris</i>	Smooth hawksbeard
		* <i>Crepis foetida</i>	Stinking hawksbeard
		* <i>Crepis setosa</i>	Bristly hawksbeard
		<i>Cymbonotus preissianus</i>	austral bear's-ears

Appendix III (continued)

* <i>Cynara cardunculus</i>	Spanish artichoke	* <i>Leontodon taraxacoides</i>	Hairy hawkbit
* <i>Delairea odorata</i>	Ivy groundsel	<i>Leptinella filicula</i>	Mountain cotula
* <i>Dittrichia graveolens</i>	Stinkweed	<i>Leptinella reptans</i>	Creeping cotula
<i>Eclipta platyglossa</i>	Yellow twin-heads	<i>Leptorhynchos linearis</i>	Shiny buttons
<i>Epilates australis</i>	Spreading nut-heads	<i>Leptorhynchos squamatus</i>	Scaly buttons
* <i>Erigeron karvinskianus</i>	Bony-tip fleabane	<i>Leptorhynchos tenuifolius</i>	Wiry buttons
<i>Erigeron pappocromus</i>	Violet fleabane	* <i>Leucanthemum vulgare</i>	Ox-eye daisy
<i>Erigeron pappocromus</i> form A	Fleabane	* <i>Logfia gallica</i>	Logfia
<i>Erigeron pappocromus</i> form C	Fleabane	* <i>Matricaria matricarioides</i>	Rounded chamomile
v <i>Erigeron pappocromus</i>	Fleabane	<i>Microseris lanceolata</i>	Yam-daisy
var. <i>oblongatus</i>		<i>Millotia muelleri</i>	Common bow-flower
* <i>Euryops abrotanifolius</i>	Euryops	<i>Millotia myosotidifolia</i>	Broad-leaf millotia
* <i>Galinsoga parviflora</i>	Galinsoga	<i>Millotia perpusilla</i>	Tiny bow-flower
<i>Gnaphalium argentifolium</i>	Silver cudweed	<i>Millotia tenuifolia</i>	Soft millotia
<i>Gnaphalium ensifer</i>	Clustered cudweed	<i>Myriocephalus rhizocephalus</i>	Wooly-heads
<i>Gnaphalium fordianum</i>	Cudweed	* <i>Notobasis syriaca</i>	Syrian thistle
<i>Gnaphalium gymnocephalum</i>	Creeping cudweed	<i>Olearia algida</i>	Mountain daisy-bush
<i>Gnaphalium indutum</i>	Tiny cudweed	<i>Olearia argophylla</i>	Musk daisy-bush
<i>Gnaphalium involucratum</i>	Cudweed	<i>Olearia asterotricha</i>	Rough daisy-bush
sensu lato		<i>Olearia axillaris</i>	Coast daisy-bush
<i>Gnaphalium involucratum</i>	Cudweed	<i>Olearia decurrens</i>	Winged daisy-bush
sensu stricto		<i>Olearia erubescens</i>	Moth daisy-bush
* <i>Gnaphalium purpureum</i>	Purple cudweed	<i>Olearia floribunda</i>	Heath daisy-bush
<i>Gnaphalium sphaericum</i>	Common cudweed	<i>Olearia glandulosa</i>	Swamp daisy-bush
<i>Gnaphalium traversii</i>	Mat cudweed	<i>Olearia glutinosa</i>	Sticky daisy-bush
r <i>Gnaphalium umbricola</i>	Cliff cudweed	<i>Olearia iodochroa</i>	Violet daisy-bush
* <i>Hedypnois cretica</i>	Cretan hedypnois	<i>Olearia lirata</i>	Snow daisy-bush
<i>Helichrysum acuminatum</i>	Orange everlasting	<i>Olearia megalophylla</i>	Large-leaf daisy-bush
<i>Helichrysum apiculatum</i>	Common everlasting	<i>Olearia myrsinoides</i>	Silky daisy-bush
<i>Helichrysum baxteri</i>	White everlasting	<i>Olearia phlogopappa</i>	Dusty daisy-bush
<i>Helichrysum bracteatum</i>	Golden everlasting	<i>Olearia phlogopappa</i>	Dusty daisy-bush
<i>Helichrysum cuneifolium</i>	Wedge-leaf everlasting	var. <i>flavescens</i>	
<i>Helichrysum dendroideum</i>	Tree everlasting	<i>Olearia phlogopappa</i>	Dusty daisy-bush
<i>Helichrysum hookeri</i>	Scaly everlasting	var. <i>phlogopappa</i>	
<i>Helichrysum leucopsidium</i>	Satin everlasting	<i>Olearia pimeleoides</i>	Pimelea daisy-bush
<i>Helichrysum obcordatum</i>	Grey everlasting	<i>Olearia ramulosa</i>	Twiggy daisy-bush
<i>Helichrysum obtusifolium</i>	Blunt everlasting	<i>Olearia rugosa</i>	Wrinkled daisy-bush
<i>Helichrysum paraliu</i>	Coast everlasting	<i>Olearia speciosa</i>	Netted daisy-bush
r <i>Helichrysum rogersianum</i>	Nunniong everlasting	r <i>Olearia</i> sp. aff. <i>lanuginosa</i>	Daisy-bush
<i>Helichrysum rosmarinifolium</i>	Rosemary everlasting	(Morningson Pen.)	
<i>Helichrysum rutidolepis</i>	Pale everlasting	<i>Olearia teretifolia</i>	Cypress daisy-bush
<i>Helichrysum scorpioides</i>	Button everlasting	* <i>Onopordum acanthium</i>	Heraldic thistle
<i>Helichrysum secundiflorum</i>	Cascade everlasting	* <i>Onopordum acaulon</i>	Stemless onopordum
<i>Helichrysum semipapposum</i>	Clustered everlasting	* <i>Picris echioides</i>	Ox-tongue
<i>Helichrysum thyrsoideum</i>	Sticky everlasting	* <i>Picris hieracioides</i>	Hawkweed picris
<i>Helichrysum viscosum</i>		<i>Podolepis jaceoides</i>	Showy podolepis
<i>Helipterum albicans</i>	Hoary sunray	<i>Podolepis robusta</i>	alpine podolepis
<i>Helipterum albicans</i>	Hoary sunray	<i>Pseudognaphalium luteo-album</i>	Jersey cudweed
ssp. <i>albicans</i>		<i>Rutidosis multiflora</i>	Small wrinklewort
<i>Helipterum albicans</i> ssp.	Hoary sunray	* <i>Schkuhria pinnata</i>	Schkuhria
<i>albicans</i> var. <i>albicans</i>		* <i>Scorzonera laciniata</i>	Scorzonera
<i>Helipterum pygmaeum</i>	Pygmy sunray	<i>Senecio X orarius</i>	Coast groundsel
<i>Hyalosperma demissum</i>	Moss sunray	<i>Senecio biserratus</i>	Jagged fireweed
* <i>Hypochoeris glabra</i>	Smooth cat's Ear	<i>Senecio cunninghamii</i>	Branching groundsel
* <i>Hypochoeris radicata</i>	Cat's ear	* <i>Senecio elegans</i>	Purple groundsel
<i>Isoetopsis graminifolia</i>	Grass cushion	<i>Senecio glomeratus</i>	Annual fireweed
* <i>Iva axillaris</i>	Poverty weed	<i>Senecio gunnii</i>	Mountain fireweed
* <i>Lactuca saligna</i>	Willow-leaf lettuce	<i>Senecio hispidulus</i>	Rough fireweed
* <i>Lactuca serriola</i>	Prickly lettuce	<i>Senecio hispidulus</i>	Rough fireweed
<i>Lagenifera gracilis</i>	Slender lagenifera	var. <i>dissectus</i>	
<i>Lagenifera huegelii</i>	Coarse lagenifera	<i>Senecio hispidulus</i>	Rough fireweed
<i>Lagenifera stipitata</i>	Common lagenifera	var. <i>hispidulus</i>	
* <i>Lapsana communis</i>	Nipplewort	* <i>Senecio jacobaea</i>	Ragwort

Appendix III (continued)

Senecio lautus	Variable groundsel	*Myosotis laxa	Water forget-me-not
Senecio linearifolius	Fireweed groundsel	*Myosotis sylvatica	Wood forget-me-not
e Senecio macrocarpus	Large-fruit groundsel		
Senecio minimus	Shrubby fireweed	BRASSICACEAE	
Senecio odoratus	Scented groundsel	*Brassica tournefortii	Mediterranean turnip
Senecio pectinatus	alpine groundsel	*Cakile edentula	Sea rocket
Senecio quadridentatus	Cotton fireweed	*Cakile maritima	Beach rocket
Senecio sp. aff. tenuiflorus	Groundsel	*Capsella bursa-pastoris	Shepherd's purse
Senecio spathulatus	Coast groundsel	*Cardamine flexuosa	Bitter-cress
Senecio squarrosus	Leafy fireweed	Cardamine gunnii	Bitter-cress
Senecio tenuiflorus	Narrow groundsel	*Cardamine hirsuta	Common bitter-cress
Senecio vagus	Saw groundsel	Cardamine paucijuga	Bitter-cress
Senecio velleioides	Forest groundsel	Cardamine tenuifolia	Slender bitter-cress
*Senecio vulgaris	Common groundsel	*Cardaria draba	Hoary cress
Sigesbeckia orientalis	Indian weed	*Coronopus didymus	Lesser swine's-cress
*Silybum marianum	Variegated thistle	*Diplotaxis muralis	Wall rocket
Solenogyne dominii	Solenogyne	*Diplotaxis tenuifolia	Sand rocket
Solenogyne gunnii	Solenogyne	*Hirschfeldia incana	Hoary mustard
*Soliva sessilis	Jo jo	*Lepidium africanum	Common pepper-cress
*Sonchus asper	Rough dow-thistle	*Lepidium bonariense	Pepper-cress
*Sonchus oleraceus	Milk thistle	Lepidium foliosum	Leafy pepper-cress
Stuartina muelleri	Spoon cudweed	Lepidium pseudohyssopifolium	Pepper-cress
*Taraxacum Sect. Vulgaria	Garden dandelion	Lepidium pseudotasmanicum	Shade pepper-grass
*Tolpis barbata	Tolpis	*Lepidium pubescens	Matted pepper-cress
*Tragopogon porrifolius	Salsify	*Lepidium sativum	Garden cress
Triptilodiscus pygmaeus	Common sunray	*Lobularia maritima	Sweet alyssum
*Vellereophyton dealbatum	White cudweed	*Raphanus raphanistrum	Wild radish
Vittadinia cervicularis	Annual New	*Raphanus sativus	Common radish
	Holland daisy	*Rapistrum rugosum	Giant mustard
Vittadinia cuneata	Fuzzy New	Rorippa dictyosperma	Forest bitter-cress
	Holland daisy	Rorippa gigantea	Long-style bitter-cress
Vittadinia dissecta	Dissected New	Rorippa laciniata	Jagged bitter-cress
	Holland daisy	*Rorippa microphylla	One-row bitter-cress
Vittadinia muelleri	Narrow-leaf New	*Rorippa nasturtium-aquaticum	Two-row bitter-cress
	Holland daisy	*Rorippa palustris	Marsh bitter-cress
Waitzia acuminata	Orange immortelle	*Sisymbrium irio	London mustard
*Xanthium spinosum	Bathurst burr	*Sisymbrium officinale	Hedge mustard
*Xanthium strumarium	Noogoora burr	*Sisymbrium orientale	Indian hedge mustard
BASELLACEAE		BRUNONIACEAE	
*Anredera cordifolia	Anredera	Brunonia australis	Blue pincushion
BERBERIDACEAE		CACTACEAE	
*Berberis darwinii	Darwin's barberry	*Opuntia aurantiaca	Prickly-pear
		*Opuntia vulgaris	Drooping prickly-pear
BIGNONIACEAE		CALLITRICHACEAE	
Pandorea pandorana	Wonga vine	*Callitriche hamulata	
		Callitriche muelleri	Round water starwort
BORAGINACEAE		Callitriche palustris	Swamp water Starwort
*Amsinckia calycina	Hairy fiddle-neck	Callitriche sonderi	Matted water Starwort
*Anchusa arvensis	Bugloss	*Callitriche stagnalis	Water starwort
*Anchusa capensis	Cape forget-me-not	r Callitriche umbonata	Water starwort
*Borago officinalis	Borago		
Cynoglossum australe	Australian		
	hound's-tongue	CAMPANULACEAE	
Cynoglossum latifolium	Forest hound's-tongue	v Hypsela tridens	Hypsela
Cynoglossum suaveolens	Sweet hound's-tongue	Isotoma axillaris	Rock isotome
*Echium plantagineum	Paterson's curse	Isotoma fluviatilis	Swamp isotome
*Heliotropium europaeum	Common heliotrope	Lobelia alata	Angled lobelia
Myosotis australis	Austral forget-me-not	Lobelia gibbosa	Tall lobelia
*Myosotis discolor	Yellow-and-blue	Lobelia pratioides	Poison lobelia
	forget-me-not	Lobelia rhombifolia	Tufted lobelia
Myosotis exarthena	Sweet forget-me-not	Pratia concolor	Poison pratia

Appendix III (continued)

<i>Pratia pedunculata</i>	Matted pratia	<i>Allocasuarina pusilla</i>	Dwarf sheoke
<i>Pratia platycalyx</i>	Salt pratia	<i>Allocasuarina verticillata</i>	Drooping sheoke
<i>Pratia surrepens</i>	Mud pratia		
<i>Wahlenbergia ceracea</i>	Waxy bluebell	CHENOPODIACEAE	
<i>Wahlenbergia communis</i>	Tufted bluebell	<i>Atriplex cinerea</i>	Coast saltbush
<i>Wahlenbergia gloriosa</i>	Royal bluebell	* <i>Atriplex hastata</i>	Hastate orache
<i>Wahlenbergia gracilentia</i>	Annual bluebell	* <i>Atriplex hortensis</i>	Garden orache
<i>Wahlenbergia gracilis</i>	Sprawling bluebell	<i>Atriplex paludosa</i>	Marsh saltbush
<i>Wahlenbergia graniticola</i>	Granite bluebell	* <i>Atriplex patula</i>	Common orache
<i>Wahlenbergia gymnoclada</i>	Naked bluebell	* <i>Atriplex prostrata</i>	Creeping saltbush
<i>Wahlenbergia luteola</i>	Yellowish bluebell	<i>Atriplex semibaccata</i>	Berry saltbush
<i>Wahlenbergia multicaulis</i>	Many-stemmed bluebell	<i>Atriplex suberecta</i>	Sprawling saltbush
<i>Wahlenbergia stricta</i>	Tall bluebell	* <i>Chenopodium album</i>	Fat hen
		<i>Chenopodium carinatum</i>	Kneeled goosefoot
CAPRIFOLIACEAE		<i>Chenopodium desertorum</i>	Frosted goosefoot
* <i>Leycesteria formosa</i>	Himalayan honeysuckle	<i>Chenopodium glaucum</i>	Glaucous goosefoot
* <i>Lonicera japonica</i>	Japanese honeysuckle	* <i>Chenopodium macrospermum</i>	Red-stem goosefoot
<i>Sambucus gaudichaudiana</i>	White elderberry	* <i>Chenopodium multifidum</i>	Scented goosefoot
* <i>Sambucus nigra</i>	Common elderberry	* <i>Chenopodium murale</i>	Sowbane
		<i>Chenopodium pumilio</i>	Clammy goosefoot
CARYOPHYLLACEAE		* <i>Chenopodium vulvaria</i>	Stinking goosefoot
<i>Arenaria leptoclados</i>	Lesser thyme-leaved sandwort	<i>Dysphania glomulifera</i>	Globular pigweed
* <i>Cerastium diffusum</i>	Mouse-ear chickweed	<i>Einadia hastata</i>	Saloop saltbush
* <i>Cerastium fontanum</i>	Mouse-ear chickweed	<i>Einadia nutans</i>	Nodding saltbush
* <i>Cerastium glomeratum</i>	Common mouse-ear chickweed	<i>Einadia trigonos</i>	Hill saltbush
		<i>Enchylaena tomentosa</i>	Ruby saltbush
* <i>Cerastium illyricum</i>	Levantine chickweed	<i>Halosarcia halocnemoides</i>	Grey glasswort
* <i>Cerastium semidecandrum</i>	Mouse-ear chickweed	<i>Halosarcia pergranulata</i>	Black-seeded glasswort
* <i>Dianthus armeria</i>	Deptford pink	<i>Hemichroa pentandra</i>	Trailing hemichroa
* <i>Minuartia hybrida</i>	Fine-leaved sandwort	<i>Maireana decalvans</i>	Common bluebush
* <i>Moenchia erecta</i>	Erect chickweed	<i>Maireana enchylaenoides</i>	Wingless bluebush
* <i>Paronychia franciscana</i>	Nailwort	<i>Rhagodia candolleana</i>	Seaberry saltbush
* <i>Petrohragia prolifera</i>	Proliferous pink	<i>Salsola kali</i>	Prickly saltbush
* <i>Petrohragia velutina</i>	Hairy pink	<i>Sarcocornia blackiana</i>	Thick-head glasswort
* <i>Polycarpon tetraphyllum</i>	Four-leaved allseed	<i>Sarcocornia quinqueflora</i>	Beaded glasswort
* <i>Sagina apetala</i>	Common pearlwort	ssp. <i>quinqueflora</i>	
* <i>Sagina maritima</i>	Sea pearlwort	e <i>Sarcocornia quinqueflora</i>	Beaded glasswort
* <i>Sagina procumbens</i>	Spreading pearlwort	ssp. <i>tasmanica</i>	
<i>Scleranthus biflorus</i>	Twin-flower knawel	<i>Sclerolaena diacantha</i>	Horned bassia
* <i>Silene conica</i>	Striated catchfly	<i>Sclerostegia arbuscula</i>	Shrubby glasswort
* <i>Silene gallica</i>	French catchfly	<i>Suaeda australis</i>	Austral seablite
* <i>Silene nocturna</i>	Mediterranean catchfly	<i>Threlkeldia diffusa</i>	Coast bonefruit
* <i>Silene pratensis</i>	Field catchfly		
* <i>Silene vulgaris</i>	Bladder campion	CLUSIACEAE	
* <i>Spergula arvensis</i>	Corn spurrey	* <i>Hypericum androsaemum</i>	Tutsan
* <i>Spergularia marina</i>	Salt sand-spurrey	* <i>Hypericum calycinum</i>	Large-flower St. John's wort
* <i>Spergularia media</i>	Coast sand-spurrey		John's wort
* <i>Spergularia rubra</i>	Red sand-spurrey	<i>Hypericum gramineum</i>	Small St. John's wort
<i>Stellaria caespitosa</i>	Starwort	<i>Hypericum japonicum</i>	Matted St. John's wort
<i>Stellaria flaccida</i>	Forest starwort	* <i>Hypericum perforatum</i>	St. John's wort
* <i>Stellaria media</i>	Chickweed	* <i>Hypericum tetrapterum</i>	Square-stem St. John's wort
<i>Stellaria multiflora</i>	Rayless starwort		
* <i>Stellaria pallida</i>	Lesser starwort	CONVOLVULACEAE	
<i>Stellaria palustris</i>	Swamp starwort	<i>Calystegia marginata</i>	Forest bindweed
<i>Stellaria pungens</i>	Prickly starwort	<i>Calystegia sepium</i>	Large bindweed
		* <i>Calystegia silvatica</i>	Greater bindweed
CASUARINACEAE		* <i>Convolvulus arvensis</i>	Common bindweed
<i>Allocasuarina littoralis</i>	Black sheoke	<i>Convolvulus erubescens</i>	Pink bindweed
<i>Allocasuarina misera/paradoxa</i>	Slender/Green sheoke	<i>Convolvulus remotus</i>	Grassy bindweed
<i>Allocasuarina paludosa</i>	Scrub sheoke	<i>Dichondra repens</i>	Kidney-weed
<i>Allocasuarina paradoxa</i>	Green sheoke		

Appendix III (continued)

Wilsonia backhousei	Narrow-leaf wilsonia	EPACRIDACEAE	
Wilsonia humilis	Silky wilsonia	Acrotriche prostrata	Trailing ground-berry
Wilsonia rotundifolia	Round-leaf wilsonia	Acrotriche serrulata	Honey-pots
		Astroloma humifusum	Cranberry heath
CRASSULACEAE		Brachyloma ciliatum	Fringed brachyloma
Crassula decumbens	Spreading crassula	Brachyloma daphnoides	Daphne heath
Crassula helmsii	Swamp crassula	v Cyathodes juniperina	Crimson berry
*Crassula natans	Crassula	Epacris breviflora	Drumstick heath
Crassula pedicellosa	Stalked crassula	Epacris coriacea	Tough heath
Crassula peduncularis	Purple crassula	Epacris impressa	Common heath
Crassula sieberiana	Sieber crassula	Epacris microphylla	Coral heath
Crassula sieberiana	Sieber crassula	Epacris obtusifolia	Blunt-leaf heath
ssp. sieberiana		Epacris paludosa	Swamp heath
Crassula sieberians	Sieber crassula	Epacris petrophila	Snow heath
ssp. tetramera		Leucopogon australis	Spike beard-heath
		Leucopogon biflorus	Twin-flower beard-heath
CUCURBITACEAE		Leucopogon collinus	Fringed beard-heath
*Citrullus colocynthis	Colocynth	Leucopogon ericoides	Pink beard-heath
*Cucumis myriocarpus	Paddy melon	Leucopogon gelidus	Drooping beard-heath
*Ecballium elaterium	Squirting cucumber	Leucopogon glacialis	Twisted beard-heath
		Leucopogon hookeri	Mountain beard-heath
CUNONIACEAE		Leucopogon juniperinus	Long-flower beard-heath
Bauera rubioides	Wiry bauera	Leucopogon lanceolatus	Lance beard-heath
		Leucopogon maccraei	Subalpine beard-heath
CUSCUTACEAE		Leucopogon parviflorus	Coast beard-heath
*Cuscuta campestris	Field dodder	Leucopogon stuartii	Sharp beard-heath
Cuscuta tasmanica	Golden dodder	Leucopogon virgatus	Common beard-heath
		Lissanthe strigosa	Peach heath
DILLENIACEAE		Melichrus urceolatus	Urn heath
Hibbertia acicularis	Prickly guinea flower	Monotoca elliptica	Tree broom-heath
Hibbertia aspera	Rough guinea-flower	Monotoca scoparia	Prickly broom-heath
Hibbertia calycina	Prickly erect guinea-flower	r Monotoca sp. aff. elliptica (alps)	Mountain broom-heath
		Pentachondra pumila	Carpet heath
Hibbertia diffusa	Wedge guinea-flower	Richea continentis	Candle richea
Hibbertia empetrifolia	Tangled guinea-flower	r Richea gunnii	Gunn's richea
Hibbertia exutiacies	Spiky guinea-flower	Sprengelia incarnata	Pink swamp-heath
Hibbertia obtusifolia	Grey guinea-flower	Trochocarpa clarkei	Lilac berry
Hibbertia procumbens	Spreading guinea-flower	r Wittsteinia vacciniacea	Baw Baw berry
Hibbertia prostrata	Bundled guinea-flower		
Hibbertia riparia	Erect guinea-flower		
Hibbertia sericea	Silky guinea-flower		
Hibbertia stricta	Upright guinea-flower		
Hibbertia virgata	Twiggy guinea-flower		
		ERICACEAE	
DIPSACACEAE		*Arbutus unedo	Strawberry tree
*Dipsacus fullonum	Wild teasel	*Erica arborea	Tree heath
*Scabiosa atropurpurea	Pincushion	*Erica baccans	Berry-flower heath
		*Erica lusitanica	Spanish heath
		Gaultheria appressa	Wax-berry
		EUPHORBIACEAE	
DROSERACEAE		Adriana hookeri	Mallee bitter-bush
Drosera arcturi	Alpine sundew	Adriana klotzschii	Coast bitter-bush
Drosera binata	Forked sundew	e Adriana quadripartita	Rare bitter-bush
Drosera glanduligera	Scarlet sundew	Amperea xiphoclada	Broom spurge
Drosera macrantha	Sundew	Beyeria lechenaultii	Pale turpentine bush
Drosera peltata	Tall sundew	r Beyeria viscosa	Pinkwood
Drosera peltata ssp. auriculata	Tall sundew	Euphorbia drummondii	Flat spurge
Drosera peltata ssp. peltata	Pale sundew	*Euphorbia lathyris	Caper spurge
Drosera pygmaea	Tiny sundew	*Euphorbia paralias	Sea spurge
Drosera spatulata	Rosy sundew	*Euphorbia peplus	Petty spurge
Drosera whittakeri	Scented sundew	Micranthemum hexandrum	Box micranthemum
		Phyllanthus gunnii	Shrubby spurge
ELATINACEAE		Phyllanthus hirtellus	Thyme spurge
Elatine gratioloides	Waterwort	Poranthera microphylla	Small poranthera
		Ricinocarpos pinifolius	Wedding bush

Appendix III (continued)

FABACEAE

<i>Aotus ericoides</i>	Common aotus	<i>Oxylobium alpestre</i>	Alpine oxylobium
<i>Bossiaea buxifolia</i>	Matted bossiaea	<i>Oxylobium arborescens</i>	Tall oxylobium
<i>Bossiaea cinerea</i>	Showy bossiaea	<i>Oxylobium ellipticum</i>	Common oxylobium
<i>Bossiaea cordigera</i>	Wiry bossiaea	<i>Oxylobium procumbens</i>	Trailing oxylobium
<i>Bossiaea foliosa</i>	Leafy bossiaea	<i>Platylobium formosum</i>	Handsome flat-pea
<i>Bossiaea obcordata</i>	Spiny bossiaea	<i>Platylobium obtusangulum</i>	Common flat-pea
<i>Bossiaea prostrata</i>	Creeping bossiaea	<i>Psoralea adscendens</i>	Mountain psoralea
* <i>Calycotome spinosa</i>	Spiny broom	* <i>Psoralea pinnata</i>	Blue psoralea
* <i>Cytisus palmensis</i>	Tree lucerne	e <i>Psoralea tenax</i>	Tough psoralea
* <i>Cytisus scoparius</i>	English broom	<i>Pultenaea canaliculata</i>	Coast bush-pea
<i>Daviesia buxifolia</i>	Box-leaf bitter-pea	<i>Pultenaea cunninghamii</i>	Grey bush-pea
<i>Daviesia latifolia</i>	Hop bitter-pea	<i>Pultenaea daphnoides</i>	Large-leaf bush-pea
<i>Daviesia leptophylla</i>	Narrow-leaf bitter-pea	<i>Pultenaea dentata</i>	Clustered bush-pea
<i>Daviesia mimosoides</i>	Blunt-leaf bitter-pea	<i>Pultenaea fasciculata</i>	Alpine bush-pea
<i>Daviesia mimosoides</i>	Blunt-leaf bitter-pea	<i>Pultenaea gunnii</i>	Golden bush-pea
var. <i>laxiflora</i>		<i>Pultenaea hispidula</i>	Rusty bush-pea
<i>Daviesia mimosoides</i>	Blunt-leaf bitter-pea	<i>Pultenaea humilis</i>	Dwarf bush-pea
var. <i>mimosoides</i>		<i>Pultenaea juniperina</i>	Prickly bush-pea
<i>Daviesia ulicifolia</i>	Gorse bitter-pea	<i>Pultenaea juniperina</i>	Prickly bush-pea
<i>Desmodium gunnii</i>	Southern tick-trefoil	var. <i>mucronata</i>	
r <i>Desmodium varians</i>	Slender tick-trefoil	<i>Pultenaea largiflorens</i>	Twiggy bush-pea
<i>Dillwynia cinerascens</i>	Grey parrot-pea	<i>Pultenaea laxiflora</i>	Loose-flower bush-pea
<i>Dillwynia glaberrima</i>	Smooth parrot-pea	<i>Pultenaea mollis</i>	Soft bush-pea
<i>Dillwynia hispida</i>	Red parrot-pea	<i>Pultenaea muelleri</i>	Mueller's bush-pea
<i>Dillwynia juniperina</i>	Prickly parrot-pea	<i>Pultenaea paleacea</i>	Chaffy bush-pea
<i>Dillwynia phyllicoides</i>	Small-leaf parrot-pea	<i>Pultenaea paleacea</i>	Chaffy bush-pea
<i>Dillwynia ramosissima</i>	Bushy parrot-pea	var. <i>williamsonii</i>	
<i>Dillwynia sericea</i>	Showy parrot-pea	<i>Pultenaea pedunculata</i>	Matted bush-pea
* <i>Dipogon lignosus</i>	Common fipogon	<i>Pultenaea platyphylla</i>	Flat-leaf bush-pea
* <i>Genista linifolia</i>	Genista	<i>Pultenaea prolifera</i>	Otway bush-pea
* <i>Genista monspessulana</i>	Montpellier broom	<i>Pultenaea prostrata</i>	Silky bush-pea
<i>Glycine clandestina</i>	Twining glycine	<i>Pultenaea retusa</i>	Blunt bush-pea
v <i>Glycine latrobeana</i>	Clover glycine	<i>Pultenaea scabra</i>	Rough bush-pea
<i>Glycine microphylla</i>	Small-leaf glycine	<i>Pultenaea stricta</i>	Rigid bush-pea
<i>Glycine tabacina sensu lato</i>	Variable glycine	<i>Pultenaea subumbellata</i>	Wiry bush-pea
<i>Glycine tabacina sensu stricto</i>	Variable glycine	<i>Pultenaea tenuifolia</i>	Slender bush-pea
<i>Gompholobium huegelii</i>	Common wedge-pea	r <i>Pultenaea weindorferi</i>	Swamp bush-pea
<i>Gompholobium latifolium</i>	Giant wedge-pea	<i>Sphaerolobium vimineum</i>	Leafless globe-pea
<i>Goodia lotifolia</i>	Golden-tip	<i>Swainsona lessertiiifolia</i>	Coast Swainson-pea
<i>Hardenbergia violacea</i>	Purple coral-pea	* <i>Trifolium angustifolium</i>	Narrow-leaf clover
<i>Hovea linearis</i>	Common hovea	* <i>Trifolium arvense</i>	Hare's foot clover
<i>Hovea montana</i>	Alpine rusty-pods	* <i>Trifolium campestre</i>	Hop clover
<i>Hovea purpurea</i>	Mountain beauty	* <i>Trifolium cernuum</i>	Drooping-flower clover
<i>Indigofera australis</i>	Austral indigo	* <i>Trifolium dubium</i>	Suckling clover
<i>Kennedia prostrata</i>	Running postman	* <i>Trifolium fragiferum</i>	Strawberry clover
* <i>Kennedia rubicunda</i>	Dusky coral-pea	* <i>Trifolium glomeratum</i>	Cluster clover
* <i>Lathyrus latifolius</i>	Sweet pea	* <i>Trifolium hybridum</i>	Alsike clover
* <i>Lotus angustissimus</i>	Slender bird's-foot trefoil	* <i>Trifolium incarnatum</i>	Crimson clover
		* <i>Trifolium ornithopodioides</i>	Birdsfoot clover
<i>Lotus australis</i>	Austral trefoil	* <i>Trifolium pratense</i>	Red clover
* <i>Lotus subbiflorus</i>	Hair bird's-foot trefoil	* <i>Trifolium repens</i>	White clover
* <i>Lotus uliginosus</i>	Greater bird's-foot trefoil	* <i>Trifolium resupinatum</i>	Shafted clover
		* <i>Trifolium scabrum</i>	Rough clover
* <i>Medicago arabica</i>	Spotted medic	* <i>Trifolium striatum</i>	Knotted clover
* <i>Medicago lupulina</i>	Black medic	* <i>Trifolium subterraneum</i>	Subterranean clover
* <i>Medicago minima</i>	Little medic	* <i>Trifolium tomentosum</i>	Woolly clover
* <i>Medicago polymorpha</i>	Burr medic	* <i>Ulex europaeus</i>	Furze
* <i>Medicago sativa</i>	Lucerne	* <i>Vicia disperma</i>	French tiny vetch
* <i>Medicago truncatula</i>	Barrel medic	* <i>Vicia hirsuta</i>	Tiny vetch
* <i>Melilotus alba</i>	Bokhara clover	* <i>Vicia sativa</i>	Common vetch
* <i>Melilotus indica</i>	Sweet melilotus	* <i>Vicia sativa ssp. nigra</i>	Slender vetch
* <i>Ornithopus pinnatus</i>	Sand bird's-foot	* <i>Vicia sativa ssp. sativa</i>	Slender vetch
		* <i>Vicia tetrasperma</i>	Slender vetch

Appendix III (continued)

<i>Viminaria juncea</i>	Golden spray	<i>Selliera radicans</i>	Shiny swamp-mat
		<i>Velleia paradoxa</i>	Spur velleia
FAGACEAE			
<i>Nothofagus cunninghamii</i>	Myrtle beech		
* <i>Quercus robur</i>	English oak		
FRANKENIACEAE			
<i>Frankenia pauciflora</i>	Southern sea-heath		
FUMARIACEAE			
* <i>Fumaria bastardii</i>	Fumitory		
* <i>Fumaria capreolata</i>	Ramping fumitory		
* <i>Fumaria densiflora</i>	Dense fumitory		
* <i>Fumaria officinalis</i>	Fumitory		
* <i>Fumaria vaillantii</i>	Fumitory		
GENTIANACEAE			
* <i>Centaurium erythraea</i>	Common centaur		
* <i>Centaurium spicatum</i>	Spike centaur		
* <i>Centaurium tenuiflorum</i>	Centaur		
* <i>Cicendia filiformis</i>	Slender cicendia		
* <i>Cicendia quadrangularis</i>	Square cicendia		
<i>Gentianella diemensis</i>	Mountain gentian		
<i>Sebaea albidiflora</i>	White sebaea		
<i>Sebaea ovata</i>	Yellow sebaea		
GERANIACEAE			
* <i>Erodium botrys</i>	Big heron's bill		
* <i>Erodium cicutarium</i>	Common heron's-bill		
<i>Erodium crinitum</i>	Blue heron's-bill		
* <i>Erodium moschatum</i>	Musky heron's-bill		
<i>Geranium antrorsum</i>	Rosetted crane's-bill		
* <i>Geranium dissectum</i>	Cut-leaf crane's-bill		
<i>Geranium homeanum</i>	Crane's-bill		
* <i>Geranium molle</i>	Dove's-foot		
<i>Geranium potentilloides</i>	Cinquefoil		
<i>Geranium retrorsum</i>	Grassland crane's-bill		
<i>Geranium solanderi</i>	austral crane's-bill		
* <i>Pelargonium asperum</i>	Rose-oil geranium		
<i>Pelargonium australe</i>	Austral stork's-bill		
* <i>Pelargonium capitatum</i>	Rosy pelargonium		
<i>Pelargonium inodorum</i>	Kopata		
<i>Pelargonium rodneyanum</i>	Magenta stork's-bill		
GESNERIACEAE			
<i>Fieldia australis</i>	Fieldia		
GOODENIACEAE			
<i>Dampiera stricta</i>	Blue dampiera		
<i>Goodenia blackiana</i>	Black's goodenia		
<i>Goodenia elongata</i>	Lanky goodenia		
<i>Goodenia geniculata</i>	Bent goodenia		
<i>Goodenia gracilis</i>	Slender goodenia		
<i>Goodenia hederacea</i>	Ivy goodenia		
<i>Goodenia humilis</i>	Swamp goodenia		
<i>Goodenia lanata</i>	Trailing goodenia		
<i>Goodenia ovata</i>	Hop goodenia		
<i>Goodenia pinnatifida</i>	Cut-leaf Goodenia		
<i>Scaevola aemula</i>	Fairy fan-flower		
<i>Scaevola albida</i>	Small fan-flower		
<i>Scaevola albida</i> var. <i>pallida</i>	Coast fan-flower		
<i>Scaevola hookeri</i>	Creeping fan-flower		
<i>Scaevola ramosissima</i>	Hairy fan-flower		
		HALORAGACEAE	
		<i>Gonocarpus elatus</i>	Tall raspwort
		<i>Gonocarpus humilis</i>	Shade raspwort
		<i>Gonocarpus micranthus</i>	Creeping raspwort
		<i>Gonocarpus montanus</i>	Mat raspwort
		<i>Gonocarpus tetragynus</i>	Common raspwort
		<i>Gonocarpus teucrioides</i>	Germander raspwort
		<i>Haloragis aspera</i>	Rough raspwort
		<i>Haloragis brownii</i>	swamp raspwort
		<i>Haloragis heterophylla</i>	Varied raspwort
		<i>Myriophyllum amphibium</i>	Broad milfoil
		* <i>Myriophyllum aquaticum</i>	Parrot's feather milfoil
		<i>Myriophyllum caput-medusae</i>	Coarse milfoil
		<i>Myriophyllum crispatum</i>	Upright milfoil
		<i>Myriophyllum integrifolium</i>	Tiny milfoil
		<i>Myriophyllum papillosum</i>	Robust milfoil
		<i>Myriophyllum pedunculatum</i>	Mat milfoil
		<i>Myriophyllum pedunculatum</i>	Mat milfoil
		ssp. <i>longibracteatum</i>	
		<i>Myriophyllum pedunculatum</i>	Mat milfoil
		ssp. <i>pedunculatum</i>	
		<i>Myriophyllum simulans</i>	Amphibious milfoil
		<i>Myriophyllum verrucosum</i>	Red milfoil
		LAMIACEAE	
		<i>Ajuga australis</i>	Austral bugle
		* <i>Clinopodium vulgare</i>	Wild basil
		* <i>Lamium purpureum</i>	Red dead-nettle
		<i>Lycopus australis</i>	Australian gipsywort
		* <i>Marrubium vulgare</i>	Horehound
		* <i>Mentha X piperita</i>	Lemon mint
		<i>Mentha australis</i>	River mint
		<i>Mentha diemenica</i>	Slender mint
		<i>Mentha laxiflora</i>	Forest mint
		* <i>Mentha pulegium</i>	Pennyroyal
		<i>Mentha sativoides</i>	Creeping mint
		* <i>Mentha spicata</i>	Spearmint
		<i>Plectranthus parviflorus</i>	Cockspur Flower
		<i>Prostanthera cuneata</i>	Alpine mint-bush
		<i>Prostanthera denticulata</i>	Rough mint-bush
		<i>Prostanthera hirtula</i>	Hairy mint-bush
		<i>Prostanthera lasianthus</i>	Victorian christmas-bush
		<i>Prostanthera melissifolia</i>	Balm mint-bush
		<i>Prostanthera nivea</i>	Snowy mint-bush
		<i>Prostanthera phyllifolia</i>	Spiked mint-bush
		<i>Prostanthera rotundifolia</i>	Round-leaf mint-bush
		<i>Prunella vulgaris</i>	Self-heal
		* <i>Salvia verbenaca</i>	Wild sage
		<i>Scutellaria humilis</i>	Dwarf skullcap
		* <i>Stachys arvensis</i>	Stagger weed
		<i>Teucrium corymbosum</i>	Forest germander
		<i>Westringia glabra</i>	Violet westringia
		<i>Westringia senifolia</i>	
		LAURACEAE	
		<i>Cassytha glabella</i>	Slender dodder-laurel
		<i>Cassytha melantha</i>	Coarse dodder-laurel
		<i>Cassytha phaeolasia</i>	Rusty dodder-laurel
		(= <i>Cassytha pubescens</i>)	

Appendix III (continued)

<i>Cassytha pubescens</i>	Downy dodder-laurel	<i>*Acacia baileyana</i>	Cootamundra wattle
LENTIBULARIACEAE		<i>Acacia brownei</i>	heath wattle
<i>Utricularia australis</i>	Yellow bladderwort	<i>Acacia dealbata</i>	Silver wattle
<i>Utricularia dichotoma</i>	Purple bladderwort	<i>Acacia deanei</i>	Deane's wattle
<i>Utricularia lateriflora</i>	Tiny bladderwort	<i>Acacia deanei</i> ssp. <i>paucijuga</i>	Deane's wattle
<i>Utricularia tenella</i>	Pink bladderwort	<i>*Acacia decurrens</i>	Early black wattle
<i>Utricularia uniflora</i>	Single bladderwort	<i>Acacia difformis</i>	Wyalong wattle
LINACEAE		<i>*Acacia elata</i>	Cedar wattle
<i>Linum marginale</i>	Native flax	<i>*Acacia floribunda</i>	White-sallow wattle
<i>*Linum trigynum</i>	French flax	<i>Acacia frutescens</i>	Forest wattle
LOGANIACEAE		<i>Acacia genistifolia</i>	Spreading wattle
<i>Logania albiflora</i>	Narrow-leaf logania	<i>Acacia gunnii</i>	Ploughshare wattle
<i>Mitrasacme distylis</i>	Tiny mitrewort	<i>Acacia implexa</i>	Lightwood
<i>r Mitrasacme montana</i>	Mountain mitrewort	<i>Acacia lanigera</i>	Woolly wattle
<i>Mitrasacme paradoxa</i>	Wiry mitrewort	<i>Acacia leprosa</i>	Cinnamon wattle
<i>Mitrasacme pilosa</i>	Hairy mitrewort	<i>Acacia longifolia</i>	Sallow wattle
<i>Mitrasacme polymorpha</i>	Varied mitrewort	<i>Acacia mearnsii</i>	Black wattle
<i>Mitrasacme serpyllifolia</i>	Thyme mitrewort	<i>Acacia melanoxylon</i>	Blackwood
LORANTHACEAE		<i>Acacia mitchellii</i>	Mitchell's wattle
<i>Amyema miquelii</i>	Box mistletoe	<i>Acacia montana</i>	Mallee wattle
<i>Amyema pendulum</i>	Drooping mistletoe	<i>Acacia mucronata</i>	Narrow-leaf wattle
<i>Amyema preissii</i>	Wire-leaf mistletoe	<i>Acacia myrtifolia</i>	Myrtle wattle
<i>Amyema quandang</i>	Grey mistletoe	<i>Acacia nano-dealbata</i>	Dwarf silver wattle
<i>Lysiana exocarpi</i>	Harlequin mistletoe	<i>Acacia obliquinervia</i>	Mountain hickory wattle
<i>Muellerina eucalyptoides</i>	Creeping mistletoe	<i>Acacia oxycedrus</i>	Spike wattle
LYTHRACEAE		<i>Acacia paradoxa</i>	Hedge wattle
<i>*Lythrum junceum</i>	Mediterranean loosestrife	<i>Acacia pravissima</i>	Ovens wattle
<i>Lythrum hyssopifolia</i>	Small loosestrife	<i>Acacia pycnantha</i>	Golden wattle
<i>Lythrum salicaria</i>	Purple loosestrife	<i>Acacia retinodes</i>	Wirilda
MALVACEAE		<i>Acacia retinodes</i> var. <i>uncifolia</i>	Wirilda
<i>Gynatrix pulchella</i>	Hemp bush	<i>Acacia rubida</i>	Red-stem wattle
<i>*Lavatera arborea</i>	Tree mallow	<i>*Acacia saligna</i>	Golden-wreath wattle
<i>*Lavatera cretica</i>	Cretan hollyhock	<i>Acacia sophorae</i>	Coast wattle
<i>Lavatera plebeia</i>	Australian hollyhock	<i>Acacia stricta</i>	Hop wattle
<i>Lavatera plebeia</i> var. <i>tomentosa</i>	Australian hollyhock	<i>Acacia suaveolens</i>	Sweet wattle
<i>Lawrenzia spicata</i>	Salt lawrenzia	<i>Acacia terminalis</i>	Sunshine wattle
<i>*Malva neglecta</i>	Dwarf mallow	<i>Acacia ulicifolia</i>	Juniper wattle
<i>*Malva nicaeensis</i>	Nice mallow	<i>Acacia verniciflua</i>	Varnish wattle
<i>*Malva parviflora</i>	Small-flowered mallow	<i>Acacia verticillata</i>	Prickly Moses
<i>*Malva sylvestris</i>	Tall mallow	<i>Acacia verticillata</i> var. <i>ovoidea</i>	Prickly Moses
<i>*Modiola caroliniana</i>	Carolina mallow	<i>Acacia verticillata</i> var. <i>verticillata</i>	Prickly Moses
MELIANTHACEAE		<i>*Paraserianthes lophantha</i>	Cape wattle
<i>*Melianthus comosus</i>	Kruidge-roer-my-nie	MONIMIACEAE	
<i>*Melianthus major</i>	Cape honey-flower	<i>Atherosperma moschatum</i>	Southern sassafras
MENYANTHACEAE		<i>Hedycarya angustifolia</i>	austral mulberry
<i>Nymphoides crenata</i>	Wavy marshwort	MORACEAE	
<i>Villarsia exaltata</i>	Erect marsh-flower	<i>*Ficus macrophylla</i>	Moreton Bay fig
<i>Villarsia reniformis</i>	Running marsh-flower	MYOPORACEAE	
MIMOSACEAE		<i>Myoporum insulare</i>	Common boobialla
<i>Acacia acinacea</i>	Gold-dust wattle	<i>Myoporum viscosum</i>	Sticky boobialla
<i>Acacia aculeatissima</i>	Thin-leaf wattle	MYRSINACEAE	
<i>Acacia alpina</i>	alpine wattle	<i>Rapanea howittiana</i>	Mutton-wood
<i>Acacia aspera</i>	Rough wattle	MYRTACEAE	
		<i>Acmena smithii</i>	Lilly pilly
		<i>Baeckea gunniana</i>	alpine baeckea
		<i>Baeckea ramosissima</i>	Rosy baeckea

Appendix III (continued)

Baeckea ramosissima ssp. ramosissima	Rosy baeckea	Eucalyptus regnans	Mountain ash
Baeckea utilis	Mountain baeckea	Eucalyptus rubida	Candlebark
Baeckea utilis var. latifolia	Mountain baeckea	Eucalyptus sideroxylon	Red ironbark
Callistemon citrinus	Crimson bottlebrush	Eucalyptus sieberi	Silver-top
Callistemon pallidus	Lemon bottlebrush	Eucalyptus smithii	Gully gum
Callistemon pityoides	Alpine bottlebrush	Eucalyptus stellulata	Black sallee
Callistemon sieberi	River bottlebrush	Eucalyptus viminalis	Manna gum
Calytrix alpestris	Snow myrtle	r Eucalyptus yarraensis	Yarra gum
Calytrix tetragona	Common fringe-myrtle	Kunzea ericifolia	Yellow kunzea
Eucalyptus albens	White box	Kunzea ericoides	Burgan
v Eucalyptus alligatrix	Mealy stringybark	Kunzea parvifolia	Violet kunzea
Eucalyptus angophoroides	Apple-topped box	Leptospermum brevipes	Slender tea-tree
Eucalyptus angophoroides/ bridgesiana	Apple-topped box/ but but	Leptospermum continentale	Prickly tea-tree
Eucalyptus aromaphloia	Scent bark	Leptospermum glabrescens sensu lato	Smooth tea-tree
Eucalyptus baxteri	Brown stringybark	Leptospermum grandifolium	Mountain tea-tree
Eucalyptus blakelyi	Hill red gum	Leptospermum laevigatum	Coast tea-tree
Eucalyptus botryoides	Bangalay	Leptospermum lanigerum	Woolly tea-tree
Eucalyptus bridgesiana	But but	Leptospermum myrsinoides	heath tea-tree
Eucalyptus camaldulensis	River red gum	Leptospermum obovatum	River tea-tree
Eucalyptus camphora	Mountain swamp gum	Leptospermum scoparium	Manuka tea-tree
Eucalyptus cephalocarpa sensu stricto	Mealy stringybark	*Melaleuca armillaris	Braclet paperbark
Eucalyptus chapmaniana	Bogong gum	Melaleuca ericifolia	Swamp paperbark
Eucalyptus cinerea	Silver-leaf stringybark	Melaleuca lanceolata	Moonah
*Eucalyptus cladocalyx	Sugar gum	Melaleuca parvistaminea	Rough paperbark
Eucalyptus considaniana	Yertchuk	Melaleuca squamea	Mealy paperbark
Eucalyptus conspicua	Mealy stringybark	Melaleuca squarrosa	Scented paperbark
e Eucalyptus crenulata	Buxton gum	Micromyrtus ciliata	Heath-myrtle
Eucalyptus cypellocarpa	Mountain grey gum		
Eucalyptus dalrympleana	Mountain gum	OLEACEAE	
Eucalyptus delegatensis	Alpine ash	Notelaea ligustrina	Privet mock-olive
Eucalyptus dives	Broad-leaved peppermint	*Olea europaea	Olive
Eucalyptus glaucescens	Tingaringy gum		
Eucalyptus globoidea	White stringybark	ONAGRACEAE	
Eucalyptus globulus	Blue gum	Epilobium billardierianum	Robust willow-herb
Eucalyptus globulus ssp. bicostata	Eurabbie	Epilobium billardierianum ssp. billardierianum	Robust willow-herb
Eucalyptus globulus ssp. globulus	Southern blue gum	Epilobium billardierianum ssp. cinereum	Variable willow-herb
Eucalyptus goniocalyx sensu stricto	Long-leaf box	Epilobium billardierianum ssp. hydrophyllum	Robust willow-herb
Eucalyptus goniocalyx/ nortonii	Long-leaf box/ silver bundy	*Epilobium ciliatum	Glandular willow-herb
Eucalyptus kitsoniana	Bog gum	Epilobium curtiseae	Bald-seeded willow-herb
Eucalyptus kybeanensis	Ash-mallee	Epilobium gunnianum	Gunn's willow-herb
Eucalyptus leucoxydon	Yellow gum	Epilobium hirtigerum	Hairy willow-herb
Eucalyptus macrorhyncha	Red stringybark	Epilobium pallidiflorum	Showy willow-herb
Eucalyptus mannifera	Brittle gum	Ludwigia peploides	Clove-strip
Eucalyptus melliodora	Yellow box		
Eucalyptus microcarpa	Grey box	OROBANCHACEAE	
Eucalyptus muelleriana	Yellow stringybark	*Orobancha minor	Lesser broomrape
r Eucalyptus neglecta	Omeo gum		
Eucalyptus nitens	Shining gum	OXALIDACEAE	
Eucalyptus obliqua	Messmate	*Oxalis articulata	Bent wood-sorrel
Eucalyptus ovata	Swamp gum	Oxalis chnoodes	Wood-sorrel
Eucalyptus pauciflora	Snow gum	Oxalis corniculata ssp. agg.	Yellow wood-sorrel
Eucalyptus perriniana	Spinning gum	*Oxalis corymbosa	Pink shamrock
Eucalyptus polyanthemus	Red box	Oxalis exilis	Shady wood-sorrel
Eucalyptus pryoriana	Coast manna gum	*Oxalis hirta	Hairy wood-sorrel
Eucalyptus radiata sensu lato	Narrow-leaf peppermint	*Oxalis incarnata	Pale wood-sorrel
		*Oxalis latifolia	Large-leaf wood-sorrel
		r Oxalis magellanica	Snowdrop wood-sorrel
		Oxalis perennans	Grassland wood-sorrel

Appendix III (continued)

* <i>Oxalis pes-caprae</i>	Soursob	* <i>Polygala vulgaris</i>	Common milkwort
* <i>Oxalis purpurea</i>	Large-flower wood-sorrel		
<i>Oxalis radicata</i>	Wood-sorrel		
PAPAVERACEAE			
* <i>Glaucium flavum</i>	Horned poppy		
* <i>Papaver dubium</i>	Long-headed poppy		
* <i>Papaver somniferum</i>	Opium poppy		
PASSIFLORACEAE			
* <i>Passiflora caerulea</i>	Brazilian passion-flower		
<i>Passiflora cinnabarina</i>	Red passion-flower		
* <i>Passiflora edulis</i>			
* <i>Passiflora mollissima</i>	Banana passionfruit		
* <i>Passiflora subpeltata</i>	White passionfruit		
PHYTOLACCACEAE			
* <i>Phytolacca octandra</i>	Red-ink weed		
PITTOSPORACEAE			
<i>Billardiera longiflora</i>	Purple apple-berry		
<i>Billardiera scandens</i>	Common apple-berry		
<i>Billardiera scandens</i>	Common apple-berry		
<i>Billardiera scandens</i> var. <i>scandens</i>	Common apple-berry		
<i>Bursaria spinosa</i>	Sweet bursaria		
<i>Bursaria spinosa</i> var. <i>macrophylla</i>	Sweet bursaria		
<i>Bursaria spinosa</i> var. <i>obovata</i>	Sweet bursaria		
<i>Bursaria spinosa</i> var. <i>spinosa</i>	Sweet bursaria		
<i>Cheiranthra cyanea</i>	Blue finger-flower		
<i>Pittosporum bicolor</i>	Banyalla		
<i>Pittosporum undulatum</i>	Sweet pittosporum		
<i>Rhytidisporum procumbens</i>	White marianth		
PLANTAGINACEAE			
<i>Plantago alpestris</i>	Veined plantain		
* <i>Plantago australis</i>	Southern plantain		
* <i>Plantago coronopus</i>	Buck's-horn plantain		
<i>Plantago debilis</i>	Shade plantain		
<i>Plantago euryphylla</i>	Broad plantain		
<i>Plantago gaudichaudii</i>	Narrow plantain		
<i>Plantago hispida</i>	Hairy plantain		
* <i>Plantago lanceolata</i>	Ribwort		
* <i>Plantago major</i>	Greater plantain		
v <i>Plantago muelleri</i>	Star plantain		
<i>Plantago varia</i>	Variable plantain		
PLUMBAGINACEAE			
<i>Limonium australe</i>	Yellow sea-lavender		
POLEMONIACEAE			
* <i>Navarretia squarrosa</i>	Californian stickweed		
POLYGALACEAE			
<i>Comesperma calymega</i>	Blue-spike milkwort		
<i>Comesperma defoliatum</i>	Leafless milkwort		
<i>Comesperma ericinum</i>	heath milkwort		
<i>Comesperma polygaloides</i>	Small milkwort		
<i>Comesperma retusum</i>	Mountain milkwort		
<i>Comesperma volubile</i>	Love creeper		
* <i>Muraltia heisteria</i>	Furze muraltia		
* <i>Polygala myrtifolia</i>	Myrtle-leaf milkwort		
		POLYGONACEAE	
		* <i>Emex australis</i>	Spiny emex
		<i>Muehlenbeckia adpressa</i>	Climbing lignum
		<i>Muehlenbeckia cunninghamii</i>	Tangled lignum
		<i>Persicaria hydropiper</i>	Water-pepper
		<i>Persicaria lapathifolia</i>	Pale knotweed
		* <i>Persicaria maculosa</i>	<i>Persicaria</i>
		<i>Persicaria prostrata</i>	Creeping knotweed
		<i>Persicaria strigosa</i>	Ridged knotweed
		<i>Persicaria subsessilis</i>	Hairy knotweed
		* <i>Polygonum arenastrum</i>	Knotweed
		* <i>Polygonum aviculare</i>	Prostrate knotweed
		<i>Polygonum minus</i>	Slender knotweed
		* <i>Rumex acetosella</i> spp. agg.	Sheep sorrel
		<i>Rumex bidens</i>	Mud dock
		<i>Rumex brownii</i>	Slender dock
		* <i>Rumex conglomeratus</i>	Clustered dock
		* <i>Rumex crispus</i>	Curled dock
		<i>Rumex crystallinus</i>	Glistening dock
		<i>Rumex dumosus</i>	Wiry dock
		* <i>Rumex obtusifolius</i>	Broad-leaf dock
		* <i>Rumex pulcher</i>	Fiddle dock
		* <i>Rumex sagittatus</i>	Arrow dock
		PORTULACACEAE	
		<i>Calandrinia calyptata</i>	Pink purslane
		<i>Calandrinia granulifera</i>	Pigmy purslane
		* <i>Claytonia perfoliata</i>	Claytonia
		<i>Montia australasica</i>	White purslane
		<i>Montia fontana</i>	Water blinks
		<i>Portulaca oleracea</i>	Common purslane
		PRIMULACEAE	
		* <i>Anagallis arvensis</i>	Pimpernel
		* <i>Anagallis minima</i>	Chaffweed
		<i>Samolus repens</i>	Creeping brookweed
		PROTEACEAE	
		<i>Banksia integrifolia</i>	Coast banksia
		<i>Banksia marginata</i>	Silver banksia
		<i>Banksia spinulosa</i>	Hairpin banksia
		<i>Grevillea alpina</i>	Cat's claws grevillea
		<i>Grevillea australis</i>	Alpine grevillea
		r <i>Grevillea barklyana</i>	Gully grevillea
		<i>Grevillea glabella</i>	Smooth grevillea
		<i>Grevillea lanigera</i>	Woolly grevillea
		<i>Grevillea lavandulacea</i>	Lavender grevillea
		<i>Grevillea miqueliana</i>	Oval-leaf grevillea
		r <i>Grevillea repens</i>	Creeping grevillea
		<i>Grevillea rosmarinifolia</i>	Rosemary grevillea
		<i>Grevillea victoriae</i>	Royal grevillea
		<i>Grevillea victoriae</i> var. <i>victoriae</i>	Royal grevillea
		<i>Hakea eriantha</i>	Tree hakea
		<i>Hakea nodosa</i>	Yellow hakea
		<i>Hakea sericea</i>	Bushy hakea
		<i>Hakea teretifolia</i>	Dagger hakea
		<i>Hakea ulicina</i>	Furze hakea
		<i>Isopogon ceratophyllus</i>	Horny cone-bush
		<i>Lomatia fraseri</i>	Tree lomatia
		<i>Lomatia ilicifolia</i>	Holly lomatia

Appendix III (continued)

<i>Lomatia myricoides</i>	River lomatia	<i>Acaena novae-zelandiae</i>	Bidgee-widgee
<i>Orites lancifolia</i>	Alpine orites	<i>Acaena ovina</i>	Australian sheep's burr
<i>Persoonia arborea</i>	Tree geebung	* <i>Aphanes arvensis</i>	Parsley piert
<i>Persoonia chamaepeuce</i>	Dwarf geebung	<i>Aphanes australiana</i>	Australian piert
<i>Persoonia confertiflora</i>	Cluster-flower geebung	* <i>Cotoneaster glaucophyllus</i>	Cotoneaster
<i>Persoonia juniperina</i>	Prickly geebung	* <i>Cotoneaster pannosus</i>	Cotoneaster
		* <i>Crataegus monogyna</i>	Hawthorn
		* <i>Duchesnia indica</i>	Indian strawberry
		* <i>Malus domestica</i> (hybrid)	Domestic apple
		* <i>Prunus cerasifera</i>	Cherry-plum
		* <i>Prunus laurocerasus</i>	Cherry laurel
		* <i>Rosa rubiginosa</i>	Sweet briar
		* <i>Rubus fruticosus</i> spp. agg.	Blackberry
		* <i>Rubus laciniatus</i>	Cut-leaf blackberry
		<i>Rubus parvifolius</i>	Small-leaf bramble
		* <i>Rubus polyanthemus</i>	Blackberry
		* <i>Rubus procerus</i>	Blackberry
		* <i>Rubus rosaceus</i>	Blackberry
		* <i>Rubus ulmifolius</i>	Blackberry
		* <i>Rubus vesitus</i>	Blackberry
		* <i>Sanguisorba minor</i>	Salad burnet
RANUNCULACEAE		RUBIACEAE	
<i>Caltha introloba</i>	Alpine marsh-marigold	<i>Asperula ambelia</i>	Stiff woodruff
<i>Clematis aristata</i>	Mountain clematis	<i>Asperula conferta</i>	Common woodruff
<i>Clematis aristata bar-</i>	Mountain clematis	<i>Asperula euryphylla</i>	Broad-leaf woodruff
<i>dennisae</i>		<i>Asperula gunnii</i>	Mountain woodruff
<i>Clematis glycinoides</i>	Forest clematis	<i>Asperula pusilla</i>	Alpine woodruff
<i>Clematis microphylla</i>	Small-leaved clematis	<i>Asperula scoparia</i>	Prickly woodruff
<i>Ranunculus collinus</i>	Strawberry buttercup	<i>Asperula subsimplex</i>	Water woodruff
* <i>Ranunculus flammula</i>	Lesser spearwort	<i>Coprosma hirtella</i>	Rough coprosma
<i>Ranunculus glabrifolius</i>	Shining buttercup	r <i>Coprosma moorei</i>	Turquoise coprosma
<i>Ranunculus gunnianus</i>	Gunn's alpine buttercup	<i>Coprosma nitida</i>	Shining coprosma
<i>Ranunculus inundatus</i>	River buttercup	r <i>Coprosma nivalis</i>	Snow coprosma
<i>Ranunculus lappaceus</i>	Australian buttercup	r <i>Coprosma perpusilla</i>	Creeping coprosma
* <i>Ranunculus muricatus</i>	Sharp buttercup	<i>Coprosma quadrifida</i>	Prickly coprosma
* <i>Ranunculus ophioglossifolius</i>	Snake-tongue buttercup	* <i>Coprosma repens</i>	Taupata
<i>Ranunculus pachycarpus</i>	Thick-fruit buttercup	* <i>Coprosma robusta</i>	Karamu
<i>Ranunculus papulentus</i>	Large-river buttercup	* <i>Galium aparine</i>	Cleavers
<i>Ranunculus pimpinellifolius</i>	Bog buttercup	<i>Galium australe</i>	Tangled bedstraw
<i>Ranunculus plebeius</i>	Forest buttercup	<i>Galium binifolium</i>	Reflexed bedstraw
<i>Ranunculus pumilio</i>	Fan-leaf buttercup	<i>Galium ciliare</i>	Hairy bedstraw
* <i>Ranunculus repens</i>	Creeping buttercup	* <i>Galium divaricatum</i>	Slender bedstraw
<i>Ranunculus rivularis</i>	Small river buttercup	<i>Galium gaudichaudii</i>	Rough bedstraw
* <i>Ranunculus sardous</i>	Pale hairy buttercup	<i>Galium migrans</i>	Bedstraw
<i>Ranunculus scapiger</i>	Subalpine buttercup	* <i>Galium murale</i>	Small bedstraw
* <i>Ranunculus sceleratus</i>	Celery buttercup	<i>Galium propinquum</i>	Maori bedstraw
<i>Ranunculus sessiliflorus</i>	Annual buttercup	<i>Nertera granadensis</i>	Matted nertera
* <i>Ranunculus trilobus</i>	Three-lobed buttercup	<i>Nertera reptans</i>	Dwarf nertera
		<i>Opercularia hispida</i>	Hairy stinkweed
		<i>Opercularia ovata</i>	broad-leaf stinkweed
		<i>Opercularia scabrida</i>	Stalked stinkweed
		<i>Opercularia varia</i>	Variable stinkweed
		<i>Pomax umbellata</i>	Pomax
		* <i>Sherardia arvensis</i>	Field madder
RESEDACEAE		RUTACEAE	
* <i>Reseda alba</i>	White mignonette	<i>Asterolasia asteriscophora</i>	Lemon star-bush
* <i>Reseda luteola</i>	Weld	<i>Asterolasia trymalioides</i>	Alpine star-bush
		<i>Boronia anemonifolia</i>	Sticky boronia
		<i>Boronia muelleri</i>	Forest boronia
		<i>Boronia nana</i>	Dwarf boronia
		<i>Boronia nana</i> var. <i>hyssopifolia</i>	Dwarf boronia
RHAMNACEAE			
<i>Cryptandra amara</i>	Bitter cryptandra		
<i>Pomaderris apetala</i>	Rough pomaderris		
<i>Pomaderris aspera</i>	Hazel pomaderris		
r <i>Pomaderris aurea</i>	Golden pomaderris		
<i>Pomaderris elachophylla</i>	Small-leaf pomaderris		
<i>Pomaderris elliptica</i>	Smooth pomaderris		
<i>Pomaderris ferruginea</i>	Rusty pomaderris		
<i>Pomaderris intermedia</i>	Citron pomaderris		
<i>Pomaderris lanigera</i>	Woolly pomaderris		
<i>Pomaderris paniculosa</i>	Scurfy pomaderris		
<i>Pomaderris paniculosa</i>	Shining coast pomaderris		
ssp. <i>paralia</i>			
<i>Pomaderris prunifolia</i>	Prunus pomaderris		
<i>Pomaderris racemosa</i>	Cluster pomaderris		
<i>Pomaderris vacciniifolia</i>	Round-leaf pomaderris		
<i>Pomaderris velutina</i>	Velvet pomaderris		
* <i>Rhamnus alaternus</i>	Italian buckthorn		
<i>Spyridium parvifolium</i>	Dusty miller		
ROSACEAE			
<i>Acaena agnipila</i>	Hairy sheep's burr		
<i>Acaena anserinifolia</i>	Bidgee-widgee		
<i>Acaena echinata</i>	Sheep's burr		

Appendix III (continued)

Boronia parviflora	Swamp boronia	*Verbascum thapsus	Great mullein
Correa alba	White correa	*Verbascum virgatum	Twiggy mullein
Correa glabra	Rock correa	*Veronica arvensis	Wall speedwell
Correa lawrenciana	Mountain correa	Veronica calycina	Hairy speedwell
Correa reflexa	Common correa	Veronica gracilis	Slender speedwell
Crocea exalata	Small Crocea	*Veronica hederifolia	Ivy-leaf speedwell
Eriostemon myoporoides	Long-leaf wax-flower	Veronica notabilis	Forest speedwell
Phebalium bilobum	Notched phebalium	*Veronica peregrina	Wandering speedwell
Phebalium lamprophyllum	Shiny phebalium	*Veronica persica	Persian speedwell
Phebalium phyllifolium	Alpine phebalium	Veronica plebeia	Trailing speedwell
Phebalium squamulosum	Forest phebalium	Veronica serpyllifolia	Thyme speedwell
v Phebalium wilsonii	Shiny phebalium	Veronica sp. aff. gracilis	Thread speedwell
Zieria arborescens	Stinkwood		
SALICACEAE		SIMAROUBACEAE	
*Populus alba	White poplar	*Ailanthus altissima	Tree-of-heaven
*Populus nigra	Lombardy poplar		
*Salix alba	White willow	SOLANACEAE	
*Salix babylonica	Weeping willow	*Cestrum parqui	Green poison-berry
*Salix cinerea	Grey willow	*Datura stramonium	Common thorn-apple
*Salix fragilis	Basket willow	*Lycium barbarum	Chinese box-thorn
		*Lycium ferocissimum	African box-thorn
SANTALACEAE		*Nicandra physalodes	Apple of peru
Choretrum pauciflorum	Dwarf sour-bush	Nicotiana suaveolens	Austral tobacco
Exocarpos cupressiformis	Cherry ballart	*Physalis peruviana	Cape gooseberry
Exocarpos nanus	Alpine ballart	*Physalis viscosa	Sticky ground-cherry
Exocarpos strictus	Pale-fruig ballart	*Salpichroa origanifolia	Pampas lily-of-the-valley
r Exocarpos syrticola	Coast ballart	Solanum americanum	Glossy nightshade
		Solanum aviculare	Kangaroo apple
SAPINDACEAE		*Solanum cinereum	Narrawa burr
Dodonaea viscosa	Sticky hop-bush	*Solanum douglasii	Douglas' nightshade
Dodonaea viscosa ssp. cuneata	Wedge-leaf hop-bush	*Solanum furcatum	Broad nightshade
		Solanum laciniatum	Large kangaroo apple
SCROPHULARIACEAE		*Solanum linnaeanum	Apple of sodom
*Digitalis purpurea	Foxglove	*Solanum marginatum	White-edged nightshade
Euphrasia collina	Purple eyebright	*Solanum nigrum	Black nightshade
Euphrasia collina	Purple eyebright	Solanum opacum	Dark nightshade
ssp. collina		*Solanum physalifolium	Cherry nightshade
e Euphrasia collina	Purple eyebright	*Solanum physalifolium	Cherry nightshade
ssp. muelleri		var. nitibaccatum	
Euphrasia collina	Purple eyebright	Solanum prinophyllum	Forest nightshade
ssp. paludosa		*Solanum pseudocapsicum	Madeira winter-cherry
r Euphrasia collina ssp.	Purple eyebright	*Solanum rostratum	Buffalo burr
trichocalycina		Solanum vescum	Gunyang
Euphrasia gibbsiae	Broad eyebright		
Glossostigma elatinoides	Small mud-mat	STACKHOUSIACEAE	
Gratiola peruviana	Brooklime	Stackhousia monogyna	Creamy candles
Gratiola pubescens	Hairy brooklime	Stackhousia pulvinaris	Alpine candles
*Kickxia elatine	Sharp-leaved fluellen	Stackhousia spathulata	Coast candles
*Kickxia spuria	Blunt-leaved fluellen	Stackhousia viminea	Slender candles
Limosella australis	Austral mudwort		
*Linaria arvensis	Corn toad-flax	STERCULIACEAE	
*Linaria pelisseriana	Pelisser's toad-flax	Lasiopetalum baueri	Slender velvet-bush
Mazus pumilio	Swamp mazus	Lasiopetalum macrophyllum	Shrubby velvet-bush
*Mimulus moschatus	Musk monkey-flower		
Mimulus repens	Creeping monkey-flower	STYLIDIACEAE	
Parahebe derwentiana	Derwent speedwell	Levenhookia dubia	Hairy stylewort
Parahebe perfoliata	Digger's speedwell	Levenhookia sonderi	Slender stylewort
Parahebe sp. C	Snow speedwell	Stylidium beaugleholei	Beauglehole's trigger-plant
*Parentucellia latifolia	Common bartsia	Stylidium graminifolium	Grass trigger-plant
*Parentucellia viscosa	Sticky bartsia	Stylidium inundatum	Hundreds and thousands
*Verbascum blattaria	Moth mullein	Stylidium perpusillum	Slender trigger-plant

Appendix III (continued)

THYMELAEACEAE		* <i>Soleirolia soleirolii</i>	Baaby's tears
<i>Pimelea alpina</i>	Alpine rice-flower	<i>Urtica incisa</i>	Scrub nettle
<i>Pimelea axiflora</i>	Bootlace bush	* <i>Urtica urens</i>	Small nettle
<i>Pimelea axiflora</i> ssp. <i>axiflora</i>	Bootlace bush		
<i>Pimelea curviflora</i>	Curved rice-flower	VALERIANACEAE	
<i>Pimelea curviflora</i>	Curved rice-flower	* <i>Centranthus ruber</i>	Red valerian
ssp. <i>micrantha</i>		* <i>Valerianella eriocarpa</i>	Italian corn-salad
<i>Pimelea flava</i>	Yellow rice-flower		
<i>Pimelea glauca</i>	Smooth rice-flower	VERBENACEAE	
<i>Pimelea humilis</i>	Common rice-flower	<i>Avicennia marina</i>	White mangrove
<i>Pimelea ligustrina</i>	Tall rice-flower	* <i>Verbena bonariensis</i>	Purple-top verbena
<i>Pimelea ligustrina</i>	Tall rice-flower	<i>Verbena officinalis</i>	Common verbena
ssp. <i>ligustrina</i>		* <i>Verbena rigida</i>	Veined verbena
<i>Pimelea linifolia</i>	Slender rice-flower		
<i>Pimelea linifolia</i> ssp. <i>linifolia</i>	Slender rice-flower	VIOLACEAE	
<i>Pimelea octophylla</i>	Woolly rice-flower	<i>Hymenanthera dentata</i>	Tree violet
<i>Pimelea pauciflora</i>	Poison rice-flower	<i>Viola betonicifolia</i>	Showy violet
<i>Pimelea phyllicoides</i>	Heath rice-flower	<i>Viola cleistogamoides</i>	Hidden violet
<i>Pimelea serpyllifolia</i>	Thyme rice-flower	<i>Viola hederacea</i>	Ivy-leaf violet
		<i>Viola hederacea</i>	Ivy-leaf violet
		ssp. <i>fuscoviolacea</i>	
TREMANDRACEAE		<i>Viola hederacea</i>	Ivy-leaf violet
<i>Tetradlea bauerifolia</i>	Heath pink-bells	ssp. <i>hederacea</i>	
<i>Tetradlea ciliata</i>	Pink-bells	<i>Viola hederacea</i>	Ivy-leaf violet
<i>Tetradlea labillardieri</i>	Glandular pink-bells	ssp. <i>seppeltiana</i>	
<i>Tetradlea pilosa</i>	Hairy pink-bells	* <i>Viola hederacea</i>	Tiny violet
<i>Tetradlea pilosa</i>	Hairy pink-bells	ssp. <i>sieberiana</i>	
ssp. <i>latifolia</i>		* <i>Viola odorata</i>	Fragrant violet
r <i>Tetradlea stenocarpa</i>	Long pink-bells		
		WINTERACEAE	
TROPAEOLACEAE		<i>Tasmania lanceolata</i>	Mountain pepper
* <i>Tropaeolum majus</i>	Nasturtium	<i>Tasmania xerophila</i>	Alpine pepper
URTICACEAE		ZYGOPHYLLACEAE	
<i>Australina pusilla</i>	Shade nettle	<i>Zygophyllum billardieri</i>	Coast twin-leaf
<i>Parietaria debilis</i>	Shade pellitory		
* <i>Parietaria judaica</i>	Open pellitory		

KEY: * - introduced species

e - endangered

r - rare

v - vulnerable

d - depleted

x - extinct

For clarification, see Gullan, P.K., Cheal D.C., and Walsh, N.G. (1990). 'Rare and Threatened Plants in Victoria'. (Department of Conservation and Environment: Melbourne.)

References

Carr, G.W. (1991). New Taxa in *Caladenia* R.Br. *Chiloglottis* R.Br., and *Gastrodia* R.Br. (Orchidaceae) from south-eastern Australia. *Indigenous Flora and Fauna association Miscellaneous Paper* No. 1. Clifton Hill, Victoria.

Ross, J.H. (1990). A Census of the Vascular Plants of Victoria. (Department of Conservation, Forests and Lands: Melbourne.)

Appendix IV

RARE AND THREATENED PLANT SPECIES

Species	Common name	Family	ROTAP ¹	VROTS ² status	Reservation	Notes
1. Species recorded since 1950, or known still to occur in the Study Area						
<i>Adiantum capillus-veneris</i>	Dainty maidenhair	Adiantaceae		c	reserved	Known only from the Mornington Peninsula, where it occurs in a sheltered position on limestone, within the Point Nepean National Park. This species has also been recorded near Bendigo, but its status as a Victorian native is uncertain.
<i>Adiantum diaphanum</i>	Filmy maidenhair	Adiantaceae		c	unreserved	A small, delicate fern of moist clay banks and rock faces, known only from four sites, three within the study area and on public land, but none within a flora conservation reserve.
<i>Adriana quadripartita</i>	Rare bitter-bush	Euphorbiaceae		c	reserved	A shrub to 3 m tall found in a small number of coastal localities from Barwon Heads to Cape Schanck.
<i>Agrostis aemula</i> var. <i>setifolia</i>	Blown grass	Poaceae		r	unreserved	A grass of damp sites on heavy soils, normally associated with plains grasslands or grassy wetlands. Known in the Study Area from a number of remnant grasslands in the Craigieburn - Epping area, but not known to occur on public land.
<i>Amphibromus pithogastrus</i>	Swollen swamp wallaby-grass	Poaceae	K	c	unreserved	A slender, tufted perennial grass recorded from grasslands in the Craigieburn area; it has not been recorded on public land.
<i>Asplenium obtusatum</i>	Shore spleenwort	Aspleniaceae		v	poorly reserved	A coastal fern with coarse, clustered, fleshy fronds, growing in rocky crevices. In the study area, it occurs on Phillip Island.
<i>Asplenium trichomanes</i>	Common spleenwort	Aspleniaceae		r	poorly reserved	A small erect fern found on a variety of rocks growing in crevices or sheltered rock ledges. It occurs at Snobs Creek Falls and near Kevington.
<i>Astelia australiana</i>	Tall astelia	Liliaceae	V	v	unreserved	A large, tufted, strongly rhizomatous lily which occurs in a small number of stands, usually in Cool Temperate Rainforest, in the Powelltown area, none within flora conservation reserves.
<i>Beyeria viscosa</i>	Pinkwood	Euphorbiaceae		r	reserved	An erect shrub to 3 m which occurs rarely in eastern Victoria and NSW, but a population is believed to survive in the Doongalla Forest section of the Dandenong Ranges National Park.
<i>Botrychium australe</i>	Austral moonwort	Ophioglossaceae		v	reserved	A fleshy, perennial herb growing from short, erect rhizomes. Scattered throughout eastern Victoria in a variety of habitats, it has been recorded from Eildon State Park.
<i>Brachyscome obovata</i>	Baw Baw daisy	Asteraceae		r	reserved	A small, perennial herb occurring around the fringes of sphagnum bogs in the Victorian Alps, including Lake Mountain Alpine Reserve and Baw Baw National Park.
<i>Burnettia cuneata</i>	Burnettia	Orchidaceae	R	r	reserved	A small, glabrous orchid with reduced, scale-like leaves, occurring on wet, peaty ground in heathlands across southern Victoria; has been recorded for Moondarra State Park and French Island State Park.

Appendix IV (continued)

Species	Common name	Family	ROTAP ¹	VROTS ²	Reservation status ³	Notes
<i>Caladenia flavovirens</i>	Summer spider-orchid	Orchidaceae		r	reserved	A widespread orchid normally of grassy forests; it has been recorded from the Dandenong Ranges National Park. A closely related species, <i>Caladenia beauleholei</i> , occurs in coastal areas.
<i>Caladenia fragrantissima</i> <i>ssp. orientalis</i>	Cream spider-orchid	Orchidaceae		?v	poorly reserved	A strongly scented orchid of coastal heathlands and heathy woodlands on deep siliceous sands. Apparently now extinct in the Port Phillip area, it is restricted to Cape Paterson and possibly Wonthaggi.
<i>Caladenia insularis</i>	Spider-orchid	Orchidaceae		?v	reserved	A short-stemmed, colourful orchid of wet coastal heathlands, and confined to French Island State Park.
<i>Caladenia oenochila</i>	Foothills spider-orchid	Orchidaceae		r	reserved	Similar to <i>Caladenia patersonii</i> , this orchid has yellow-green petals and sepals, and occurs in forests of the southern foothills of the Great Dividing Range. It has been recorded from a conservation reserve in Belgrave South, Warrandyte State Park and the Dandenong Ranges National Park.
<i>Caladenia rosella</i>	Rosella spider-orchid	Orchidaceae		e	unreserved	A spider orchid with a flowering stem to 17 cm tall, bearing a pale to bright pink, sweetly musk-scented flower. Exceedingly rare and apparently much depleted, being restricted to a small number of populations on private land in the Husrbridge area, and near Stawell in western Victoria.
<i>Callitriche umbonata</i>	Water starwort	Callitrichaceae		r	unknown	A small aquatic plant of swamps from Port Phillip to south-western Victoria, also recorded from the Goulburn River and Baw Baw National Park.
<i>Carex alsophila</i>	Forest sedge	Cyperaceae		r	poorly reserved	A sedge to 0.5 m tall, occurring on wet flats and stream banks, usually above 700 m in the Central Highlands. Most occurrences are along drainage lines in State Forest.
<i>Carex tasmanica</i>	Curly sedge	Cyperaceae	E	v	unreserved	A short, wiry, clumped, perennial sedge with short, dense flower spikes. This species occurs on waterlogged, often slightly saline sites in grasslands or grassy woodlands from Melbourne to the Hamilton area. Not reserved within the Study Area, where it is known only from remnant grasslands on private land in the Craigieburn - Whittlesea area.
<i>Coprosma moorei</i>	Turquoise coprosma	Rubiaceae		r	reserved	A small, prostrate herb of sphagnum bogs, occurring on Lake Mountain and in the Baw Baw National Park.
<i>Coprosma nivalis</i>	Snow coprosma	Rubiaceae		r	reserved	A small, matted or prostrate shrub, scattered in rocky places in alpine and sub-alpine areas in eastern Victoria. Reserved in the Baw Baw National Park.
<i>Coprosma perpusilla</i>	Creeping coprosma	Rubiaceae		r	reserved	A prostrate alpine or sub-alpine herb, widespread in the Baw Baw National Park. Also found on higher peaks to the east.
<i>Corybas despectans</i>	Helmet-orchid	Orchidaceae		r	reserved	A tiny terrestrial orchid with red-purple flowers. It grows in small colonies on sandy soil in coastal scrub. It has been recorded near Cape Schanck, in the Point Nepean National Park.
<i>Cyathea cunninghamii</i>	Slender tree-fern	Cyathaceae	R	r	poorly reserved	A tree-fern with a slender trunk to 20 m in height. The crown of lacy fronds is small and rather dark. It is confined to deep gullies in wet forests from the Otways to East Gippsland. In the Study Area, it is known from Sassafras Creek and Mt Worth State Park.
<i>Cyathea X marescens</i>	Skirted tree-fern	Cyathaceae		r	poorly reserved	A small tree-fern to 8 m tall, with a thick trunk and large crown. It is thought to be a hybrid between <i>C. australis</i> and <i>C. cunninghamii</i> , but its characters are remarkably stable. Its distribution mirrors that of <i>C. cunninghamii</i> .

<i>Cyathodes juniperina</i>	Crimson berry	Epacridaceae	v		unreserved	A shrub to 2 m with sharp-pointed leaves and red fleshy fruits. In Victoria, it occurs on seacliffs at Wilsons Promontory and along the south coast of Phillip Island.
<i>Desmodium varians</i>	Slender tick-trefoil	Fabaceae	r		unknown	A slender trailing shrub with wiry stems bearing trifoliate leaves and pea flowers in racemes. It is scattered through forests in the hilly parts of eastern Victoria. The distribution of this species is uncertain owing to the previous amalgamation of records with those of <i>Desmodium gunnii</i> (formerly known as <i>D. varians</i> var <i>gunnii</i>).
<i>Diuris punctata</i>	Purple diuris	Orchidaceae	v		unreserved	An orchid with purple, lilac or white flowers, occurring in open forest and moist grasslands across the State except in the north-west. Apparently restricted in the Study Area to a railway reserve in the Langwarrin area. Other unreserved occurrences in the Beaconsfield area are believed to have been recently eliminated.
<i>Erigeron pappocromus</i> var. <i>oblongatus</i>	Fleabane	Asteraceae	v		reserved	A small, rosetted herb with pale mauve to violet flower-heads to 15 cm tall. Found in grasslands and herbfields at 3 sites on the Baw Baw Plateau.
<i>Eucalyptus alligatrix</i>	Mealy stringybark	Myrtaceae	n/a	n/a	unreserved	A recently described species which is closely related to <i>Eucalyptus cinerea</i> and <i>Eucalyptus cephalocarpa</i> . The type locality for this species is near the junction of Big and Taponga Rivers, west of Jamieson. This is the only known locality for this species in the Study Area. Although not officially listed as such, it is considered vulnerable.
<i>Eucalyptus crenulata</i>	Buxton gum	Myrtaceae	V	e	reserved	A small, much-branched tree of swampy sites near rivers. It bears small, blue-grey leaves, and occurs naturally only at Buxton and near Yarra Glen. It has been planted extensively in gardens and along roadsides. It is reserved in the Silver Gum Reserve at Buxton.
<i>Eucalyptus kitsoniana</i>	Bog gum	Myrtaceae	V	r	reserved	A stunted, mallee-form tree of low-lying areas from Wonthaggi to Wilsons Promontory, and the Cape Otway area. Occurs within the Study Area in the Outtrim Flora Reserve.
<i>Eucalyptus neglecta</i>	Omeo gum	Myrtaceae	R	r	unreserved	A small, rather inconspicuous tree of sheltered sites, often near streams, and bearing distinctive round, bluish foliage. The only record of this species within the Study Area is in the Frenchmans Creek - Big River area.
<i>Eucalyptus yarraensis</i>	Yarra gum	Myrtaceae	R	r	poorly reserved	A tree from 12 to 20 m tall with a short, rough-barked trunk and a large, spreading crown. Restricted to alluvial flats between the Grampians and the La Trobe Valley, with records in the Study Area from the Yan Yean Water Catchment, the Yarra Valley and Dandenong Creek area.
<i>Euphrasia collina</i> ssp. <i>muelleri</i>	Purple eyebright	Scrophulariaceae		e	poorly reserved	A small, perennial herb to 0.4 m, once widespread across the State, now restricted within the Study Area to Point Nepean National Park, Arthurs Seat State Park and near Woods Point.
<i>E. collina</i> ssp. <i>trichocalycina</i>	Purple eyebright	Scrophulariaceae		r	unknown	Similar to <i>E. collina</i> ssp. <i>muelleri</i> ; found on sandy soils in heathlands and forests, and recorded from Tarrawarra near Healesville.
<i>Exocarpos syrticola</i>	Coast ballart	Santalaceae		r	poorly reserved	A stiff, erect shrub to 2 m tall, restricted to southern coastal dunes and cliffs from Wilsons Promontory to Port Lincoln in South Australia. It has been recorded from Phillip Island.
<i>Gahnia grandis</i>	Brickmakers' saw-sedge	Cyperaceae	v		poorly reserved	A sedge forming a large tussock to 3 m tall, occupying wet sites and recorded from the upper Yarra Valley and the Bunyip State Park.

Appendix IV (continued)

Species	Common name	Family	ROTAP ¹	VROTS ²	Reservation status ³	Notes
<i>Genoplesium pumilum</i>	Green midge-orchid	Orchidaceae		r	reserved	Formerly known as <i>Prasophyllum viride</i> and/or <i>Prasophyllum pumilum</i> , this small orchid has a leaf to 20 cm long, with a flowering stem to 25 cm, bearing 8-15 flowers in a loose spike. Formerly known in Victoria only from a site near Mallacoota, it has more recently been discovered in French Island State Park.
<i>Glycine latrobeana</i>	Clover glycine	Fabaceae	R	v	reserved	A slender, prostrate or ascending perennial twiner, with a scattered distribution throughout southern areas of the State; occurs in the Arthurs Seat State Park, Yan Yean Water Catchment and the Dandenong Ranges National Park.
<i>Gnaphalium umbricola</i>	Cliff cudweed	Asteraceae		r	poorly reserved	A small, stoloniferous, perennial herb of shaded rock faces in the hills and sub-alps. In the Study Area, it is recorded from Kinglake National Park and the Gaffneys Creek area.
<i>Grevillea barklyana</i>	Gully grevillea	Proteaceae	R	r	poorly reserved	A large-leaved, shrub to 10 m tall, confined to the eastern tributaries of the Bunyip River, where it occupies moist, shaded slopes. Some stands occur within Bunyip State Park.
<i>Grevillea repens</i>	Creeping grevillea	Proteaceae	R	r	reserved	A trailing, wiry shrub of dry forests in central Victoria; occurs in Kinglake National Park.
<i>Halophila decipiens</i>	Devious sea-wrack	Hydrocharitaceae		r	unknown	A rhizomatous, sub-marine perennial herb, found submerged in shallow seawater. It is known from several sites along the Victorian coast, including Sorrento.
<i>Helichrysum rogersianum</i>	Nunniong everlasting	Asteraceae		r	unreserved	An erect shrub to 2.5 m tall, found by streams and in swampy heaths. Scattered from the Otways to East Gippsland, it occurs in the Study Area in the Upper Yarra area.
<i>Hypsela tridens</i>	Hypsela	Campanulaceae		v	poorly reserved	A weak riparian herb of lagoons, including several on the Goulburn and Mitta Mitta rivers, also recorded from Yan Yean Water Catchment.
<i>Isolepis wakefieldiana</i>	Tufted club-sedge	Cyperaceae		r	poorly reserved	A small, tufted sedge of moist sites, known from the Upper Yarra area, but also occurring beyond the Study Area to the east and west.
<i>Lastreopsis hispida</i>	Bristly shield-fern	Dryopteridaceae		r	poorly reserved	A tufted ground-fern to 0.5 m tall, found in rainforest and fern-gullies in the Upper Yarra and Bunyip River areas, and in the Otways. Recorded from Bunyip State Park.
<i>Lindsaea microphylla</i>	Lacy wedge-fern	Lindsaeaceae		r	unknown	A delicate ground-fern found in heathlands and open forests; recorded from the Launching Place and Labertouche areas, but its reservation status is unknown.
<i>Lycopodium australianum</i>	Fir clubmoss	Lycopodiaceae		r	reserved	Low-growing perennial clubmoss with densely leafy stems. In Victoria, it is usually restricted to cool mountain or sub-alpine grassy areas or bogs. It is reserved in Baw Baw National Park.
<i>Lycopodium scariosum</i>	Spreading clubmoss	Lycopodiaceae		r	reserved	A creeping, branched clubmoss; the leaves on the prostrate stems are scale-like and appressed, while those on the erect stems are in two rows, flattened into one plane. Found in alpine bogs and swampy heathlands in the Baw Baws and Bogong High Plains. It is reserved in the Baw Baw National Park.
<i>Lycopodium serpentinum</i>	Bog clubmoss	Lycopodiaceae	K	r	reserved	A prostrate, creeping, densely-leafy and much branched clubmoss found in bogs or on wet peaty soils. In the Study Area, it has been recorded from areas around Western Port, and is reserved in the French Island State Park.

<i>Lycopodium varium</i>	Long clubmoss	Lycopodiaceae	v	unreserved	A clubmoss with leafy stems to 30 cm long, growing in clumps on rocks or tree-fern trunks in sub-alpine or montane scrubs and rainforest. In the Study Area, known only from a recent record in rainforest on the Middle Tyers River, south of Mt Baw Baw, where it is unreserved.	
<i>Microtis orbicularis</i>	Swamp onion-orchid	Orchidaceae	r	unreserved	A slender, inconspicuous orchid with a tall flower stem, bearing many short-stalked, small, green flowers. Plants grow in loose colonies in swamps, with their bases immersed in water. Recorded from the south-west of Victoria and the Wonthaggi area, but apparently unreserved.	
<i>Mitrasacme montana</i>	Mountain mitrewort	Loganiaceae	r	reserved	A prostrate, matted herb of damp sites in the alps and sub-alps, recorded from the Baw Baws and Bogong High Plains.	
<i>Monotoca</i> sp. aff. <i>elliptica</i> (Alps)	Mountain broom-heath	Epacridaceae	r	reserved	A shrub to 5 m tall, occurring in sub-alpine woodlands, and recorded from the Baw Baws and Mt Useful in the Study Area, and some mountain tops further east. (<i>Monotoca elliptica</i> is a shrub of coastal dunes).	
<i>Olearia</i> sp. aff. <i>lanuginosa</i> ³	Daisy-bush	Asteraceae	r	reserved	A small shrub of coastal heathlands, known from Port Campbell National Park, Phillip Island Coastal Wildlife Reserve, Point Nepean National Park, and Tasmania.	
<i>Oxalis magellanica</i>	Snowdrop wood-sorrel	Oxalidaceae	r	poorly reserved	A small, rhizomatous herb with white flowers, frequently found beside streams in shaded rainforest or fern gullies, often forming mats on boulders. Recorded from Baw Baw National Park.	
<i>Persoonia arborea</i>	Tree geebung	Proteaceae	r	poorly reserved	A tall shrub to small tree, restricted to the wet forests of the Study Area, where it may be locally common. Its reproductive biology is poorly understood, and it is poorly reserved.	
<i>Phebalium wilsonii</i>	Shiny phebalium	Rutaceae	R	v	unreserved	A shrub or small tree to 10 m tall which is known to occur only in the MMBW O'Shannassy Water Catchment. A specimen collected in 1892 near Woods Point is referable to this species, but no recent record has been obtained from this area.
<i>Plantago muelleri</i>	Star plantain	Plantaginaceae	v	reserved	A small, perennial, rosette-forming herb, previously known only from the Bogong High Plains and Mt Wellington, but recorded in 1980 from Mustering Flat in the Baw Baw National Park.	
<i>Pomaderris aurea</i>	Golden pomaderris	Rhamnaceae	r	unreserved	A spreading shrub to 2 m tall bearing panicles of golden flowers, occurring on dry slopes in the foothills of the eastern highlands. Recorded from the Jamieson area, where apparently unreserved.	
<i>Prasophyllum frenchii</i>	Slaty leek-orchid	Orchidaceae	r	unreserved	A large orchid with flowering stems to 60 cm tall, bearing 30 to 60 green and red flowers. Scattered through the cooler parts of Victoria, normally in grassy areas, and known from a railway reserve in the Tooradin area.	
<i>Prasophyllum lindleyanum</i>	Green leek-orchid	Orchidaceae	v	reserved	A large orchid occurring in open forest, coastal scrubs and heathlands in southern Victoria, with flowering stems to 35 cm tall, bearing 12-50 yellow-green, fragrant flowers. Recorded from a reserve in Belgrave South, Dandenong Ranges National Park, and a number of small patches of native vegetation in the Stony Point area.	
<i>Prasophyllum parviflorum</i>	Slender leek-orchid	Orchidaceae	v	reserved	A large orchid with flowering stems to 40 cm tall, bearing 6-18 pale green and white flowers with reddish veins. Occurs in heathlands on sandy soils, and is known from French Island State Park, Wilsons Promontory National Park and coastal heathlands in East Gippsland.	

Appendix IV (continued)

Species	Common name	Family	ROTAP ¹	VROTS ²	Reservation status ³	Notes
<i>Prostanthera rhombea</i>	Sparkling mint-bush	Lamiaceae		v	unreserved	An aromatic shrub with small leaves, recorded from an exposed, rocky ridge near the Howqua River, at 1000 m elevation. This is the only record from the Study Area, although this species is also known from the upper Macalister River area.
<i>Psoralea tenax</i>	Tough scurf-pea	Fabaceae		e	unreserved	A small plant of grasslands, mostly in central and north-western parts of Victoria, with an isolated occurrence on private land in the Whittlesea area.
<i>Pteris comans</i>	Netted brake	Adiantaceae		r	reserved	A ground-fern with large, dark-green fronds, occurring in wet, shaded gullies. In the Study Area, it has been recorded from Kinglake National Park, Point Nepean National Park and Dandenong Ranges National Park.
<i>Pterostylis cucullata</i>	Leafy greenhood	Orchidaceae	V	v	poorly reserved	An orchid to 15 cm tall, bearing a distinctive, solitary, reddish-brown flower. This species occurs in coastal areas on sandy soils, often growing under shrubs. Recorded from Point Nepean National Park.
<i>Pterostylis grandiflora</i>	Cobra greenhood	Orchidaceae		r	reserved	A greenhood orchid to 40 cm tall, occurring in south-eastern Victoria in forests and in protected sites in coastal scrubs. Known from a number of small reserves around Western Port.
<i>Pterostylis pedoglossa</i>	Prawn greenhood	Orchidaceae		v	reserved	An orchid to 15 cm tall, restricted in Victoria to a few isolated areas of coastal heathland, where it grows under shrubs on sandy or peaty soils. There are several old records from the eastern shore of Port Phillip Bay. Reserved in the Langwarrin Flora and Fauna Reserve.
<i>Pultenaea weindorferi</i>	Swamp bush-pea	Fabaceae	R	r	reserved	A slender, erect shrub to 2 m tall. Endemic in Victoria, where it is restricted to poorly drained sites in heathlands and heathy woodlands between Daylesford and Nar Nar Goon. Known from Kinglake National Park and the Bunyip State Park.
<i>Richea gunnii</i>	Gunn's richea	Epacridaceae		r	reserved	A rigid, spiny-leaved shrub to 2 m tall, occurring in sub-alpine sphagnum bogs in the Baw Baw National Park and Mt Bullfight.
<i>Sarcocornia quinqueflora</i> ssp. <i>tasmanica</i>	Beaded glasswort	Chenopodiaceae		e	unreserved	A decumbent, herbaceous plant of saltmarshes, in Victoria known only from two occurrences along the foreshore of Port Phillip Bay at Mornington and Mount Martha.
<i>Schoenus carsei</i>	Wiry bog-sedge	Cyperaceae		r	reserved	A densely tufted, rhizomatous sedge, 30-75 cm tall, locally plentiful in damp heathlands from south-western Victoria to Wilsons Promontory, including a record from the Bunyip State Park.
<i>Senecio macrocarpus</i>	Large-fruit groundsel	Asteraceae	V	e	unreserved	A herb to 60+ cm tall, with linear leaves and bearing up to 30 large flowering heads. Formally known from western Victoria and south-eastern South Australia, it has recently been recorded in Yan Yean Water Catchment.
<i>Spirodela polyrrhiza</i>	Large duckweed	Lemnaceae		r	unreserved	A floating aquatic plant with a thick thallus to 1 cm wide, often purplish beneath, bearing many roots. This species has been recorded from lagoons on the upper Murray River, the Thomson River near Heyfield and the Yarra River at Yarra Glen. The latter site is unreserved.
<i>Stipa gibbosa</i>	Short-crown spear-grass	Poaceae		r	unreserved	A spear-grass of basalt plains grasslands and grassy woodlands. Occurs in grassland remnants in the Craigieburn area on private land.

<i>Tetradlea stenocarpa</i>	Long pink-bells	Tremandraceae	R	r	poorly reserved	A perennial shrub to 1 m tall, bearing showy pink flowers along the near-leafless stems. It occurs in hilly country between Emerald and the Baw Baws, in the Pyrete Ranges north-west of Melbourne and on French Island. Reserved in Bunyip State Park and French Island State Park.
<i>Thelymitra benthamiana</i>	Blotched sun-orchid	Orchidaceae		r	reserved	An orchid to 45 cm tall with 2-10 pale yellow-green flowers with reddish-brown spots. Found in open-forests on sandy and clay soils, mainly in the west of the State, but with isolated occurrences on French Island and Wilsons Promontory.
<i>Thelymitra circumsepta</i>	Bog sun-orchid	Orchidaceae		v	poorly reserved	An orchid of high-rainfall mountain areas in eastern Victoria and in the Otways, which grows to 60 cm tall, and bears 3-10 greenish-white, pale blue or lilac flowers. Recorded from the Upper Yarra Water Catchment and Tarago State Forest (Beaglehole, 1983).
<i>Thelymitra media</i> var. <i>carolutea</i>	Tall sun-orchid	Orchidaceae		r	unknown	A sun-orchid to 90 cm tall with 5-25 flesh-pink flowers, and known only from Tynong North in West Gippsland. Current reservation status unknown.
<i>Thelymitra mucida</i>	Hoary sun-orchid	Orchidaceae		v	reserved	An orchid of moist depressions in coastal heathlands, discovered in Victoria in 1969; recorded from French Island State Park. It bears 2-5 dark blue or pinkish-blue flowers on a stem to 50 cm tall.
<i>Thismia rodwayi</i>	Fairy lanterns	Burmanniaceae	K	v	unknown	A small, leafless, more or less subterranean saprophyte, which occurs in tree-fern butts and damp humus in dense fern gullies. It has been recorded from the Dandenong Ranges National Park, but its cryptic habit makes accurate assessment of its distribution difficult.
<i>Tmesipteris elongata</i>	Elongate fork-fern	Psilotaceae		v	unreserved	An epiphytic fern-ally, occurring usually on tree-fern trunks in rainforest and fern gullies. In Victoria, it had been recorded previously only from the Otway Ranges and South Gippsland. A recently discovered occurrence in the Study Area is on the Middle Tyers River, south of Mt Baw Baw, where it is unreserved.
<i>Tmesipteris ovata</i>	Oval fork-fern	Psilotaceae		r	reserved	A small epiphytic fern-ally with pendulous fronds, occurring on tree-fern trunks in fern gullies and rainforest in the Bunyip-Tarago area. Reserved in the Bunyip State Park, this species also occurs in South and East Gippsland.
<i>Uncinia compacta</i>	Compact hook-sedge	Cyperaceae		r	reserved	A very small sedge forming a dense tussock of stiff leaves. Restricted to exposed alpine sites, including the Baw Baw National Park.
<i>Wittsteinia vacciniacea</i>	Baw Baw berry	Epacridaceae		r	reserved	A small, decumbent shrub of rainforest and montane riparian scrubs and sub-alpine woodlands, rarely far from a drainage line. Endemic in the Central Highlands, and reserved in the Baw Baw National Park.

2. Species recorded from the Study Area prior to 1950, but unrecorded since, and now presumed extinct in the Study Area.

<i>Acacia penninervis</i>	Hickory wattle	Mimosaceae		r	presumed extinct	A densely foliated shrub to small tree, localised in Victoria, and last recorded in the Study Area near Avenal in 1880.
<i>Actinotus bellidioides</i>	Tiny flannel-flower	Apiaceae		x	presumed extinct	This herb was last recorded in 1947 from a site in the Baw Baws, now within the National Park.

Appendix IV (continued)

Species	Common name	Family	ROTAP ¹	VROTS ²	Reservation status ³	Notes
<i>Asplenium terrestre</i>	Ground spleenwort	Aspleniaceae		r	doubtful record	An erect, leathery fern of wet forests. It has been recorded from the Otways, but a single record from the Baw Baw area late last century is the only evidence of this species in the Study Area.
<i>Bergia ammanioides</i>	Jerry water-fire	Elatinaceae		v	presumed extinct	Little current information exists for this species which has a doubtful record from Emerald.
<i>Brachyscome debilis</i>	Weak daisy	Asteraceae		v	unknown	A rare annual daisy bearing white ray florets, known from western Victoria, but with two records from the "Seymour" and "Delatite" districts prior to 1950.
<i>Caladenia concolor</i>	Maroon spider-orchid	Orchidaceae		v	doubtful record	A hairy orchid with dark purple to red flowers. Occurs in open forests, and has been recorded in the Seymour area, but the precise locality is unknown.
<i>Caladenia leptochila</i>	Narrow-lip spider-orchid	Orchidaceae		v	doubtful record	A hairy orchid with yellow-green flowers bearing a central red stripe, known mainly from pre-1950 records; some doubt exists as to whether this species ever occurred in the Study Area.
<i>Caladenia patersonii</i>	Common spider-orchid	Orchidaceae		r	doubtful record	A sparsely hairy orchid with creamy-yellow, red-striped flowers. A recent revision resulted in a stricter circumscription of this species, which now appears unlikely to occur in the Study Area.
<i>Diuris palustris</i>	Swamp diuris	Orchidaceae		v	presumed extinct	A tufted orchid with scented, brown-spotted, yellow flowers. It is found scattered across the State, in grassy areas, especially low-lying sites with moist soils. It is presumed extinct in the Study Area, but it persists in western Victoria.
<i>Philydrum lanuginosum</i>	Woolly waterlily	Philydraceae		r	presumed extinct	An aquatic plant of freshwater swamps, previously known from wetlands on the eastern shore of Port Phillip.
<i>Pterostylis truncata</i>	Brittle greenhood	Orchidaceae		e	presumed extinct	A greenhood orchid with distinctive, large, forward-leaning flowers, occurring on gravelly soils. This species has a scattered distribution, mostly to the west of Melbourne; an isolated population at Belgrave South is now presumed extinct.
<i>Thelymitra epipactoides</i>	Metallic sun-orchid	Orchidaceae		e	presumed extinct	A striking orchid bearing flowers with a metallic sheen, formerly known from Black Rock. This species is now restricted to a few heathland localities in south-eastern South Australia and Victoria, including the Grampians, Anglesea - Point Lonsdale area, Little Desert, south Gippsland and the Port Campbell National Park.

KEY TO APPENDIX IV

Reservation status -

- Unreserved - not recorded from the flora conservation reserve system, although may occur in a land use category affording some protection (eg. water catchments)
- Poorly reserved - major occurrences outside the flora conservation reserve system
- Reserved - major occurrences within the flora conservation reserve system
- Unknown - precise localities and therefore reservation status unknown
- Presumed extinct - no extant population within the Study Area, although the species may still occur elsewhere.

Notes:

1. Australian conservation status code from Briggs, J.D. and Leigh J.H. (1988). Rare or Threatened Australian Plants (ROTAP):
X = presumed extinct; E = endangered; V = vulnerable; R = rare; K = poorly known.
2. Victorian conservation status code from Gullan, P.K., Cheal D.C., and Walsh N.G. (1990). Rare or threatened plants in Victoria (VROTS):
x = extinct; e = endangered; v = vulnerable; r = rare; d = depleted.
3. (Mornington Peninsula)
4. 'Reservation status' should not be confused with conservation status: the former refers simply to the land status of sites; conservation status includes additional considerations of population viability, threats, management issues, etc.

References

1. Beauglehole, A.C. (1983). 'The Distribution and Conservation of Vascular Plants in the Melbourne area, Victoria'. (Western Victorian Field Naturalists Clubs Association: Portland, Victoria.)
2. Carr, G.W. 1991 'New Taxa in *Caladenia* R.Br. *Chiloglottis* R.Br., and *Gastrodia* R.Br. (*Orchidaceae*) from south-eastern Australia'. *Indigenous Flora and Fauna association Miscellaneous Paper* No. 1.
3. Costermans, L.F. (1986). *Native Trees and Shrubs of South-eastern Australia*. (Rigby: Dee Why West, New South Wales.)
4. Jones, D.L. (1988). 'Native Orchids of Australia'. Reed Books Pty Ltd: Frenchs Forest, New South Wales.)
5. Willis, J.H. (1970). 'A Handbook to plants in Victoria', *Volumes I & II*, Melbourne University Press.

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Appendix V

VERTEBRATE FAUNA: DISTRIBUTION BY BROAD VEGETATION CATEGORY AND VEGETATION COMMUNITY

KEY:

Dry forests

- Foothill forest complex - includes herb-rich, shrubby, and heathy foothill forest
- Heathy dry forest
- Dry sclerophyll forest - includes valley forest
- Rocky outcrop community complex

Plains vegetation

- Box woodland
- Floodplain riparian woodland (includes plains grassy woodland)
- Wetland community complex

Heathland vegetation

- Heathy woodland
- Wet heathland - includes swamp heathland
- Sand heathland
- Coastal heathland

Coastal vegetation

- Coastal grassy forest
- Dry coast complex - includes coastal dune scrub, coastal banksia woodland, and coastal tussock grassland
- Coastal saltmarsh
- Swamp scrub

Farmland

- Coastal embayments and oceans

Distribution

Distribution has been assessed in Australia, Victoria, and the Melbourne Area, District 2 using the following criteria:

- R restricted (occurs in less than 10% of the area)
- M moderate (occurs in 10--50% of the area)
- W widespread (occurs in greater than 50% of the area)

Abundance

Abundance has been assessed within the known distribution of each species within Australia, Victoria, and the Melbourne Area, District 2. For those species confined to the study area, the abundance in areas other than the study area is not relevant and so has been left blank.

- R rare
- U uncommon
- C common
- A abundant
- ? abundance not known.

Note:

Both distribution and abundance are subjective assessments based on:

- for Australia - the scientific literature
 - for Victoria - the scientific literature and the Atlas of Victorian Wildlife
 - for Melbourne Area, District 2 - the scientific literature and extensive survey data collected in recent years.
-

MAMMALS

MAMMALS		SUB-ALPINE VEGETATION		MONTANE VEGETATION		MOIST FORESTS				DRY FOREST				PLAINS VEGETATION		HEATHLAND VEGETATION					COASTAL VEGETATION					FARMLAND		EMBAYMENTS & OCEANS		DISTRIBUTION		ABUNDANCE		SENSITIVITY	
		Sub-alpine Heathland Complex	Sub-alpine Woodland	Montane Dry Woodland	Montane Forest Complex	Cool Temperate Rainforest	Wet Sclerophyll Forest	Damp Sclerophyll Forest	Riparian Forest	Foothill Forest Complex	Heathy Dry Forest	Dry Sclerophyll Forest	Box Woodland	Floodplain Riparian Woodland	Heathy Woodland	Wet Heathland	Sand Heathland	Coastal Heathland	Coastal Grassy Forest	Dry Coast Complex	Coastal Saltmarsh	Swamp Scrub													
Short-beaked Echidna	<i>Tachyglossus aculeatus</i>					X	+	+	+	X	+	+	+	X	+	+	+	X	+	+															
Platypus	<i>Ornithorhynchus anatinus</i>					X			+																										
Yellow-footed Antechinus	<i>Antechinus flavipes</i>																																		
Swamp Antechinus	<i>Antechinus minimus</i>														X		+	+			+														
Brown Antechinus	<i>Antechinus stuartii</i>	X	+	X	+	X	+	+	+	X	+	+	+		X	+	+	+		X	+	+													
Dusky Antechinus	<i>Antechinus swainsonii</i>	X	+	X	+	X	+	+	+	X	+				X	+	+																		
Tiger Quoll	<i>Dasyurus maculatus</i>					X		+																											
Brush-tailed Phascogale	<i>Phascogale tapoatafa</i>					X		+		X		+																							
Fat-tailed Dunnart	<i>Sminthopsis crassicaudata</i>																																		
White-footed Dunnart	<i>Sminthopsis leucopus</i>					X		+	+	X		+	+						X		+														
Common Dunnart	<i>Sminthopsis murina</i>									X		+																							
Southern Brown Bandicoot	<i>Isodon obesulus</i>									X	+				X		+	+	+																
Long-nosed Bandicoot	<i>Perameles nasuta</i>			X	+	X		+	+	X		+																							
Mountain Brushtail Possum	<i>Trichosurus caninus</i>			X	+	X		+	+	X	+	+																							
Common Brushtail Possum	<i>Trichosurus vulpecula</i>					X		+	+	X	+	+	X	+	X	+	+	+	X	+															
Feathertail Glider	<i>Acrobates pygmaeus</i>			X	+	X		+	+	X	+				X																				
Eastern Pygmy-possum	<i>Cercartetus nanus</i>	X	+	X	+	X	+	+	+	X	+	+	+		X		+																		
Leadbeater's Possum	<i>Gymnobelideus leadbeateri</i>			X	+	X		+	+																										
Yellow-bellied Glider	<i>Petaurus australis</i>			X	+	X		+	+	X	+				X	+																			
Sugar Glider	<i>Petaurus breviceps</i>			X	+	X		+	+	X	+	+	X	+	X	+	+		X	+															
Squirrel Glider	<i>Petaurus norfolcensis</i>												X	+																					
Common Ringtail Possum	<i>Pseudocheirus peregrinus</i>			X	+	X		+	+	X	+	+	X	+	X	+	+	+	X	+	+	+	X												
Greater Glider	<i>Petauroides volans</i>			X	+	X		+	+	X	+	+																							
Long-nosed Potoroo	<i>Potorous tridactylus</i>									X	+				X		+	+																	
Eastern Grey Kangaroo	<i>Macropus giganteus</i>					X			+	X	+	+	+	X	+	+	+		X	+		+	X												
Swamp Wallaby	<i>Wallabia bicolor</i>			X	+	X		+	+	X	+	+	+		X	+	+	+	X	+	+														
Koala	<i>Phascolarctos cinereus</i>					X		+		X	+	+	+	X	+	+	+		X	+															
Common Wombat	<i>Vombatus ursinus</i>	X	+	X	+	X	+	+	+	X	+	+	+		X	+	+		X	+															
Grey-headed Flying-fox	<i>Pteropus poliocephalus</i>																																		

		SUB-ALPINE VEGETATION		MONTANE VEGETATION		MOIST FORESTS		DRY FOREST		PLAINS VEGETATION		HEATHLAND VEGETATION		COASTAL VEGETATION		FARMLAND		EMBAYMENTS & OCEANS		DISTRIBUTION		ABUNDANCE		SENSITIVITY				
		Sub-alpine Heathland Complex	Sub-alpine Woodland	Montane Dry Woodland	Montane Forest Complex	Cool Temperate Rainforest	Wet Sclerophyll Forest	Damp Sclerophyll Forest	Riparian Forest	Foot-hill Forest Complex	Heathy Dry Forest	Dry Sclerophyll Forest	Box Woodland	Floodplain Riparian Woodland	Heathy Woodland	Wet Heathland	Sand Heathland	Coastal Heathland	Coastal Grassy Forest	Dry Coast Complex	Coastal Saltmarsh	Swamp Scrub						
Little Red Flying-fox	<i>Pteropus scapulatus</i>																											
Eastern Horseshoe-bat	<i>Rhinolophus megaphyllus</i>									X		+													R	R	+	
Little Mastiff-bat (long penis)	<i>Mormopterus planiceps</i>												X	+											R	R	+	
Little Mastiff-bat (short penis)	<i>Mormopterus planiceps</i>												X	+											R	R	+	
White-striped Mastiff-bat	<i>Tadarida australis</i>	X	+	X	+	X	+	+	+	X	+	+	X	+	X		+		X				X		R	R	+	
Gould's Wattled Bat	<i>Chalinolobus gouldii</i>	X	+	X	+	X	+	+	+	X	+	+	X	+	X	+	+	+	X	+	+		X		W	U	+	
Chocolate Wattled Bat	<i>Chalinolobus morio</i>	X	+	X	+	X	+	+	+	X	+	+	X	+	X	+	+	+							W	C	+	
Large Forest Eptesicus	<i>Eptesicus darlingtoni</i>	X	+	X	+	X	+	+	+	X	+	+	X	+	X	+	+		X	+					W	C	+	
King River Eptesicus	<i>Eptesicus regulus</i>	X	+	X	+	X	+	+	+	X	+	+	X	+	X		+		X	+	+				W	C	+	
Little Forest Eptesicus	<i>Eptesicus vulturinus</i>					X	+	+	+	X	+	+	X	+	X	+	+		X	+	+				W	C	+	
Great Pipistrelle	<i>Falsistrellus tasmaniensis</i>			X	+	X	+	+	+	X	+	+													W	U	+	
Common Bent-wing Bat	<i>Miniopterus schreibersii</i>					X	+	+	+	X	+	+	X	+					X						W	U		
Large-footed Myotis	<i>Myotis adversus</i>					X			+				X	+											W	R		
Lesser Long-eared Bat	<i>Nyctophilus geoffroyi</i>	X	+	X	+	X	+	+	+	X	+	+	X	+	X	+	+		X	+	+	+	X		W	C	+	
Gould's Long-eared Bat	<i>Nyctophilus gouldi</i>	X	+	X	+	X	+	+	+	X	+	+													W	C	+	
Eastern Broad-nosed Bat	<i>Scotorepens orion</i>					X			+	X			X	+											R	R	+	
Water-rat	<i>Hydromys chrysogaster</i>					X		+	+	X		+							X			+			W	C		
Broad-toothed Rat	<i>Mastacomys fuscus</i>	X	+			X		+	+																W	U		
House Mouse (I)	<i>Mus musculus</i>					X			+	X	+		X	+	X	+	+	+	X	+	+	+	+	X		W	C	
Smoky Mouse	<i>Pseudomys fumeus</i>	X	+	X	+					X	+	+													R	U	+	
New Holland Mouse	<i>Pseudomys novaehollandiae</i>														X		+								R	R		
Bush Rat	<i>Rattus fuscipes</i>	X	+	X	+	X	+	+	+	X	+	+			X	+	+	+	X			+			W	A		
Swamp Rat	<i>Rattus lutreolus</i>									X	+				X	+	+	+	X	+	+	+	X		W	C		
Brown Rat (I)	<i>Rattus norvegicus</i>																								R	R		
Black Rat (I)	<i>Rattus rattus</i>					X		+							X		+	+	X	+	+	+	X		W	U		
Dog (feral) (I)	<i>Canis familiaris</i>	X	+	X	+	X	+	+	+	X	+	+			X	+			X	+					W	C		
Fox (I)	<i>Vulpes vulpes</i>	X	+	X	+	X	+	+	+	X	+	+	X	+	X	+	+		X	+	+	+	X		W	C		
Cat (feral) (I)	<i>Felis catus</i>					X		+	+	X	+	+			X		+	+	X	+			X		W	C		
Goat (feral) (I)	<i>Capra hircus</i>																								R	U		

		SUB-ALPINE VEGETATION Sub-alpine Heathland Complex Sub-alpine Woodland	MONTANE VEGETATION Montane Dry Woodland Montane Forest Complex	MOIST FORESTS Cool Temperate Rainforest Wet Sclerophyll Forest Damp Sclerophyll Forest Riparian Forest	DRY FOREST Foothill Forest Complex Heathy Dry Forest Dry Sclerophyll Forest	PLAINS VEGETATION Box Woodland Floodplain Riparian Woodland	HEATHLAND VEGETATION Heathy Woodland Wet Heathland Sand Heathland Coastal Heathland	COASTAL VEGETATION Coastal Grassy Forest Dry Coast Complex Coastal Saltmarsh Swamp Scrub	FARMLAND	EMBAYMENTS & OCEANS	DISTRIBUTION	ABUNDANCE	SENSITIVITY
Hog Deer (I)	<i>Cervus porcinus</i>												
Sambar (I)	<i>Cervus unicolor</i>	X +	X +	X + + + +	X +						R	R	
Fallow Deer (I)	<i>Cervus dama</i>										R	R	C
Pig (feral) (I)	<i>Sus scrofa</i>			X							R	R	
Brown Hare (I)	<i>Lepus capensis</i>										R	R	
Rabbit (I)	<i>Oryctolagus cuniculus</i>	X +	X + +	X + + +	X + + +	X + +	X + + + +	X + + + +	X		M	U	
New Zealand Fur-seal	<i>Arctocephalus forsteri</i>									X	R	R	
Australian Fur-seal	<i>Arctocephalus pusillus</i>									X	R	C	
Leopard Seal	<i>Hydrurga leptonyx</i>									X	R	R	
Elephant Seal	<i>Mirounga leonina</i>									X	R	R	
Southern Right Whale	<i>Balaena glacialis</i>									X	R	R	
Minke Whale	<i>Balaenoptera acutorostrata</i>									X	R	R	
Fin Whale	<i>Balaenoptera physalus</i>									X	R	R	
Humpback Whale	<i>Megaptera novaeangliae</i>									X	R	R	
Pygmy Sperm Whale	<i>Kogia breviceps</i>									X	R	R	
Sperm Whale	<i>Physeter catodon</i>									X	R	R	
Gray's Beaked Whale	<i>Mesoplodon grayi</i>									X	R	R	
Common Dolphin	<i>Delphinus delphis</i>									X	R	U	
Pilot Whale	<i>Globicephala melaena</i>									X	R	R	
False Killer-whale	<i>Pseudorca crassidens</i>									X	R	R	
Killer-whale	<i>Orcinus orca</i>									X	R	R	
Bottle-nosed Dolphin	<i>Tursiops truncatus</i>									X	R	U	

BIRDS

		SUB-ALPINE VEGETATION Sub-alpine Woodland	MONTANE VEGETATION Montane Dry Woodland Montane Forest: Complex	MOIST FORESTS Cool Temperate Rainforest Wet Sclerophyll Forest Damp Sclerophyll Forest Riparian Forest	DRY FOREST Foothill Forest: Complex Heathy Dry Forest Dry Sclerophyll Forest	PLAINS VEGETATION Box Woodland Floodplain Riparian Woodland Wetland Community Complex	HEATHLAND VEGETATION Heathy Woodland Wet Heathland Sand Heathland Coastal Heathland	COASTAL VEGETATION Coastal Grassy Forest Dry Coast Complex Coastal Saltmarsh Swamp Scrub	FARMLAND	EMBAYMENTS & OCEANS	DISTRIBUTION	ABUNDANCE	SENSITIVITY
Great Crested Grebe	<i>Podiceps cristatus</i>					X				X	R	U	
Australasian Grebe	<i>Tachybaptus novaehollandiae</i>					X	+			X	M	C	
Hoary-headed Grebe	<i>Polioccephalus poliocephalus</i>					X				X	M	C	
Rockhopper Penguin	<i>Eudyptes chrysocome</i>							X		X	V		
Fiordland Penguin	<i>Eudyptes pachyrhynchus</i>							X		X	V		
Little Penguin	<i>Eudyptula minor</i>							X	+	X	M	U	
Wandering Albatross	<i>Diomedea exulans</i>									X	R	C	
Royal Albatross	<i>Diomedea epomophora</i>									X	R	R	
Black-browed Albatross	<i>Diomedea melanophrys</i>									X	R	C	
Yellow-nosed Albatross	<i>Diomedea chlororhynchos</i>									X	R	U	
Grey-headed Albatross	<i>Diomedea chrysostoma</i>									X	R	U	
Shy Albatross	<i>Diomedea cauta</i>									X	R	C	
Sooty Albatross	<i>Phoebastria fusca</i>									X	V		
Southern Fulmar	<i>Fulmarus glacialis</i>									X	R	R	
Southern Giant-Petrel	<i>Macronectes giganteus</i>									X	R	U	
Great-winged Petrel	<i>Pterodroma macroptera</i>									X	R	R	
White-headed Petrel	<i>Pterodroma lessonii</i>									X	R	R	
Cape Petrel	<i>Daption capense</i>									X	R	U	
Blue Petrel	<i>Halobaena caerulea</i>									X	R	R	
Kerguelen Petrel	<i>Pterodroma brevirostris</i>									X	R	U	
Fairy Prion	<i>Pachyptila turtur</i>									X	R	U	
Antarctic Prion	<i>Pachyptila desolata</i>									X	R	U	
Lesser Broad-billed Prion	<i>Pachyptila salvini</i>									X	R	U	
Slender-billed Prion	<i>Pachyptila belcheri</i>									X	R	U	
Fluttering Shearwater	<i>Puffinus gavia</i>									X	R	U	
Hutton's Shearwater	<i>Puffinus huttoni</i>									X	R	U	
Sooty Shearwater	<i>Puffinus griseus</i>									X	R	R	
Short-tailed Shearwater	<i>Puffinus tenuirostris</i>							X	+	X	R	A	
Flesh-footed Shearwater	<i>Puffinus carneipes</i>									X	R	R	

		SUB-ALPINE VEGETATION Sub-alpine Woodland	MONTANE VEGETATION Montane Dry Woodland Montane Forest Complex	MOIST FORESTS Cool Temperate Rainforest Wet Sclerophyll Forest Damp Sclerophyll Forest Riparian Forest	DRY FOREST Foothill Forest Complex Heathy Dry Forest Dry Sclerophyll Forest	PLAINS VEGETATION Box Woodland Floodplain Riparian Woodland Wetland Community Complex	HEATHLAND VEGETATION Heathy Woodland Wet Heathland Sand Heathland Coastal Heathland	COASTAL VEGETATION Coastal Grassy Forest Dry Coast Complex Coastal Saltmarsh Swamp Scrub	FARMLAND	EMBAYMENTS & OCEANS	DISTRIBUTION	ABUNDANCE	SENSITIVITY
White-faced Storm-Petrel	<i>Pelagodroma marina</i>									X	R	U	
Common Diving-Petrel	<i>Pelecanoides urinatrix</i>									X	R	U	
Australian Pelican	<i>Pelecanus conspicillatus</i>		X	+		X		X	+		M	C	
Australasian Gannet	<i>Morus serrator</i>									X	R	C	
Darter	<i>Anhinga melanogaster</i>					X					M	U	
Great Cormorant	<i>Phalacrocorax carbo</i>		X	+		X	X	+	+	X		W	C
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>		X			X	X	+				W	C
Black-faced Shag	<i>Leucocarbo fuscescens</i>									X	R	C	
Pied Cormorant	<i>Phalacrocorax varius</i>									X	M	U	
Little Pied Cormorant	<i>Phalacrocorax melanoleucos</i>		X	+		X	X	+		X		W	C
White-faced Heron	<i>Ardea novaehollandiae</i>		X	+	X	X	X	+	+	X	X	W	C
Pacific Heron	<i>Ardea pacifica</i>				X	X				X	X	M	U
Little Egret	<i>Egretta garzetta</i>					X	+			X	X	M	U
Great Egret	<i>Egretta alba</i>					X				X	M	C	
Cattle Egret	<i>Ardeola ibis</i>										X	M	U
Rufous Night Heron	<i>Nycticorax caledonicus</i>					X	+	+				M	U
Little Bittern	<i>Ixobrychus minutus</i>					X				X		R	R
Australasian Bittern	<i>Botaurus poiciloptilus</i>					X	+			X		R	R
Glossy Ibis	<i>Plegadis falcinellus</i>					X					R	R	
Sacred Ibis	<i>Threskiornis aethiopicus</i>					X	+	X	+	X	X	W	C
Straw-necked Ibis	<i>Threskiornis spinicollis</i>					X	+	X	+	X		W	C
Royal Spoonbill	<i>Platalea regia</i>									X		M	C
Yellow-billed Spoonbill	<i>Platalea flavipes</i>		X	+		X	+			X		M	C
Plumed Whistling-Duck	<i>Dendrocygna eytoni</i>					X	+					R	R
Black Swan	<i>Cygnus atratus</i>					X				X	X	M	C
Cape Barren Goose	<i>Cereopsis novaehollandiae</i>									X		R	R
Cotton Pigmy Goose	<i>Nettion coromandelianus</i>											V	
Mallard (I)	<i>Anas platyrhynchos</i>											R	U
Maned Duck	<i>Chenonetta jubata</i>		X	+	+	X	+			X		W	C

		SUB-ALPINE VEGETATION Sub-alpine Woodland	MONTANE VEGETATION Montane Dry Woodland Montane Forest Complex	MOIST FORESTS Cool Temperate Rainforest Wet Sclerophyll Forest Damp Sclerophyll Forest Riparian Forest	DRY FOREST Foothill Forest Complex Heathy Dry Forest Dry Sclerophyll Forest	PLAINS VEGETATION Box Woodland Floodplain Riparian Woodland Wetland Community Complex	HEATHLAND VEGETATION Heathy Woodland Wet Heathland Sand Heathland Coastal Heathland	COASTAL VEGETATION Coastal Grassy Forest Dry Coast Complex Coastal Saltmarsh Swamp Scrub	FARMLAND	EMBAYMENTS & OCEANS	DISTRIBUTION	ABUNDANCE	SENSITIVITY
Australian Shelduck	<i>Tadoma tadornoides</i>					X				X	M	U	
Pacific Black Duck	<i>Anas superciliosa</i>			X	+	X		X		X	M	C	
Chestnut Teal	<i>Anas castanea</i>					X		X		X	M	C	
Grey Teal	<i>Anas gibberifrons</i>					X		X		X	M	C	
Australasian Shoveler	<i>Anas rhynchos</i>					X				X	M	U	
Pink-eared Duck	<i>Malacorhynchus membranaceus</i>					X				X	M	U	
Freckled Duck	<i>Stictonetta naevosa</i>					X					R	R	
Hardhead	<i>Aythya australis</i>					X					M	U	
Blue-billed Duck	<i>Oxyura australis</i>					X				X	M	R	
Musk Duck	<i>Biziura lobata</i>					X					M	U	
Spotted Harrier	<i>Circus assimilis</i>					X				X	R	R	
Marsh Harrier	<i>Circus aeruginosus</i>					X		X	+		R	C	
Grey Goshawk	<i>Accipiter novaehollandiae</i>			X	+	X		X	+		R	R	
Brown Goshawk	<i>Accipiter fasciatus</i>	X	+	X	+	X		X	+		W	C	
Collared Sparrowhawk	<i>Accipiter cirrhocephalus</i>					X					M	U	
Wedge-tailed Eagle	<i>Aquila audax</i>	X		X	+	X	+				W	U	
Little Eagle	<i>Hieraaetus morphnoides</i>					X		X	+		M	U	
White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>					X		X		X	R	R	
Whistling Kite	<i>Haliastur sphenurus</i>					X		X		X	M	U	
Black Kite	<i>Milvus migrans</i>			X							V		
Square-tailed Kite	<i>Lopholictinia isura</i>				X						R	R	
Black-shouldered Kite	<i>Elanus notatus</i>					X		X	+	X	M	C	
Letter-winged Kite	<i>Elanus scriptus</i>										V		
Australian Hobby	<i>Falco longipennis</i>	X	+		X	+					M	U	
Peregrine Falcon	<i>Falco peregrinus</i>			X		X				X	M	U	
Black Falcon	<i>Falco subniger</i>					X					V		
Brown Falcon	<i>Falco berigora</i>				X	+	X	X	+		M	C	
Australian Kestrel	<i>Falco cenchroides</i>	X	+		X		X	X		X	M	C	
Stubble Quail	<i>Coturnix novaezelandiae</i>				X		X			X	M	C	

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Brown Quail	<i>Coturnix australis</i>						X	X			R	U	
King Quail	<i>Coturnix chinensis</i>						X	X			R	R	
Painted Button-quail	<i>Turnix varia</i>	X	+		X	+	X		+		M	U	
Little Button-quail	<i>Turnix velox</i>				X	+					R	R	
Plains-wanderer	<i>Pedionomus torquatus</i>					X				X	R	R	
Lewin's Rail	<i>Rallus pectoralis</i>			X	+	X		X	+		M	R	
Buff-banded Rail	<i>Rallus philippensis</i>			X		X	+	X			R	R	
Australian Crake	<i>Porzana fluminea</i>					X		X			R	U	
Baillon's Crake	<i>Porzana pusilla</i>					X		X			R	R	
Spotless Crake	<i>Porzana tabuensis</i>					X		X			R	R	
Black-tailed Native-hen	<i>Gallinula ventralis</i>										R	R	
Dusky Moorhen	<i>Gallinula tenebrosa</i>			X	+	X	+			X	M	C	
Purple Swamphen	<i>Porphyrio porphyrio</i>			X	+	X	+	X	+	X	M	C	
Eurasian Coot	<i>Fulica atra</i>			X		X	+			X	M	C	
Painted Snipe	<i>Rostratula benghalensis</i>					X					R	R	
Bush Thick-knee	<i>Burhinus magnirostris</i>				X						R	R	
Pied Oystercatcher	<i>Haematopus longirostris</i>									X	M	U	
Sooty Oystercatcher	<i>Haematopus fuliginosus</i>									X	R	U	
Masked Lapwing	<i>Vanellus miles</i>			X	+	X	+	X		X	X	W	C
Banded Lapwing	<i>Vanellus tricolor</i>									X	R	R	
Red-kneed Dotterel	<i>Erythgonys cinctus</i>					X					R	U	
Grey Plover	<i>Pluvialis squatarola</i>									X	R	R	
Lesser Golden Plover	<i>Pluvialis dominica</i>							X		X	R	U	
Hooded Plover	<i>Charadrius rubricollis</i>							X		X	R	U	
Mongolian Plover	<i>Charadrius mongolus</i>									X	R	R	
Double-banded Plover	<i>Charadrius bicinctus</i>							X		X	R	C	
Large Sand Plover	<i>Charadrius leschenaultii</i>									X	R	R	
Oriental Plover	<i>Charadrius veredus</i>									X	V		
Red-capped Plover	<i>Charadrius ruficapillus</i>							X	+	X	R	C	

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Black-fronted Plover	<i>Charadrius melanops</i>			x		x		x			x	m	u
Black-winged Stilt	<i>Himantopus himantopus</i>									x	r	u	
Banded Stilt	<i>Cladorhynchus leucocephalus</i>										v		
Red-necked Avocet	<i>Recurvirostra novaehollandiae</i>									x	r	r	
Ruddy Turnstone	<i>Arenaria interpres</i>									x	r	u	
Eastern Curlew	<i>Numenius madagascariensis</i>									x	r	u	
Whimbrel	<i>Numenius phaeopus</i>									x	r	r	
Bar-tailed Godwit	<i>Limosa lapponica</i>									x	r	u	
Wood Sandpiper	<i>Tringa glareola</i>					x		x			v		
Grey-tailed Tattler	<i>Tringa brevipes</i>									x	r	r	
Common Sandpiper	<i>Tringa hypoleucos</i>							x		x	r	u	
Greenshank	<i>Tringa nebularia</i>							x		x	r	u	
Marsh Sandpiper	<i>Tringa stagnatilis</i>							x			v		
Terek Sandpiper	<i>Tringa terek</i>									x	r	r	
Curlew Sandpiper	<i>Calidris ferruginea</i>									x	r	c	
Red-necked Stint	<i>Calidris ruficollis</i>									x	r	c	
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>							x		x	r	u	
Pectoral Sandpiper	<i>Callidris melanotos</i>							x			v		
Red Knot	<i>Calidris canutus</i>									x	r	r	
Great Knot	<i>Calidris tenuirostris</i>									x	r	r	
Sanderling	<i>Calidris alba</i>									x	r	r	
Broad-billed Sandpiper	<i>Limicola falcinellus</i>									x	v		
Latham's Snipe	<i>Gallinago hardwickii</i>					x		x	+		m	u	
Oriental Pratincole	<i>Glareola maldivarum</i>										v		
Great Skua	<i>Stercorarius skua</i>									x	r	u	
Arctic Jaeger	<i>Stercorarius parasiticus</i>									x	m	u	
Pomarine Jaeger	<i>Stercorarius pomarinus</i>									x	r	u	
Silver Gull	<i>Larus novaehollandiae</i>							x		x	m	a	
Pacific Gull	<i>Larus pacificus</i>							x	+	x	m	c	

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Kelp Gull	<i>Larus dominicanus</i>									X	R	U	
Whiskered Tern	<i>Chlidonias hybrida</i>									X	R	U	
Arctic Tern	<i>Sterna paradisaea</i>									X	R	R	
White-fronted Tern	<i>Sterna striata</i>									X	R	C	
Common Tern	<i>Sterna hirundo</i>									X	M	R	
Gull-billed Tern	<i>Gelochelidon nilotica</i>									X	R	R	
Caspian Tern	<i>Hydroprogne caspia</i>									X	M	U	
Crested Tern	<i>Sterna bergii</i>									X	M	C	
Little Tern	<i>Sterna albifrons</i>									X	R	R	
Fairy Tern	<i>Sterna nereis</i>									X	R	R	
Feral Pigeon (I)	<i>Columba livia</i>					X	+			X	M	C	
Spotted Turtle-Dove (I)	<i>Streptopelia chinensis</i>			X	+	X	+	X	+	X	M	C	
Peaceful Dove	<i>Geopelia placida</i>					X	+				R	R	
Common Bronzewing	<i>Phaps chalcoptera</i>	X	+	X	+	X	+	X	+		M	C	
Brush Bronzewing	<i>Phaps elegans</i>		X	+	X	+	+	X	+	+	M	C	
Crested Pigeon	<i>Ocyphaps lophotes</i>					X	+	X	+	+	R	R	
Wonga Pigeon	<i>Leucosarcia melanoleuca</i>		X	+	X	+	+	X	+	+	M	U	
Yellow-tailed Black-Cockatoo	<i>Calyptorhynchus funereus</i>		X	+	X	+	+	X	+	+	W	C	+
Gang-gang Cockatoo	<i>Callocephalon fimbriatum</i>	X	+	X	+	X	+	X	+	+	W	C	+
Sulphur-crested Cockatoo	<i>Cacatua galerita</i>			X	+	X	+	X	+		W	C	
Pink Cockatoo	<i>Cacatua leadbeateri</i>									X	V		
Little Corella	<i>Cacatua sanguinea</i>			X	+	X	+	X	+	X	R	U	
Long-billed Corella	<i>Cacatua tenuirostris</i>			X	+	X	+	X	+	X	R	U	
Galah	<i>Cacatua roseicapilla</i>			X	+	X	+	X	+	X	M	C	
Rainbow Lorikeet	<i>Trichoglossus haematodus</i>				X		+	X	+		M	U	+
Scaly-breasted Lorikee (E)	<i>Trichoglossus chlorolepidotus</i>										R	R	
Musk Lorikeet	<i>Glossopsitta concinna</i>				X	+	X	+			M	U	+
Purple-crowned Lorikeet	<i>Glossopsitta porphyrocephala</i>			X	+	X	+				R	U	
Little Lorikeet	<i>Glossopsitta pusilla</i>				X	+	X	+			R	U	

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Budgerigar	<i>Melopsittacus undulatus</i>										V		
Swift Parrot	<i>Lathamus discolor</i>			X	+	X	+	X	+		M	R	
Cockatiel	<i>Nymphicus hollandicus</i>										V		
Australian King-Parrot	<i>Alisterus scapularis</i>		X	+	+	X	+				M	U	
Crimson Rosella	<i>Platycercus elegans</i>	X	+	X	+	X	+	X	+		M	C	
Eastern Rosella	<i>Platycercus eximius</i>			X	+	X	+	X	+		M	C	
Pale-headed Rosella (E)	<i>Platycercus adscitus</i>										R	R	
Port Lincoln Ringneck (E)	<i>Barnardius zonarius</i>					X	+				R	R	
Red-rumped Parrot	<i>Psephotus haematonotus</i>			X	+	X	+	X	+		M	C	
Turquoise Parrot	<i>Neophema pulchella</i>										V		+
Orange-bellied Parrot	<i>Neophema chrysogaster</i>										R	R	
Blue-winged Parrot	<i>Neophema chrysostoma</i>			X	+	X	+	X	+	X	M	U	+
Pallid Cuckoo	<i>Cuculus pallidus</i>					X	+	X	+	X	M	C	
Fan-tailed Cuckoo	<i>Cuculus pyrrhophanus</i>	X	+	X	+	X	+	X	+		M	C	
Brush Cuckoo	<i>Cuculus variolosus</i>		X	+	+	X	+				M	U	
Black-eared Cuckoo	<i>Chrysococcyx osculans</i>					X	+				R	R	
Horsfield's Bronze-Cuckoo	<i>Chrysococcyx basalis</i>					X	+	X	+		M	C	
Shining Bronze-Cuckoo	<i>Chrysococcyx lucidus</i>		X	+	+	X	+	X	+		M	C	
Southern Boobook	<i>Ninox novaeseelandiae</i>	X	X	+	+	X	+	X	+		M	C	+
Barking Owl	<i>Ninox connivens</i>			X		X	+				R	R	
Powerful Owl	<i>Ninox strenua</i>			X	+	X	+	X	+		M	U	+
Barn Owl	<i>Tyto alba</i>			X	+	X	+	X	+	X	M	C	
Sooty Owl	<i>Tyto tenebricosa</i>		X	+	X	+	+				M	U	+
Tawny Frogmouth	<i>Podargus strigoides</i>		X	+	X	+	+	X	+		M	C	
Australian Owlet-nightjar	<i>Aegotheles cristatus</i>		X	+	X	+	+	X	+		M	C	+
White-throated Nightjar	<i>Caprimulgus mystacalis</i>			X	+	X	+				M	U	
Spotted Nightjar	<i>Caprimulgus guttatus</i>										V		
White-throated Needletail	<i>Hirundapus caudacutus</i>		X	+	X	+	+	X	+		M	C	
Fork-tailed Swift	<i>Apus pacificus</i>										M	R	

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Azure Kingfisher	<i>Ceyx azurea</i>					X +					M	R	
Laughing Kookaburra	<i>Dacelo novaeguineae</i>		X + +	X + + +	X + + +	X +	X + + + +	X +			M	C	
Forest Kingfisher	<i>Halcyon macleayii</i>			X +							V		
Sacred Kingfisher	<i>Halcyon sancta</i>			X + +	X + + +	X + +	X +	X +			M	C	
Rainbow Bee-eater	<i>Merops ornatus</i>			X +	X +	X + +					M	U	
Dollarbird	<i>Eurystomus orientalis</i>			X +	X +	X					R	R	
Superb Lyrebird	<i>Menura novaehollandiae</i>	X +	X + +	X + + + +	X +		X +				M	C	
Common Skylark (I)	<i>Alauda arvensis</i>				X +	X +	X +	X + +	X		M	C	
Singing Bushlark	<i>Mirafra javanica</i>					X			X		R	R	
Welcome Swallow	<i>Hirundo neoxena</i>			X + + +	X +	X +	X + + +	X + + + +	X		U	C	
White-backed Swallow	<i>Cheramoeca leucosternum</i>					X +					V		
Tree Martin	<i>Cecropis nigricans</i>			X +	X +	X + +		X +			M	C	
Fairy Martin	<i>Cecropis ariel</i>				X +	X +					M	U	
Richard's Pipit	<i>Anthus novaeseelandiae</i>				X +	X			X		M	C	
Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>		X + +	X + + +	X + + +	X + +	X + + +	X + +	X		M	C	
White-bellied Cuckoo-shrike	<i>Coracina papuensis</i>				X +						V		
Cicadabird	<i>Coracina tenuirostris</i>			X +	X +						M	U	
White-winged Triller	<i>Lalage sueurii</i>			X +	X +	X +					M	U	
White's Thrush	<i>Zoothera dauma</i>	X +	X + +	X + + + +	X +		X +				M	C	
Common Blackbird (I)	<i>Turdus merula</i>		X +	X + + + +	X +	X +	X + + +	X + + + +	X		M	C	
Song Thrush (I)	<i>Turdus philomelos</i>										R	U	
Scarlet Robin	<i>Petroica multicolor</i>			X +	X + + +		X + + + +	X +	X		M	C	
Red-capped Robin	<i>Petroica goodenovii</i>				X +	X +					R	R	
Flame Robin	<i>Petroica phoenicea</i>	X +	X + +	X + + + +	X + + + +		X +	X +	X		M	C	
Pink Robin	<i>Petroica rodinogaster</i>			X + + + +	X +		X +				M	U	
Rose Robin	<i>Petroica rosea</i>		X +	X + + + +	X +						M	C	
Hooded Robin	<i>Melanodryas cucullata</i>				X +						R	R	
Eastern Yellow Robin	<i>Eopsaltria australis</i>	X +	X + +	X + + + +	X + + + +	X + +	X + + + +	X + + + +	X		M	C	
Jacky Winter	<i>Micropodops leucophaea</i>			X +	X +		X +	X +	X		M	C	

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Crested Shrike-tit	<i>Falcunculus frontatus</i>		X +	X + + +	X + + +	X + +	X + + +	X +			W	C	
Golden Whistler	<i>Pachycephala pectoralis</i>		X +	X + + +	X + + +	X + +	X + + +	X +			W	C	
Rufous Whistler	<i>Pachycephala rufiventris</i>			X + + +	X + + +	X + +	X + + +	X +			W	C	
Olive Whistler	<i>Pachycephala olivacea</i>	X +	X +	X + + +	X +		X +	X +			W	U	
Grey Shrike-thrush	<i>Colluricincla harmonica</i>	X +	X + +	X + + +	X + + +	X + +	X + + +	X +			W	C	
Crested Bellbird	<i>Oreoica gutturalis</i>			X +							V		
Black-faced Monarch	<i>Monarcha melanopsis</i>			X							R	R	
Leaden Flycatcher	<i>Myiagra rubecula</i>			X	X +	X + +					M	U	
Satin Flycatcher	<i>Myiagra cyanoleuca</i>		X +	X + + +	X + + +			X +			M	U	
Grey Fantail	<i>Rhipidura fuliginosa</i>	X +	X + +	X + + +	X + + +	X + +	X + + +	X + + + +	X		W	C	
Rufous Fantail	<i>Rhipidura rufifrons</i>		X +	X + + +	X +			X +			M	C	
Willie Wagtail	<i>Rhipidura leucophrys</i>		X +	X +	X +	X + +	X + + +	X + + +	X		W	C	
Restless Flycatcher	<i>Myiagra inquieta</i>			X +	X +	X + +			X		M	U	
Eastern Whipbird	<i>Psophodes olivaceus</i>	X +	X +	X + + +	X +		X + +				W	C	
Spotted Quail-thrush	<i>Cinclosoma punctatum</i>		X +	X +	X + + +		X +				M	U	
Grey-crowned Babbler	<i>Pomatostomus temporalis</i>						X +	X +			R	R	
Little Grassbird	<i>Megalurus gramineus</i>			X		X		X + + +			M	U	
Clamorous Reed-Warbler	<i>Acrocephalus stentoreus</i>			X		X + +			X		M	U	
Golden-headed Cisticola	<i>Cisticola exilis</i>			X		X +	X + +	X + + +	X		M	C	
Brown Songlark	<i>Cinchorhamphus cruralis</i>				X	X +					R	U	
Rufous Songlark	<i>Cinchorhamphus mathewsi</i>				X	X +					M	U	
Southern Emu-wren	<i>Stipiturus malachurus</i>				X +		X + +	X + + +			R	U	
Superb Fairy-wren	<i>Malurus cyaneus</i>			X + + +	X + + +	X + +	X + + +	X + + + +	X		W	C	
Pilotbird	<i>Pycnophilus floccosus</i>		X +	X + + +	X +						M	C	
White-browed Scrubwren	<i>Sericornis frontalis</i>	X +	X + +	X + + +	X + + +	X + +	X + + +	X + + +			W	C	
Large-billed Scrubwren	<i>Sericornis magnirostris</i>			X + + +							M	U	
Chestnut-rumped Hylacola	<i>Sericornis pyrrhopygus</i>				X + +		X				M	R	
Calamanthus	<i>Sericornis fuliginosus</i>						X	X + + +			R	C	
Speckled Warbler	<i>Sericornis sagittatus</i>				X	X +					R	U	

		SUB-ALPINE VEGETATION Sub-alpine Woodland	MONTANE VEGETATION Montane Dry Woodland Montane Forest Complex	MOIST FORESTS Cool Temperate Rainforest Wet Sclerophyll Forest Damp Sclerophyll Forest Riparian Forest	DRY FOREST Foothill Forest Complex Heathy Dry Forest Dry Sclerophyll Forest	PLAINS VEGETATION Box Woodland Floodplain Riparian Woodland Wetland Community Complex	HEATHLAND VEGETATION Heathy Woodland Wet Heathland Sand Heathland Coastal Heathland	COASTAL VEGETATION Coastal Grassy Forest Dry Coast Complex Coastal Saltmarsh Swamp Scrub	FARMLAND	EMBAYMENTS & OCEANS	DISTRIBUTION	ABUNDANCE	SENSITIVITY
Striated Thornbill	<i>Acanthiza lineata</i>	X +	X + +	X + + + +	X + + +	X + +	X + + + +	X +					
Yellow Thornbill	<i>Acanthiza nana</i>			X + +	X + +	X +		X +	X				
Brown Thornbill	<i>Acanthiza pusilla</i>	X +	X + +	X + + + +	X + + +	X + +	X + + + +	X + + + +					
Buff-rumped Thornbill	<i>Acanthiza reguloides</i>			X + +	X + + +	X +	X + + + +	X + + + +					
Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>			X + + +	X + + +	X + +	X + + + +	X + + + +	X				
White-throated Gerygone	<i>Gerygone olivacea</i>			X + + +	X + + +	X +							
Brown Gerygone	<i>Gerygone mouki</i>			X + +									
Western Gerygone	<i>Gerygone fusca</i>				X + +	X +							
Weebill	<i>Smicromis brevirostris</i>				X + +	X +							
Southern Whiteface	<i>Aphelocephala leucopsis</i>					X +							
Varied Sittella	<i>Daphoenositta chrysoptera</i>		X	X + +	X + + +	X + +	X + +	X +					
Brown Treecreeper	<i>Climacteris picumnus</i>				X + +	X +							
White-throated Treecreeper	<i>Climacteris leucophaea</i>	X +	X +	X + + + +	X + + + +	X +	X + + + +	X + + + +					
Red-browed Treecreeper	<i>Climacteris erythrops</i>		X + +	X + + + +	X + + +								
Little Wattlebird	<i>Anthochaera chrysoptera</i>				X + +		X + +	X +					
Red Wattlebird	<i>Anthochaera carunculata</i>	X +	X + +	X + + + +	X + + + +	X	X + + + +	X + + + +					
Spiny-cheeked Honeyeater	<i>Acanthagenys rufogularis</i>				X			X + + + +					
Noisy Friarbird	<i>Philemon corniculatus</i>			X + + +	X + +	X +							
Little Friarbird	<i>Philemon citreogularis</i>			X + + +	X + +								
Regent Honeyeater	<i>Xanthomyza phrygia</i>			X + + + +	X + +	X +							
Bell Miner	<i>Manorina melanophrys</i>			X + + + +	X + + +	X	X + + +	X + + + +					
Noisy Miner	<i>Manorina melanocephala</i>			X + + + +	X + + +	X +	X + + + +	X + + + +	X				
Lewin's Honeyeater	<i>Meliphaga lewinii</i>			X + + + +	X + +								
Yellow-faced Honeyeater	<i>Lichenostomus chrysops</i>	X +	X + +	X + + + +	X + + + +	X +	X + + + +	X + + + +					
Singing Honeyeater	<i>Lichenostomus virescens</i>						X	X + + + +					
Yellow-tufted Honeyeater	<i>Lichenostomus melanops</i>			X + + +	X + + +								
Helmeted Honeyeater	<i>Lichenostomus melanops cassidix</i>			X + + +	X + + +								
White-eared Honeyeater	<i>Lichenostomus leucotis</i>	X +	X + +	X + + + +	X + + +		X + + + +	X + + + +					
Fuscous Honeyeater	<i>Lichenostomus fuscus</i>				X + +								

		SUB-ALPINE VEGETATION Sub-alpine Woodland	MONTANE VEGETATION Montane Dry Woodland Montane Forest Complex	MOIST FORESTS Cool Temperate Rainforest Wet Sclerophyll Forest Damp Sclerophyll Forest Riparian Forest	DRY FOREST Foothill Forest Complex Heathy Dry Forest Dry Sclerophyll Forest	PLAINS VEGETATION Box Woodland Foodplain Riparian Woodland Wetland Community Complex	HEATHLAND VEGETATION Heathy Woodland Wet Heathland Sand Heathland Coastal Heathland	COASTAL VEGETATION Coastal Grassy Forest Dry Coast Complex Coastal Saltmarsh Swamp Scrub	FARMLAND	EMBAYMENTS & OCEANS	DISTRIBUTION	ABUNDANCE	SENSITIVITY
White-plumed Honeyeater	<i>Lichenostomus penicillatus</i>			X	X +	X +	X + +	X +	X		W	C	
Black-chinned Honeyeater	<i>Melithreptus gularis</i>				X	X + +					R	R	
Brown-headed Honeyeater	<i>Melithreptus brevirostris</i>	X +	X + +	X + + +	X + + +		X + +	X +			W	C	
White-naped Honeyeater	<i>Melithreptus lunatus</i>	X +	X + +	X + + +	X + + +	X +	X + +	X +			W	C	
Painted Honeyeater	<i>Grantiella picta</i>				X						R	R	
New Holland Honeyeater	<i>Phylidonyris novaehollandiae</i>			X	X +	X	X + + +	X + + +	X		W	C	
Crescent Honeyeater	<i>Phylidonyris pyrrhoptera</i>		X +	X + + +	X + + +		X + + +	X +			W	C	
Tawny-crowned Honeyeater	<i>Phylidonyris melanops</i>				X		X	X +			R	R	
Black Honeyeater	<i>Certhionyx niger</i>										V		
Eastern Spinebill	<i>Acanthorhynchus tenuirostris</i>	X +	X +	X + + +	X + + +	X +	X + +	X + +			W	C	
Scarlet Honeyeater	<i>Myzomela sanguinolenta</i>										V		
White-fronted Chat	<i>Ephthianura albilfrons</i>				X	X +	X + +	X + +			M	C	
Mistletoebird	<i>Dicaeum hirundinaceum</i>			X + + +	X + + +	X + +	X + + +	X + +	X		W	C	
Spotted Pardalote	<i>Pardalotus punctatus</i>		X + +	X + + +	X + + +	X + +	X + + +	X + +			W	C	
Striated Pardalote	<i>Pardalotus striatus</i>	X +	X + +	X + + +	X + + +	X + +	X + + +	X + + +	X		W	C	
Silvereye	<i>Zosterops lateralis</i>	X +	X + +	X + + +	X + + +	X + +	X + + +	X + +	X		W	C	
European Goldfinch (I)	<i>Carduelis carduelis</i>				X +	X +	X + + +	X + + +	X		M	C	
European Greenfinch (I)	<i>Carduelis chloris</i>			X	X +	X +		X	X		M	C	
Eurasian Tree Sparrow (I)	<i>Passer montanus</i>				X	X +	X				M	U	
House Sparrow (I)	<i>Passer domesticus</i>				X +	X +		X +	X		W	C	
Beautiful Firetail	<i>Emblema bella</i>			X							R	R	
Diamond Firetail	<i>Emblema guttata</i>					X +					R	R	
Zebra Finch	<i>Poephila guttata</i>										V		
Chestnut-breasted Mannikin (E)	<i>Lonchura castaneothorax</i>										R	R	
Red-browed Firetail	<i>Emblema temporalis</i>			X + + +	X +	X +	X + +	X + +			W	C	
Common Myna (I)	<i>Acridotheres tristis</i>			X	X +	X +	X + +	X + +	X		W	C	
Common Starling (I)	<i>Sturnus vulgaris</i>			X	X +	X +	X + +	X + +	X		W	C	
Olive-backed Oriole	<i>Oriolus sagittatus</i>			X	X + +	X	X +	X +			W	C	
Spangled Drongo	<i>Dicrurus hottentottus</i>										V		

		SUB-ALPINE VEGETATION Sub-alpine Woodland	MONTANE VEGETATION Montane Dry Woodland Montane Forest Complex	MOIST FORESTS Cool Temperate Rainforest Wet Sclerophyll Forest Damp Sclerophyll Forest Riparian Forest	DRY FOREST Foothill Forest Complex Heathy Dry Forest Dry Sclerophyll Forest	PLAINS VEGETATION Box Woodland Floodplain Riparian Woodland Wetland Community Complex	HEATHLAND VEGETATION Heathy Woodland Wet Heathland Sand Heathland Coastal Heathland	COASTAL VEGETATION Coastal Grassy Forest Dry Coast Complex Coastal Saltmarsh Swamp Scrub	FARMLAND	EMBAYMENTS & OCEANS	DISTRIBUTION	ABUNDANCE	SENSITIVITY
Satin Bowerbird	<i>Ptilonorhynchus violaceus</i>			X + + +	X						X	U	
White-winged Chough	<i>Corcorax melanorhamphos</i>			X + + +	X	X					X	U	
Australian Magpie-lark	<i>Grallina cyanoleuca</i>			X + + +	X +	X + +	X +	X +	X		U	C	
Masked Woodswallow	<i>Artamus personatus</i>				X						R	R	
White-browed Woodswallow	<i>Artamus superciliosus</i>				X						R	R	
Dusky Woodswallow	<i>Artamus cyanopterus</i>			X + +	X +	X +	X + + +	X +			U	C	
Pied Butcherbird	<i>Cracticus nigrogularis</i>										V	C	
Grey Butcherbird	<i>Cracticus torquatus</i>			X + +	X + + +	X	X + + + +	X +			U	C	
Australian Magpie	<i>Gymnorhina tibicen</i>			X + + +	X + + +	X +	X + + + +	X + + + +	X		U	C	
Pied Currawong	<i>Strepera graculina</i>	X +	X + +	X + + +	X + + +	X +	X +	X +			U	C	
Grey Currawong	<i>Strepera versicolor</i>	X +	X + +	X + + +	X + + +	X	X + + + +	X + +			U	C	
Australian Raven	<i>Corvus coronoides</i>		X + +	X + + +	X + + +	X +	X + + + +	X + + + +	X		U	C	
Little Raven	<i>Corvus mellori</i>			X + +	X +	X +	X + + +	X + + + +	X		U	C	

REPTILES

		SUB-ALPINE VEGETATION Sub-alpine Heathland Complex Sub-alpine Woodland	MONTANE VEGETATION Montane Dry Woodland Montane Forest Complex	MOIST FORESTS Cool Temperate Rainforest Wet Sclerophyll Forest Damp Sclerophyll Forest Riparian Forest	DRY FOREST Foothill Forest Complex Heathy Dry Forest Dry Sclerophyll Forest Rocky Outcrop Community Complex	PLAINS VEGETATION Box Woodland Floodplain Riparian Woodland	HEATHLAND VEGETATION Heathy Woodland Wet Heathland Sand Heathland Coastal Heathland	COASTAL VEGETATION Coastal Grassy Forest Dry Coast Complex Coastal Saltmarsh Swamp Scrub	FARMLAND	DISTRIBUTION	ABUNDANCE
Common Long-necked Tortoise	<i>Chelodina longicollis</i>					X +			X	W	C
Murray River Tortoise	<i>Emydura macquarii</i>					X				R	R
Marbled Gecko	<i>Phyllodactylus marmoratus</i>				X	X +				R	U
Striped Legless Lizard	<i>Delma impar</i>					X +				R	R
Common Scaly-foot	<i>Pygopus lepidopodus</i>							X +		R	R
Mountain Dragon	<i>Amphibolurus diemensis</i>		X +		X + +					M	U
Tree Dragon	<i>Amphibolurus muricatus</i>				X + + +		X + + +	X + + +		W	C
Gippsland Water Dragon	<i>Physignathus lesueurii howittii</i>			X						R	R
Eastern Bearded Dragon	<i>Pogona barbatus</i>					X +				R	R
Lined Earless Dragon	<i>Tympanocryptis lineata pinguiicola</i>					X +				R	R
Tree Goanna	<i>Varanus varius</i>			X	+ +	X +		X +		W	U
Large Striped Skink	<i>Ctenotus robustus</i>				X	+ +				X	M
(striped skink)	<i>Ctenotus uber orientalis</i>					X				R	R
Swamp Skink	<i>Egernia coventryi</i>						X +	X + +		R	U
Cunningham's Skink	<i>Egernia cunninghami</i>				X + +	X +				X	R
Black Rock Skink	<i>Egernia saxatilis intermedia</i>			X	+ +	X + + +	X + +			W	C
White's Skink	<i>Egernia whitii</i>	X +		X	+ + +		X + + +	X + + +		W	U
Three-toed Skink	<i>Hemiergis decresiensis</i>				X + +	X +				R	C
Delicate Skink	<i>Lampropholis delicata</i>			X	+ +	X + +	X + +	X + +		M	C
Garden Skink	<i>Lampropholis guichenoti</i>		X +	X + + +	X + + +	X + +	X + + + +	X + + +	X	W	A
Weasel Skink	<i>Lampropholis mustelina</i>			X + + +	X + + +		X + +	X +		X	W
Coventry's Skink	<i>Leiopisma coventryi</i>	X +	X +	X + + + +	X + + + +					W	C
Eastern Three-lined Skink	<i>Leiopisma duerreyi</i>				X + + +	X +	X + + +	X + + +		W	C
Grass Skink FORM A	<i>Leiopisma entrecasteauxii A</i>	X +			X + + +	X +				X	R
Grass Skink FORM B	<i>Leiopisma entrecasteauxii B</i>	X +	X + +		X + +			X +		M	C
Metallic Skink	<i>Leiopisma metallicum</i>	X		X + + +	X +		X + +	X +	X	W	C
Glossy Grass Skink	<i>Leiopisma rawlinsoni</i>						X	X + + +		R	U
Bougainville's Skink	<i>Lerista bougainvillii</i>				X + + +	X +		X		X	M
McCoy's Skink	<i>Nannoscincus maccoyi</i>	X +	X +	X + + +	X + + +		X +	X +	X	W	C

		SUB-ALPINE VEGETATION		MONTANE VEGETATION		MOIST FORESTS				DRY FOREST				PLAINS VEGETATION		HEATHLAND VEGETATION				COASTAL VEGETATION				FARMLAND		DISTRIBUTION	ABUNDANCE
		Sub-alpine Heathland Complex	Sub-alpine Woodland	Montane Dry Woodland	Montane Forest Complex	Cool Temperate Rainforest	Wet Sclerophyll Forest	Damp Sclerophyll Forest	Riparian Forest	Foot-hill Forest Complex	Heathy Dry Forest	Dry Sclerophyll Forest	Rocky Outcrop Community Complex	Box Woodland	Floodplain Riparian Woodland	Heathy Woodland	Wet Heathland	Sand Heathland	Coastal Heathland	Coastal Grassy Forest	Dry Coast Complex	Coastal Saltmarsh	Swamp Scrub				
Spencer's Skink	<i>Pseudemoia spenceri</i>	X	+	X	+	X	+	+	+	X	+	+	+												M	C	
Southern Water Skink CTF	<i>Sphenomorphus tympanum CTF</i>	X	+	X	+	X	+	+	+	X	+	+		X	+	X	+	+	+	X	+	+		X	M	C	
Southern Water Skink WTF	<i>Sphenomorphus tympanum WTF</i>					X			+	X	+	+													M	C	
Blotched Blue-tongued Lizard	<i>Tiliqua nigrolutea</i>					X		+	+	X	+	+	+	X	+	X		+	+	X	+				M	C	
Common Blue-tongued Lizard	<i>Tiliqua scincoides</i>									X		+	+	X	+	X				X			+	X	M	C	
(blind snake)	<i>Ramphotyphlops nigrescens</i>									X				X											R	R	
(blind snake)	<i>Ramphotyphlops proximus</i>																								R	R	
Highland Copperhead	<i>Austrelaps ramsayi</i>			X	+	X		+	+	X	+	+	+												M	C	
Lowland Copperhead	<i>Austrelaps superbus</i>									X	+		+	X	+	X				X	+		+	X	M	C	
Eastern Small-eyed Snake	<i>Cryptophis nigrescens</i>									X	+		+			X	+	+		X	+			X	M	U	
White-lipped Snake	<i>Drysdalia coronoides</i>					X			+	X		+				X		+							M	U	
Tiger Snake	<i>Notechis scutatus</i>			X	+	X	+	+	+	X	+	+		X	+	X	+	+		X	+			X	M	C	
Red-bellied Black Snake	<i>Pseudochis porphyriacus</i>					X			+					X	+										R	U	
Eastern Brown Snake	<i>Pseudonaja textilis</i>									X	+	+	+	X	+					X	+			X	M	C	
Little Whip Snake	<i>Unechis flagellum</i>									X			+	X	+									X	R	C	

AMPHIBIANS

		SUB-ALPINE VEGETATION	MONTANE VEGETATION	MOIST FORESTS	DRY FOREST	PLAINS VEGETATION	HEATHLAND VEGETATION	COASTAL VEGETATION	FARMLAND	DISTRIBUTION	ABUNDANCE
		Sub-alpine Heathland Complex	Montane Dry Woodland	Cool Temperate Rainforest	Foothill Forest Complex	Box Woodland	Heathy Woodland	Coastal Grassy Forest			
		Sub-alpine Woodland	Montane Forest Complex	Wet Sclerophyll Forest	Heathy Dry Forest	Floodplain Riparian Woodland	Wet Heathland	Dry Coast Complex			
				Damp Sclerophyll Forest	Dry Sclerophyll Forest		Sand Heathland	Coastal Saltmarsh			
				Riparian Forest	Rocky Outcrop Community Complex		Coastal Heathland	Swamp Scrub			
Blue Mountain's Tree Frog	<i>Litoria citropa</i>			X					X	R	R
Southern Brown Tree Frog	<i>Litoria ewingii</i>			X	X	X	X	X	X	W	C
Lesueur's Frog	<i>Litoria lesueuri</i>			X						M	U
Plains Brown Tree Frog	<i>Litoria paraewingii</i>				X	X				M	C
Peron's Tree Frog	<i>Litoria peronii</i>					X				R	U
Leaf Green Tree Frog	<i>Litoria phyllochroa</i>			X						R	U
Growling Grass Frog	<i>Litoria raniformis</i>			X	X	X	X		X	W	U
Spotted Tree Frog	<i>Litoria spenceri</i>			X						R	R
*Alpine Tree Frog	<i>Litoria verreauxii alpina</i>	X								R	U
*Verreaux's Tree Frog	<i>Litoria verreauxii verreauxii</i>			X	X	X		X	X	W	C
Victorian Smooth Froglet	<i>Geocrinia victoriana</i>	X	X	X	X		X		X	W	C
Giant Burrowing Frog	<i>Heleioporus australiacus</i>				X					R	R
Southern Bullfrog	<i>Limnodynastes dumerilii</i>			X	X	X	X	X	X	W	C
Striped Marsh Frog	<i>Limnodynastes peronii</i>			X		X			X	M	U
Spotted Marsh Frog	<i>Limnodynastes tasmaniensis</i>			X	X	X	X	X	X	W	C
Common Spadefoot Toad	<i>Neobatrachus sudelli</i>					X			X	M	U
Haswell's Froglet	<i>Paracrinia haswellii</i>						X	X		R	U
Baw Baw Frog	<i>Philoria frosti</i>	X								R	U
Bibron's Toadlet	<i>Pseudophryne bibronii</i>				X	X				W	C
Dendy's Toadlet	<i>Pseudophryne dendyi</i>			X						M	C
Southern Toadlet	<i>Pseudophryne semimarmorata</i>			X	X		X	X	X	W	C
Plains Froglet	<i>Ranidella parinsignifera</i>			X	X	X			X	R	U
Common Froglet	<i>Ranidella signifera</i>	X		X	X	X	X	X	X	W	A

*Subspecies of *Litoria verreauxii*

Appendix VI

SIGNIFICANT AND NOTABLE VERTEBRATE FAUNA

Common name	Scientific name	Distribution			Abundance			Conservation status		Population trends in Victoria	Comments
		Aust	Vict	Mbn2	Aust	Vict	Mbn2	Aust	Vict		
<u>Significant Taxa</u>											
Tiger quoll	<i>Dasyurus maculatus</i>	R	M	M	U	R	R	-	V	D	A vulnerable species whose range has decreased markedly since European settlement.
Leadbeaters possum	<i>Gymnobelideus leadbeateri</i>	R	R	M	-	-	U	E	E	D	The entire range of this endangered species is within the study area.
Large-footed myotis	<i>Myotis adversus</i>	M	M	M	R	R	R	-	IND	?	A rare species of bat which feeds exclusively over permanent water bodies.
Eastern broad-nosed bat	<i>Scotorepens orion</i>	R	M	R	R	R	R	-	IND	?	A rarely recorded bat of which virtually nothing is known of its biology.
New Holland mouse	<i>Pseudomys novaehollandiae</i>	R	R	R	C	R	R	-	E	D?	This native rodent has a disjunct coastal distribution, and is reliant on regenerating heaths.
Australian fur-seal	<i>Arctocephalus pusillus</i>	R	R	R	C	C	C	-	-	D	The largest Victorian breeding colony is on Seal Rocks off Phillip Island.
Southern right whale	<i>Balaena glacialis</i>	R	R	R	R	R	R	E	V	D	Hunted to the brink of extinction last century, this species is now slowly recovering in numbers.
Humpback whale	<i>Megaptera novaeangliae</i>	R	R	R	R	R	R	E	E	D	Hunting over the last two centuries has drastically reduced the numbers of this migratory whale.
Little penguin	<i>Eudyptula minor</i>	M	M	M	U	U	U	-	-	D	Phillip Island colony is approximately 30% of the estimated Victorian breeding population.
Short-tailed shearwater	<i>Puffinus tenuirostris</i>	R	M	R	A	A	A	-	-	S?	Phillip Island has the largest breeding colony in Victoria - up to 645 000 burrows.
Australian pelican	<i>Pelicanus conspicillatus</i>	W	W	M	C	C	C	-	R/C	?	French Island has one of only four permanent breeding colonies in Victoria.
Pied cormorant	<i>Phalacrocorax varius</i>	W	W	M	U	U	U	-	R/C	?	Western Port colony is one of only two regularly used nesting sites in Victoria.
Square-tailed kite	<i>Lophoictinia isura</i>	W	W	R	R	R	R	-	V	D?	May be distributed throughout open forests and woodlands of lower altitudes at very low density.
King quail	<i>Coturnix chinensis</i>	R	R	R	R	R	R	-	R	D	French Island is the stronghold in Victoria for this species.
Plains-wanderer	<i>Pedionomus torquatus</i>	M	M	R	R	R	R	V	V	D	Study area has probably never been important to this species.

Appendix VI (continued)

Common name	Scientific name	Distribution			Abundance			Conservation status		Population trends in Victoria	Comments
		Aust	Vict	Mbn2	Aust	Vict	Mbn2	Aust	Vict		
Bush thick-knee	<i>Burhinus magnirostris</i>	W	M	R	U	R	R	-	V	D	Declined in the study area and there is now only one small population known, north-east of Seymour
Pied oystercatcher	<i>Haematopus longirostris</i>	M	M	M	U	U	U		-	?	Breeding on beaches, this species is vulnerable to disturbance by people, dogs, and foxes. Western Port is a very important breeding area.
Hooded plover	<i>Charadrius rubricollis</i>	M	M	R	U	U	U	V	V	D?	Vulnerable to disturbance while nesting on ocean beaches.
Eastern curlew	<i>Numenius madagascariensis</i>	M	M	R	U	U	U	-	R	S	Western Port is a major overwintering site. Approximately 5% of the total world population winter there.
Little tern	<i>Sterna albifrons</i>	R	R	R	R	R	R	E	E	D	The smallest species of tern, which has a breeding population in Victoria of only 120 pairs. Western Port is only visited occasionally.
Fairy tern	<i>Sterna nereis nereis</i>	M	M	R	R	R	R	-	V	D	French Island contained an important breeding site at Rams Island until 1987. There now appears to be no breeding in the study area.
Swift parrot	<i>Lathamus discolor</i>	R	M	M	R	R	R	V	IND	D	A winter migrant, present in the study area in variable numbers depending on seasonal variation in flowering by eucalypts.
Orange-bellied parrot	<i>Neophema chrysogaster</i>	R	R	R	R	R	R	E	E	D	Migrates from Tasmania to mainland each year. This very rare, endemic parrot winters in coastal salt marsh in south-east Australia. Saltmarsh on French Island are important in early winter.
Sooty owl	<i>Tyto tenebricosa</i>	R	M	M	R	R	U	-	R	D?	This species is restricted to tall wet forests containing large mature trees. Timber harvesting and predicted climate change are threats to its conservation.
Pink robin	<i>Petroica rodinogaster</i>	R	M	W	R	U	U	-	-	?	Breeding is restricted primarily to cool-temperate rainforest gullies.
Grey-crowned babbler	<i>Pomatostomus superciliosus</i>	W	M	R	C	R	R	-	V	D	Range in southern Victoria has contracted substantially. Study area contains last populations south of Great Divide which are now threatened with extinction.

Regent honeyeater	<i>Xanthomyza phrygia</i>	R	M	R	R	R	R	E	E	D	Severe decline to present population of <1000 individuals. Clearance of high-fertility box-ironbark forests is probably the major reason.
Helmeted honeyeater	<i>Lichenostomus melanops cassidix</i>	R	R	R	R	R	R	E	E	D	Subspecies of a more widespread species. The remaining tiny endangered by fragmentation and competition with bell miners.
Spotted tree frog	<i>Litoria spenceri</i>	R	R	R	R	R	R	E	E	D	This endangered species is currently known from only 2 localities - one of which is in the study area on the Taponga River.
Giant burrowing frog	<i>Heleioporus australiacus</i>	R	R	R	R	R	R	-	IND	?	Within the study area this large, burrowing frog is restricted to the extreme eastern boundary. It has not been recorded from there since 1966.
Baw Baw frog	<i>Philoria frosti</i>	R	R	R	-	-	U	V	V	D?	The entire global distribution of this alpine-adapted frog occurs on the Baw Baw Plateau. Current threats from recreational activities may degrade its habitat of wet alpine heath communities.
Striped legless lizard	<i>Delma impar</i>	R	M	R	R	R	R	V	V	D	This cryptic species, only known from a few records, is restricted to the basaltic plains in the west of the study area. It is threatened by intensive cultivation.
Lined earless dragon	<i>Tympanocryptis lineata</i>	R	R	R	R	R	R	E	E	D?	This endangered dragon is limited by the lack of suitable native grasslands.
Swamp skink	<i>Egernia coventryi</i>	R	M	R	R	U	U	-	R	D	This rare lizard occurs in disjunct populations favouring the swamp scrub, wet heathland, and salt-marsh communities of the study area.
Metallic skink	<i>Leiopisma metallicum</i>	R	R	W	C	C	C	-	-	?	A large proportion of this species' Victorian range occurs within the study area.
<u>Notable Taxa</u>											
Swamp antechinus	<i>Antechinus minimus</i>	R	R	R	R	R	R	-	R	D?	A rare insectivorous marsupial restricted to wet heaths and tussock grasslands near the coast.
Brush-tailed phascogale	<i>Phascogale tapoatafa</i>	M	M	M	C	U	U	-	R	D	There has been a considerable reduction in the distribution and abundance since European settlement, of this species.
Common dunnart	<i>Sminthopsis murina</i>	M	M	R	C	R	R	-	R	D?	The study area is the eastern limit of the Victorian distribution of this rare marsupial.

Appendix VI (continued)

Common name	Scientific name	Distribution			Abundance			Conservation status		Population trends in Victoria	Comments
		Aust	Vict	Mbn2	Aust	Vict	Mbn2	Aust	Vict		
Squirrel glider	<i>Petaurus norfolcensis</i>	M	M	R	R	R	R	-	R	D?	A rare possum restricted to remnant forests and woodlands of the inland plains. The protection of roadside reserves within the Seymour district is vital for the future survival of this species within the study area.
Eastern horseshoe-bat	<i>Rhinolophus megaphyllus</i>	R	M	R	C	U	R	-	R/C	I?	A threatened species whose range has extended into the study area since European settlement by using mineshafts.
Common bent-wing Bat	<i>Miniopterus schreibersii</i>	M	M	M	A	C	U	-	R/C	S?	A cave roosting species found in mineshafts and tunnels in the study area.
Broad-toothed rat	<i>Mastacomys fuscus</i>	R	M	M	U	U	U	-	R	D?	A rare native rodent restricted to areas with high rainfall and a dense ground layer of grasses, sedges and herbs.
Smoky mouse	<i>Pseudomys fumeus</i>	R	M	R	R	U	U	-	R	D?	In the study area this species is restricted to dry ridge-top forest with a diverse heathy understorey.
Little bittern	<i>Ixobrychus minutus</i>	M	M	R	R	R	R	-	R	D	Secretive inhabitant of dense wetland vegetation, mainly in the north of the State. Rarely recorded in the study area.
Australasian bittern	<i>Botaurus poiciloptilus</i>	M	M	R	U	R	R	-	INS	D	Secretive inhabitant of dense wetland vegetation. Appears now to be quite uncommon in Victoria.
Grey goshawk	<i>Accipiter novaehollandiae</i>	M	M	R	U	R	R	-	R	?	A rarely recorded inhabitant of low-elevation forests in study area.
White-bellied sea-Eagle	<i>Haliaeetus leucogaster</i>	M	M	R	U	R	R	-	R	D	Declined in study area. There is now only 1 breeding pair in the study area.
Freckled duck	<i>Stricktonetta naevosa</i>	M	M	R	R	R	R	-	R	?	This species is only occasionally recorded in the study area.
Blue-billed duck	<i>Oxyura australis</i>	M	W	M	U	R	R	-	R	D	Lives on deep permanent swamps. Suitable habitat has been substantially reduced in the study area.
Lewins rail	<i>Rallus pectoralis</i>	M	M	M	?	R	R	-	INS	D	A secretive, rarely observed bird living in heavily vegetated swamps and saltmarsh. There are many records from around Western Port.
Baillon's crake	<i>Porzana pusilla</i>	M	M	R	U	R	R	-	INS	D?	A small, cryptic inhabitant of freshwater wetlands, which is a summer migrant.
Painted snipe	<i>Rostratula benghalensis</i>	M	W	R	U	R	R	-	IND	?	A cryptic wetland species, which is rare throughout Victoria.

Powerful owl	<i>Ninox strenua</i>	R	M	M	R	R	U	-	R	D	Old-growth mixed-species forest is important for the survival of this species. Timber harvesting reduces densities of prey species and nesting hollows and is probably the main threat to the species conservation.
Barking owl	<i>Ninox connivens</i>	M	M	R	U	R	R	-	R	D?	A rare inhabitant of dry woodlands and forests.
Painted honeyeater	<i>Grantiella picta</i>	M	M	R	?	R	R	-	IND	D?	Specialises on the fruits of mistletoes, in drier forests and woodlands. Vegetation on roadsides and private land are probably very important.
Beautiful firetail	<i>Emblema bella</i>	R	M	R	U	U	R	-	-	D	Clearance of heaths and heathy woodlands has substantially reduced the distribution of this species in study area.
Blue mountains Tree frog	<i>Litoria citropa</i>	R	R	R	U	U	R	-	IND	?	Known within the study area only from 3 specimens collected from the Aberfeldy area in the 1920s. This locality is widely separated from the East Gippsland populations.
Common scaly-foot	<i>Pygopus lepidopodus</i>	M	M	R	U	U	R	-	-	D?	Historic records of this legless lizard come from Bittern and Bunyip. Now confined within the study area to isolated populations on the Mornington Peninsula.
Mountain dragon	<i>Amphibolurus diemensis</i>	R	M	M	U	U	U	-	INS	?	A rarely recorded dragon. Virtually nothing is known of its biology.
Tree goanna	<i>Varanus varius</i>	M	W	W	U	U	U	-	INS	D?	This large reptile (also known as the lace monitor), appears to be more common in drier habitats of the study area. It may be undergoing a reduction in range.
Glossy grass skink	<i>Leiopisma rawlinsoni</i>	R	R	R	U	U	U	-	INS	?	This recently described species has only been found in paperbark scrub and saltmarsh. May be recognised as more widespread with further searching.
(blind snake)	<i>Ramphotyphlops proximus</i>	M	M	R	?	R	R	-	R	D?	This rare blind snake has only been recorded from Kerrisdale and Seymour within the study area. It has not been seen in the study area since the start of this century.

Key to Appendix VI is shown on page 390

KEY TO APPENDIX VI

Distribution¹

Distribution has been assessed in Australia, Victoria, and the Melbourne District 2 study area using the following criteria -

- R restricted (occurs in less than 10% of area)
- M moderate (occurs in 10-50% of area)
- W widespread (occurs in greater than 50% of area)

Conservation status

Conservation status in Australia is taken from the 'Draft List of Australian Endangered Vertebrate Fauna' (September 1990) compiled by CONCOM Working Group on Endangered Fauna.

- E endangered²
- V vulnerable³
- R rare⁴
- IND indeterminate⁵
- INS insufficiently known⁶
- R/C restricted colonial breeding or roosting sites⁷

Abundance¹

Abundance has been assessed within the known distribution of each species within Australia, Victoria, and the Melbourne District 2 study area. For those species confined to the study area, the abundance in areas other than the study is not relevant and so has been left blank.

- R rare
- U uncommon
- C common
- A abundance
- ? abundance not known

Population trend in Victoria (number or distribution)

- D decrease (number or distribution of records has decreased since European settlement)
- S stable (no apparent change in number or distribution of records since European settlement)
- I increase (number or distribution of records has increased since settlement)
- D? possible decrease (based on known habitat)
- S? possibly stable (based on known habitat)
- I? possible increase (based on known habitat)
- ? unknown

Notes:

1. Both distribution and abundance are subjective assessments based on: for Australia - the scientific literature; for Victoria - the scientific literature and the Atlas of Victorian Wildlife; and for Melbourne, District 2 study area - the scientific literature and extensive survey data collected in recent years.
2. Endangered - taxa in danger of extinction in Victoria and whose survival is unlikely if the causal factors continue operating.
3. Vulnerable - taxa believed likely to move into the endangered category in the near future if the causal factors continue operating.
4. Rare - taxa with small Victorian populations that are not at present endangered or vulnerable but are at risk.
5. Indeterminate - taxa *known* to be endangered, vulnerable or rare in Victoria but where there is not enough information to say which of the three categories is appropriate.
6. Insufficiently known - taxa that are *suspected* but not definitely known to belong to any of the above categories, because of lack of information.
7. Retricted colonial breeding or roosting sites - taxa that concentrate at specific points for special life cycle events are included on the threatened species list if there are only a number of these critical sites in Victoria.

Appendix VII

RECENT TAXONOMIC AND NOMENCLATURAL CHANGES OF THE MAMMALS, REPTILES, AND AMPHIBIANS

Explanations of some inclusions and exclusions from the list for the Melbourne Area, District 2

This list highlights differences in the taxonomic status of species since the original Land Conservation Council's Melbourne report, to enable readers to make use of this earlier literature. The names used in the Council's (1973) report are given first, followed by the more recent information. The references will be available in a forthcoming public DCE report on the study area's fauna.

Mammals

Greater glider - *Schoinobates volans* - now *Petauroides volans* (McKay 1982)

Little flat bat - *Tadarida planiceps* - now little mastiff-bat (*Mormopterus planiceps*) Freeman 1981. There are two forms of this species (Adams *et al.* 1988) which are to be recognised as distinct species. At present only males are distinguishable (by the length of the penis) and the two forms are referred to as long penis' and 'short penis' forms.

Little bat - *Eptesicus pumilus* - this species has now been divided into a number of species, of which three are present in the study area - large forest eptesicus (*E. darlingtoni*), King River eptesicus (*E. regulus*) and little forest eptesicus (*E. vulturinus*) (McKean *et al.* 1978, Kitchener *et al.* 1987).

Little broad-nosed bat - *Nycticeius greyi* - there are no records of this species for the study area, however, there are records of the eastern broad-nosed bat (*Scotorepens orion*). The generic name was revised by Kitchener and Caputi (1985).

Greater long-eared bat - *Nyctophilus timoriensis* - records of this species from the study area are not considered to be Goulds long-eared bat (*N. gouldi*).

Tasmanian pipistrelle (mistakenly written as Dipistrelle) - *Pipistrellus tasmaniensis* - now great pipistrelle (*Falsistrellus tasmaniensis*) (Kitchener *et al.* 1986).

Reptiles and Amphibians

Amphibolurus barbatus - in a revision of the bearded dragons, Storr (1982) split this large genus into a number of genera and included this species as *Pogona barbatus*.

Ergenia luctuosa - this species group contains two species of which one, *E. luctuosa* is confined to south-west Australia (Storr 1978). The Victorian representative, *E. coventryi*, occurs in the Melbourne Area, District 2.

Leiopisma delicata, *L. guichenoti* and *L. mustelinum* - these species have all been placed within the genus *Lampropholis* (Mittleman 1952).

Leiopisma entrecasteauxii - the genus *Leiopisma* is currently undergoing revision, with the *L. entrecasteauxii* group through to contain a number of taxa. As yet, *L. rawlinsoni* (Hutchinson and Donnellan 1988) is the only taxon to be formally described with other forms referred to as *L. entrecasteauxii* Group 1 (Form A) and *L. entrecasteauxii* Group 2 (Form B) (Donnellan and Hutchinson 1990).

L. trilineatum - this species group contains two species of which one, *L. trilineatum* is confined to the south-west corner of Australia (Greer 1982). The Victorian representative *L. duperreyi* occurs in the Melbourne Area, District 2.

L. weekesae - in 1973 this taxon was believed to be an 'undescribed species' (LCC 1973). However, *L. weekesae* is no longer a valid name and is now considered to be synonym of *Pseudemoia spenceri* (Rawlinson 1975). Other specimens, referred to as *L. weekesae* in the past, are now known to be *L. coventryi*.

Anotis maccoyi - Czechura (1981) noted that the generic name was preoccupied and therefore assigned this species to *Nannoscincus maccoyi*.

Typhlops spp. - the generic name *Ramphotyphlops* now applies (Robb 1966).

Austrelaps superba - the copperhead snake has long been referred to as two distinct forms, viz., highland and lowland (Rawlinson 1969). The highland copperhead is now referred to as *Austrelaps ramsayi* (see Sutherland 1983, originally described by Krefft 1894), while *Austrelaps superbus* is now applied only to the lowland copperhead.

Suta flagellum - now referable to *Unechis flagellum* (Cogger 1986).

Litoria aurea raniformis - has been elevated to full specific status as *Litoria raniformis* (Courtice and Grigg 1975).

Litoria maculata - now *L. spenceri* (Dubois 1984).

Crinia haswelli - a complex genus receiving a considerable degree of taxonomic attention; this species is currently listed under *Paracrinia haswellii* (Heyer and Liem 1976).

Neobatrachus pictus - Roberts (1978) resurrected *N. sudelli* from the synonym to include these populations from the Melbourne Area, District 2.

Appendix VIII

FRESHWATER FISH IN THE STUDY AREA

Table 1: CONSERVATION STATUS OF NATIVE SPECIES RECORDED IN THE STUDY AREA

Common name	Scientific name	Conservation status in Victoria
Brown galaxias	<i>Galaxias olidus</i> var. <i>fuscus</i>	Engangered
Australian grayling	<i>Prototroctes maraena</i>	Vulnerable
Macquarie perch	<i>Macquarie australasica</i>	
Murray cod	<i>Maccullochella peeli</i>	
Broad-finned galaxias	<i>Galaxias brevipinis</i>	Potentially threatened
Dwarf galaxias	<i>Galaxias pusilla</i>	
Pouched lamprey	<i>Geotria australis</i>	
Spotted galaxias	<i>Galaxias truttaceus</i>	
Flat-headed galaxias	<i>Galaxias rostratus</i>	Indeterminate
Freshwater blackfish	<i>Gadopsis marmoratus</i>	
Mountain galaxias	<i>Galaxias olidus</i>	
Two-spined blackfish	<i>Gadopsis bispinosus</i>	Restricted
Australian smelt	<i>Retopinna semoni</i>	Presently common and/or widespread
Common galaxias	<i>Galaxias maculatus</i>	
Flat-headed gudgeon	<i>Philynodon grandiceps</i>	
Long-finned eel	<i>Anguilla reinhardtii</i>	
Short-headed lamprey	<i>Mordacia mordax</i>	
Short-finned eel	<i>Anguilla australis</i>	
Southern pigmy perch	<i>Nannoperca australis</i>	
Tupong	<i>Pseudaphritis urvillia</i>	

Source: DWR (1989), Koehn & Morrison (1990)

Table 2: ADDITIONAL SPECIES WHOSE PROBABLE NATIVE RANGE IS WITHIN THE STUDY AREA

Common name	Scientific name	Conservation status in Victoria
Blue-spot goby	<i>Pseudogobius olorum</i>	Presently common and/or widespread
Bridled goby	<i>Arenigobius bifrenatus</i>	Presently common and/or widespread
Estuary perch	<i>Macquaria colonorum</i>	Presently common and/or widespread
Small-mouthed hardyhead	<i>Atherinosoma microstoma</i>	Presently common and/or widespread
Tamar river goby	<i>Favonigobius tamarensis</i>	Presently common and/or widespread
Trout cod	<i>Maccullochella macquariensis</i>	Endangered

Sources: Cadwallader and Backhouse (1983), Koehn and O'Connor (1990)

Table 3: INTRODUCED FRESHWATER FISH IN THE STUDY AREA

Fish species common name	Scientific name	Fish species common name	Scientific name
Brown trout	<i>Salmo trutta</i>	Rainbow trout	<i>Salmo gairdneri</i>
Carp	<i>Cyprinus carpio</i>	Roach	<i>Rutilus rutilus</i>
English perch	<i>Perca fluviatilis</i>	Tench	<i>Tinca tinca</i>
Goldfish	<i>Carassius auratus</i>	Leach	<i>Misgurnus anguillicaudatus</i>
Mosquitofish	<i>Gambusia holbrooki</i>	Yellow-fin goby	<i>Acanthogobius flavimanus</i>

Source: DWR (1989)

Appendix IX

GLOSSARY OF LANDSCAPE EVOLUTION AND SOIL TERMS

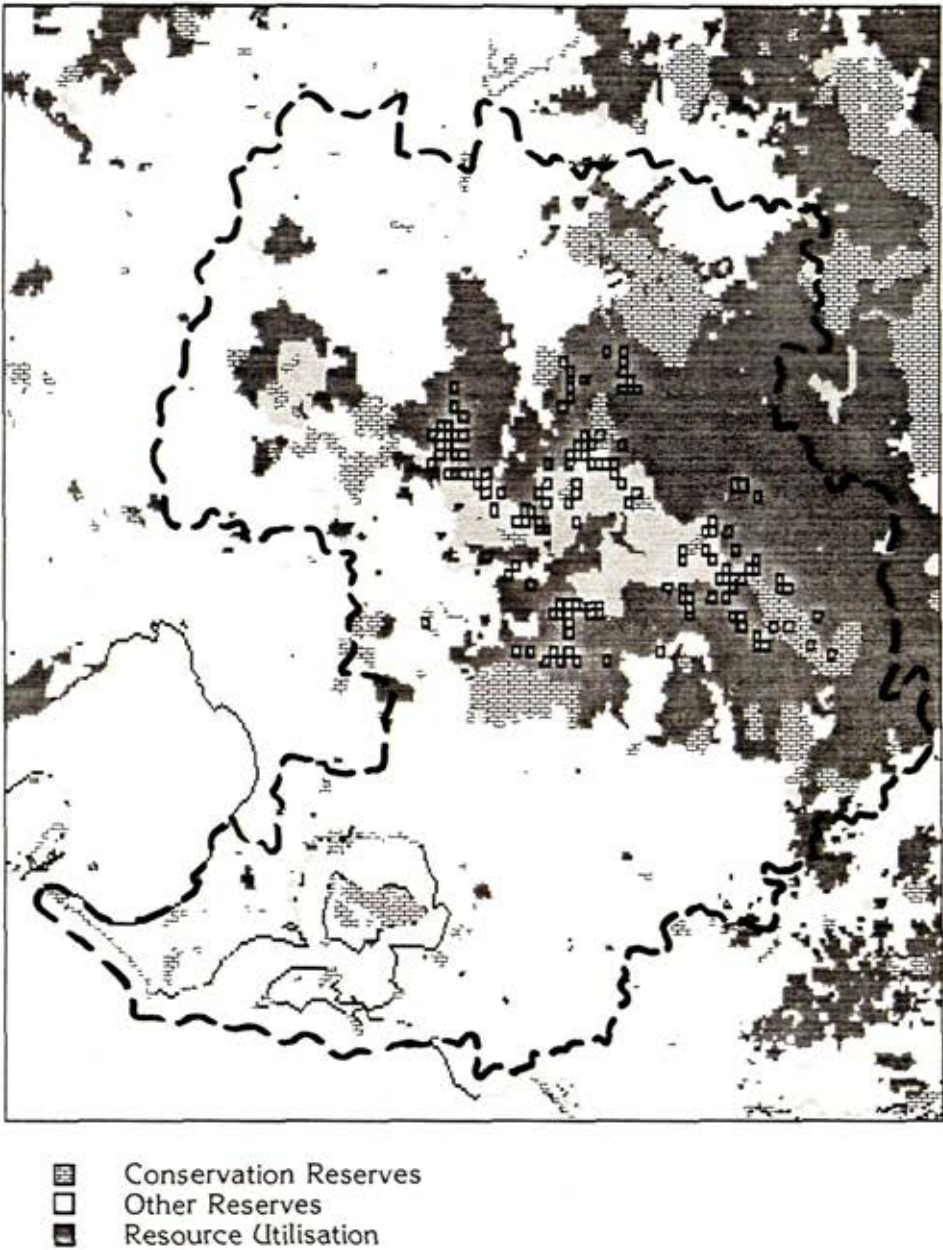
Alluvium	A general name for sediments deposited in land environments by watercourses.
Arkose	A sedimentary sandstone, containing at least 25% feldspar, as well as quartz, and other minerals in lesser amounts.
Basalt	An igneous rock, dark-coloured and fine-grained, with a relatively low silica content.
Calcareous	Containing calcium carbonate.
Conglomerate	A clastic sedimentary rock containing numerous rounded pebbles or larger particles.
Clastic rocks	Rocks composed of fragments of pre-existing rocks and sediments and organic skeletal remains, produced by weathering and erosion, and transported to a site of deposition.
Escarpment	A steep slope or cliff.
Eustatic sea-level change	A world-wide sea-level change resulting from an alternation in the amount of water or the capacity of the ocean basin.
Fault	A fracture in a rock along which the opposite sides have been relatively displaced.
Fold	A flexure of rocks involving a change in the dip of a bed, and possibly the change in direction.
Glaciation	The effects of the massive movement of ice altering the land surface.
Granite	An igneous rock, coarse-grained and predominantly consisting of quartz and alkali feldspars.
Horst	An upthrown area between two parallel faults.
Igneous	A rock or mineral formed by the solidification of molten silicate materials.
Lava	Molten silicate materials reaching the earth's surface.
Limestone	A sedimentary rock, predominantly consisting of calcium carbonate.
Monadnock	A conspicuous residual hill of resistant rock rising above the general level of a plain.

Appendix IX (continued)

Monocline	A type of fold, in which a flexure resulting in a sudden increase in the dip of a bed to a near vertical position, is followed by a flattening to the original dip. On either side of the flexure the strata are horizontal or dip uniformly at low angles.
Plateau	An extensive upland, underlain by essentially horizontal strata, and having large areas where the surface is nearly flat.
Sandstone	A clastic sedimentary rock, consisting predominantly of sand-sized particles.
Sediment	Non-cemented rock fragments that have been transported and deposited by air, water, or ice.
Sedimentary rock	Rock formed by cementation of sediment or by other processes.
Shale	A sedimentary rock, composed of clay-sized and silt-sized particles of unspecified mineral composition.
Siltstone	A clastic sedimentary rock, consisting predominantly of silt-sized particles.
Tectonic	Relating to the processes that tend to build up the various features of the earth's crust.
Topography	The relief and form of a land surface.
Vulcanicity	Processes associated with volcanic activity.
Weathering	The process whereby rock materials are broken down or chemically altered during exposure to air, moisture, and organic matter.

Appendix X

FIGURE 16:
LEADBEATER'S POSSUM



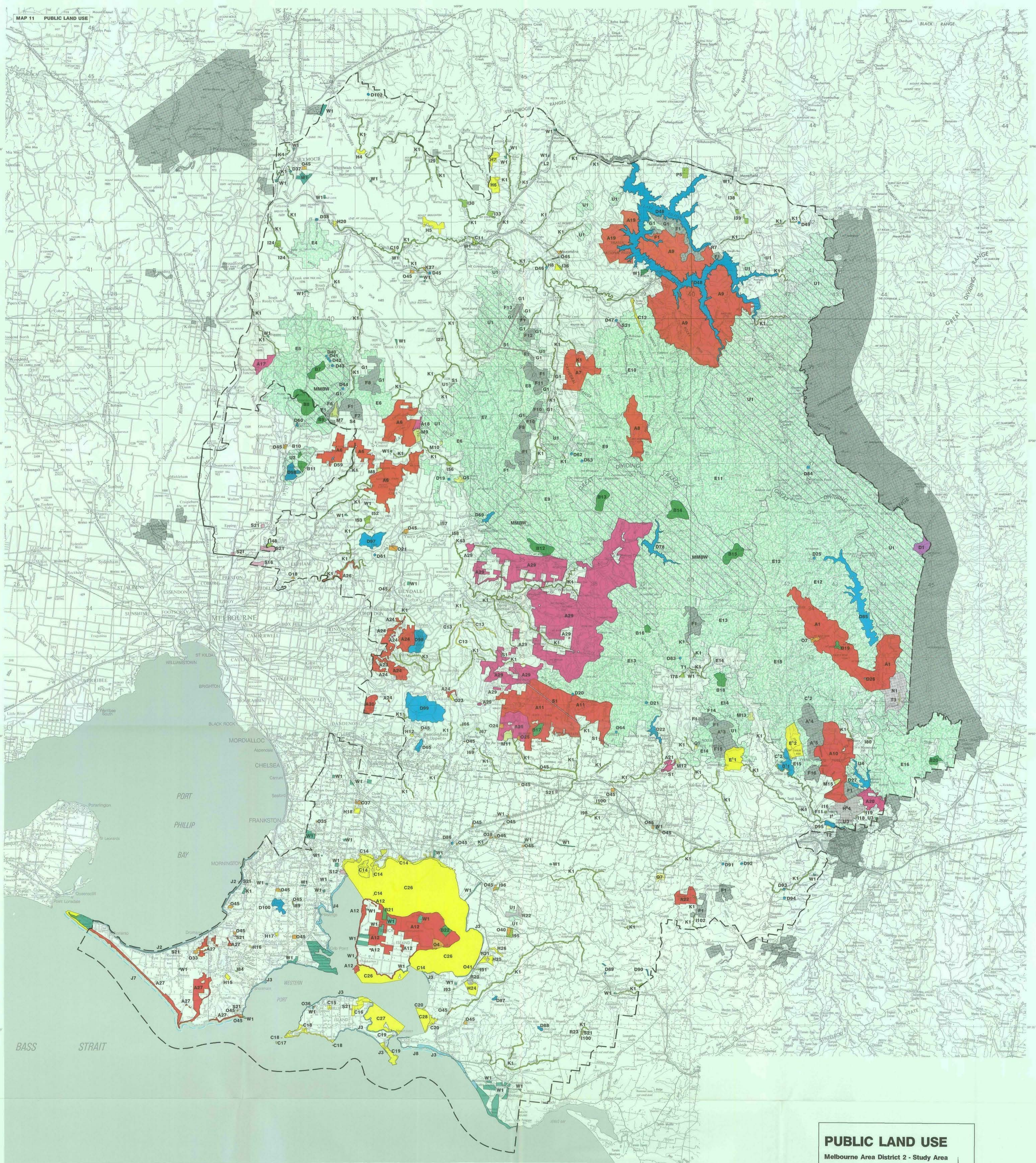
The distribution of Leadbeater's Possum *Gymnobelideus leadbeateri* since 1961, within land use categories.

'Conservation Reserves' are reserves where conservation is one of the primary aims (e.g. national and State parks, flora and fauna reserves).

'Other Reserves' are those where conservation is not the primary aim (e.g. Board of Works protected catchments).

'Resource Utilisation' is predominantly State forest

Distribution is shown on a 1' latitude by longitude grid basis.



PUBLIC LAND USE

Melbourne Area District 2 - Study Area

1 : 250 000

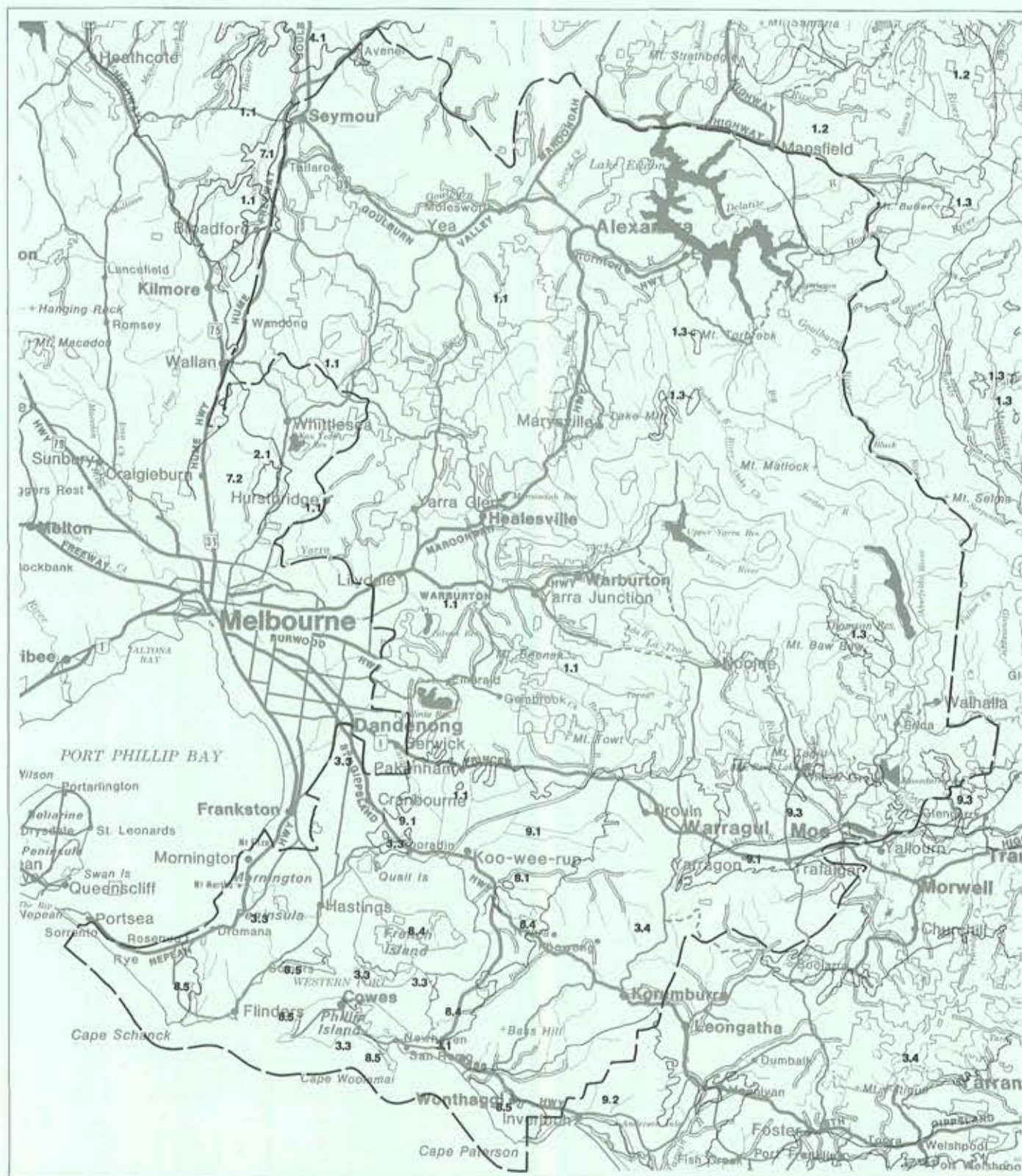
Land Conservation Council Victoria

- Notes:**
- The recommendation numbers refer to the Land Conservation Council's final recommendations for the Melbourne Study Area, published in 1977. Recommendations were made in the subsequent LCC special investigations of Hill End and La Trobe that altered Council's earlier Melbourne study area recommendations. Government amendments to Council's recommendations also altered the earlier Melbourne study area recommendations. In all cases the most recent recommendation is shown on the map.
 - Council's Review of Melbourne Study Area, District 1 covered the western portion of the original Melbourne study area. In the Melbourne Study Area, District 1 Review, many of the earlier Melbourne study area recommendation numbers were altered. Readers should note that the Melbourne Study Area, District 1 Final Recommendations contains recommendation numbers for different areas than those shown on this map. This map of Melbourne Study Area, District 2 retains the original Melbourne study area recommendation numbers.
 - Some public land water frontage reserves and transmission line easements and many other small areas of public land cannot be accurately depicted at this scale and are not shown.
 - Areas shown as 'State Forest' include the earlier recommendations of 'hardwood production', 'uncommitted' and 'forest areas', although the original recommendation numbers are shown.
 - The Borough of Wertheim has been added to the study area since Council's earlier investigation. As such, Council has no recommendations over the public land in the Borough. These public lands are therefore shown as 'Other Reserves and Public Land'.
 - Although included in Council's earlier investigation, the City of Whittlesea is now excluded - for reasons explained in the Descriptive Report. The City is located immediately north of metropolitan Melbourne, and its boundaries are marked accordingly.

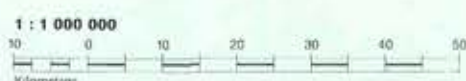
LEGEND			
NATIONAL PARKS	A1 A23-A24 A27	Bar Bar Dandenong Ranges Point Nepean	A6 A19 Kinglake Fraser
STATE PARKS	A7 A8 A9 A10 A11	Cardinal Lake Mountain Mount North Moondarra Bump	A12 A22 A25 A30 French Island Mount Sturt Gembrook Lyonsfield Park
REGIONAL PARKS	A17 A18 A20	Wandong Yea River Tiers	A21 A25 A30 Crosser Gembrook Lyonsfield Park
MULTI-PURPOSE PARK	A29	Yarra Valley	
HIGHWAY PARK	L2	Merton	
REFERENCE AREAS	B7 B8 B9 B10 B11 B12 B13 B14	Stony Creek Disappointment Joy Creek Yan Yean (north) Yan Yean (south) Watts River Deep Creek Walsh Creek	B15 B16 B17 B18 B19 B20 B21 B22 Mount Gregory Bernie Creek Diamond Creek Hawthorn Creek Baw Baw Eaglehawk Creek French Island (north) French Island (south)
WILDLIFE RESERVES	C9 C10 C11 C12 C13 C14	Freshwater Swamp Homewood Moorooduc Snake Creek Valleyglen Western Port	C15 C16 C17 C18 C19 C20 Phillip Island (inland) Rhyll Swamp Seal Rocks Phillip Island (coastal) Newhaven Swamp Reef Island-Bass River
WILDLIFE MANAGEMENT CO-OPERATIVE AREAS	C25 C26	Point Nepean Western Port	C27 C28 Rhyll-Newhaven Reef Island-Bass River
FLORA RESERVES	H4-H6, H11-H12, H15-H19		
FLORA AND FAUNA RESERVES	H20	Various	E11 Sweetwater Creek Bull Best Creek
BUSHLAND RESERVES	I24, I27-I30, I32-I39, I48-I51, I53-I74, I76-I80, I84-I105, F11		
SCENIC RESERVES	P4, P5, P6		
PUBLIC LAND WATER FRONTAGE RESERVES	K1	Various	
STREAMSIDE RESERVES	K24-K30, K40-K45, K49	Various	
RECREATION	O4, O7, O17-O25, O33-O42, O45	Various	
WATER PRODUCTION	D15, D19-D27, D37-D49, D55-D65, D67-D95, D97-D103, D11		
COASTAL RESERVES	J3	Flinders to Hares Inlet-Phillip Island and Watson's Inlet to Cape Patterson	J4 Hares Inlet to Watson's Inlet
SCENIC COAST	J7 J8	Point Nepean to West Head, Flinders Elliff Point, San Remo to Black Head, Kilcunda	
STATE FOREST HARDWOOD PRODUCTION	E4 E5 E6 E7 E8 E9 E10 E11	Tallarook Forest Mount Disappointment Forest Toolang Forest Murrumbidgee Forest Black Range Forest Marysville Forest Rusby Forest Big River Forest	E12 E13 E14 E15 E16 E17 E18 E19 Thomson Forest Tarago-La Trobe Forest Neeson East Forest Tanjil-Tyers Forest Bottle Bottle Forest Tanjil River Various
UNCOMMITTED	U1 U2 U3	Various Yan Yean System SEC Land	I4 I16 I14 SEC land for disposal SEC land for disposal Land to be retained by SEC
SOFTWOOD PRODUCTION	F6-F12 F14-F16 A3	Central & Benalla/Mansfield zones La Trobe zone Harold Creek	A4 A15 Good Hope Creek Serpentine
EDUCATION AREAS	M7 M8 M9 M10 M11	Kinglake West Kinglake Andrews Hill Castella Ternbulluk	M12 M13 M14 M15 Crosser Furness South Tanjil Boggy Creek
AGRICULTURE	Q1, Q2 Q5	Toolangi	Q7 Ellinbank
TOWNSHIP LAND	T1	Various	T3 Wahalla
HISTORIC AREA	N1	Wahalla	
NATURAL FEATURE ZONE	D1	Mount Useful	
MINERALS AND STONE	R6, R7, R13-R16, R18-R24		
UTILITIES AND SURVEY	S1 S4-S6, S8 S11	Existing powerlines Waste disposal sites Railway lines	S12 S19 S21 Possible future power stations Western Port Existing utilities-various
OTHER RESERVES AND PUBLIC LAND	W1	Various	

Commonwealth land (not public land as defined in the Land Conservation Act 1970)

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PHYSIOGRAPHIC UNITS



Land Conservation Council
Victoria

LEGEND

- Geomorphic Unit Boundaries
- 1.1 Geomorphic Unit Map Symbol
- Boundary of Study Area

GEOMORPHIC UNITS

GEOMORPHIC UNITS											
Geomorphic Unit		Map Symbol	Description	Geomorphic Unit		Map Symbol	Description	Geomorphic Unit		Map Symbol	Description
Central Victorian Uplands	East Victorian Uplands	1.1	Dissected uplands	Murray Basin Plains	Riverine Plains	4.1	Present floodplain (Murray Valley)	South Victorian Coastal Plains		8.1	Ridges and flats (Follett)
		1.2	Dissected plateaux (Wellington uplands)			4.2	Older alluvial plain (Shepparton)			8.2	Dissected plains (Port Campbell)
		1.3	High plains (Dargo, Bogong, etc)		5.1	Low calcareous dunes (Ouyen)	8.3			Sand and clay plains (Moorabbin)	
	West Victorian Uplands	2.1	Dissected uplands (Midlands,etc)		5.2	High siliceous dunes (Big Desert/Sunset)	8.4			Fans and terraces (Western Port)	
		2.2	Prominent ridges (Grampians)		Wimmera Plains	6.1	Clay plains (Nhill)			8.5	Barrier complexes (Discovery Bay/Gippsland Lakes)
		2.3	Dissected tableland (Dundas Tableland)			6.2	Ridges and flats (Goroke)	South Victorian Riverine Plains	9.1	Present floodplains (Gippsland)	
		2.4	Dissected tableland (Merino Tableland)			6.3	Low siliceous dunes (Little Desert)		9.2	Intermediate terraces (Gippsland)	
	South Victorian Uplands		3.1		Dissected fault blocks (Otway Ranges)	West Victorian Volcanic Plains		7.1	Undulating plains (Western District)		
3.2			Moderately dissected block (Barrabool Hills)	7.2	Stony undulating plains (Western District)						
3.3			Moderately dissected ridge (Mornington Peninsula)								
3.4			Dissected fault blocks (S. Gippsland Ranges)								
3.5			Dissected outlier (Wilsons Promontory)								

LAND SYSTEMS AND GEOMORPHIC UNITS

1 : 500 000
0 10 20 30 40
Kilometres
Land Conservation Council
Victoria

Notes:

- Each land system is identified firstly by the geomorphic unit in which it lies. These units are listed (to the left) and their symbols (1.1 to 9.3) are shown in bold type on the map. Boundaries between geomorphic units are shown by a heavy line.
- Within each geomorphic unit the land systems are identified by composite symbols which reflect the landform (upper case letters), lithology (lower case letters) and climate (numbers 2 to 9) characteristic of that land system. When more than one letter is used for landform or lithology, the land system contains a mixture with the order of letters reflecting the decreasing abundance of each feature. The subscripts differentiate land systems which have otherwise similar symbols, but which have variations in soils, indigenous vegetation or both.
- The Land System Table (see microfiche card in the map pocket), outlines for each land system its indigenous vegetation, soils, soil process limitations, and equivalent land systems in published studies.
- The maps were compiled by J.N. Rowan, Land Protection Division, from various sources, mainly Land Protection Division and Soil Conservation Authority publications. Additional land systems mapping was carried out by J.N. Rowan in areas marked on the reliability diagram. Geomorphic units were identified by J.J. Jenkin and J.N. Rowan.
- Additional data
The 1:500 000 map boundaries shown have been simplified from the Statewide land system map series prepared at 1:250 000 scale. That series and the report "Land systems of Victoria" are available from the Land Conservation Council and the Land Protection Division of the Department of Conservation and Environment. The report includes the Land System Table, Locality plan and references for published studies, and explanatory information.

LEGEND

- Geomorphic Unit Boundaries
- Land System Boundaries
- Land System Boundary - Rainfall
- 1.1 Geomorphic Unit Map Symbol
- P14, Land System Map Symbol

KEY TO LAND SYSTEM SYMBOLS

LANDFORM

- C Coastal dune
- E East-west dune
- F Present floodplain
- G Gentle to moderate hill
- I Irregular dune
- L Lunette
- P Plain above flood level
- R Stranded beach ridge, usually trending n-nw-sse
- S Steep mountain and hill
- W Weakly elongated dune
- Y Gypsaceous dune

LITHOLOGY (rock or sediment type)

- c Coarsely-textured unconsolidated deposits
- f Finely-textured unconsolidated deposits
- g Granites and gneisses
- l Limestone
- s Sedimentary rocks
- v Volcanic rocks
- z Saline finely-textured deposits

CLIMATE (mean annual rainfall)

- 2 200-300 mm
- 3 300-400 mm
- 4 400-500 mm
- 5 500-600 mm
- 6 600-700 mm
- 7 >700 mm temperate
- 8 >700 mm montane
- 9 >700 mm sub-alpine

GEOMORPHIC UNITS

Geomorphic Unit	Map Symbol	Description	Geomorphic Unit	Map Symbol	Description	Geomorphic Unit	Map Symbol	Description
Central Victorian Uplands	1.1	Dissected uplands	Murray Basin Plains	4.1	Present floodplain (Murray Valley)	South Victorian Coastal Plains	8.1	Ridges and flats (Follett)
	1.2	Dissected plateaux (Wellington uplands)		4.2	Older alluvial plain (Shepparton)		8.2	Dissected plains (Port Campbell)
	1.3	High plains (Dargo, Bogong, etc)		5.1	Low calcareous dunes (Ouyen)		8.3	Sand and clay plains (Moorabbin)
	2.1	Dissected uplands (Midlands etc)		5.2	High siliceous dunes (Big Desert/Sunset)		8.4	Fans and terraces (Western Port)
	2.2	Prominent ridges (Gramscans)		6.1	Clay plains (Nhill)		8.5	Barrier complexes (Discovery Bay/Gippsland Lakes)
	2.3	Dissected tableland (Dundas Tableland)	Wimmera Plains	6.2	Ridges and flats (Goroke)	South Victorian Riverine Plains	9.1	Present floodplains (Gippsland)
South Victorian Uplands	2.4	Dissected tableland (Merino Tableland)		6.3	Low siliceous dunes (Little Desert)		9.2	Intermediate terraces (Gippsland)
	3.1	Dissected fault blocks	West Victorian Volcanic Plains	7.1	Undulating plains (Chewy Ranges)		9.3	High terraces and fans (Gippsland)
	3.2	Moderately dissected block (Barrabool Hills)		7.2	Stony undulating plains (Western District)			
	3.3	Moderately dissected ridge (Mornington Peninsula)						
	3.4	Dissected fault blocks (S. Gippsland Ranges)						
	3.5	Dissected outlier (Wilson's Promontory)						

MAP 9

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