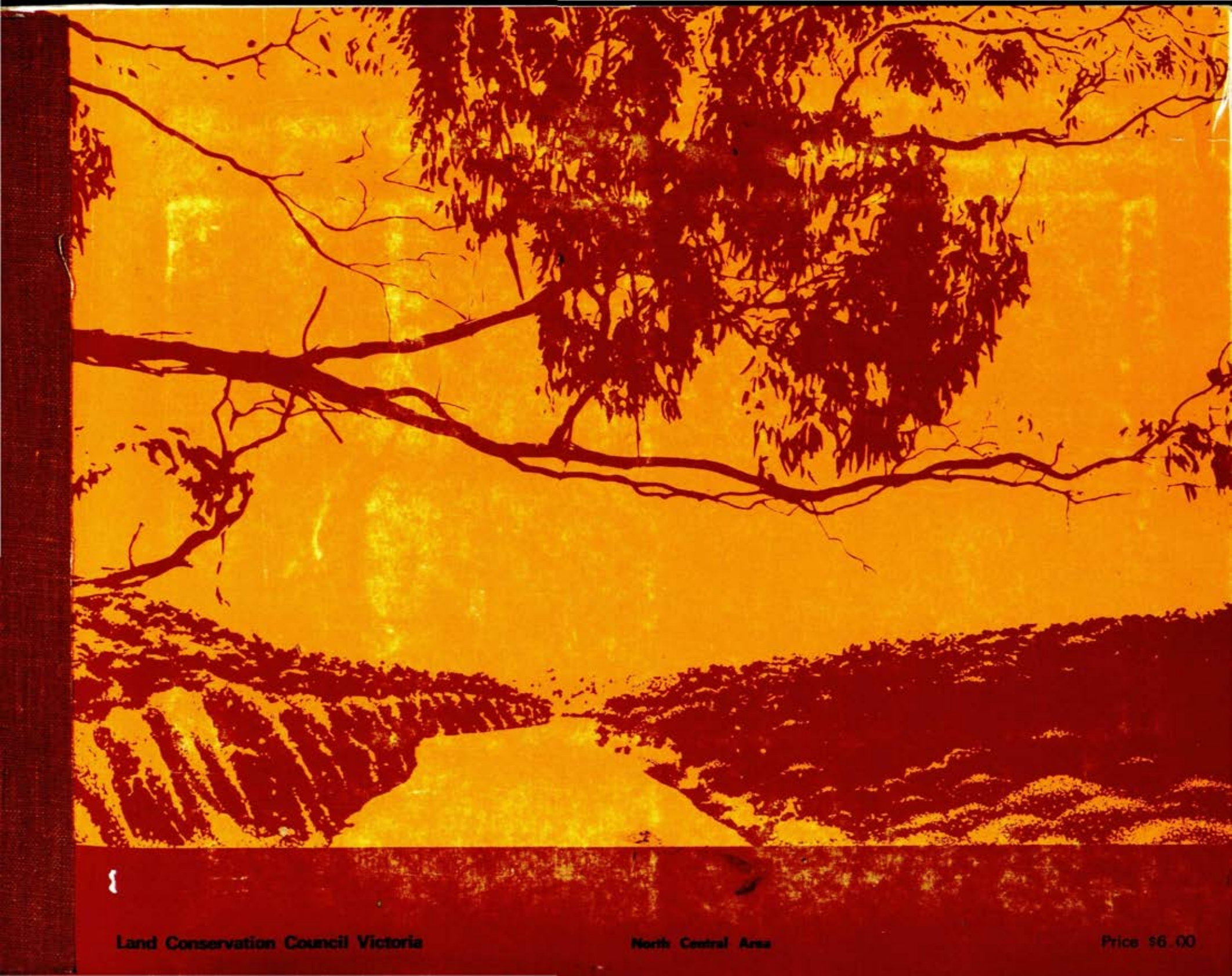


Land Conservation Council Victoria

North Central Area

Price $6.00

ERRATA

Page (iv)	Table 24	Read "Facing 134"
Page (iv)	Table 25	Read "138" not "137"
Facing P.52	Table 25	Delete "Open Forest I" from "Whipstick Mallee Alliance"
Facing P.52	Table 25	Read "Pultenaea" for "Pultenea"
Facing P.52	Table 25	Read "Xanthorrhoea" for "Xanthorrhea"
Page 58	Heading	Read "Whipstick Mallee open scrub" for "Whipstick Mallee open forest I"
Page 61	Line 20	Read "Pultenaea" for "Pultenea"
Page 113	Line 28	Read "predominantly" for "predo-inantly"
Page 122	Line 22	Read "Map 7" for "Map A"
Page 130	Line 64	Read "approximately" for "approxijately"
Page 136	Line 52	Read "restricted" for "constricted"
Page 148	Line 23	Read "lode" for "lod"
Page 238	Line 10	Read "Cervus" for "Carvus"

TELEPHONES:
267 1311, 267 1098

GOVERNMENT OF VICTORIA

LAND CONSERVATION COUNCIL

464 ST. KILDA ROAD, MELBOURNE, VICTORIA, 3004

REPORT

NORTH CENTRAL AREA

This Report is published to allow all who are interested in the use of public land the opportunity to comment by making written submissions to the Land Conservation Council.

All such submissions must reach the Secretary no later than Friday, 22nd December 1978.

These submissions will be considered by the Council before Proposed Recommendations are made on the use of public land in the study area.

Blackman

for I. KUNARATNAM
Secretary
Land Conservation Council

REPORT

ON THE

NORTH CENTRAL STUDY AREA

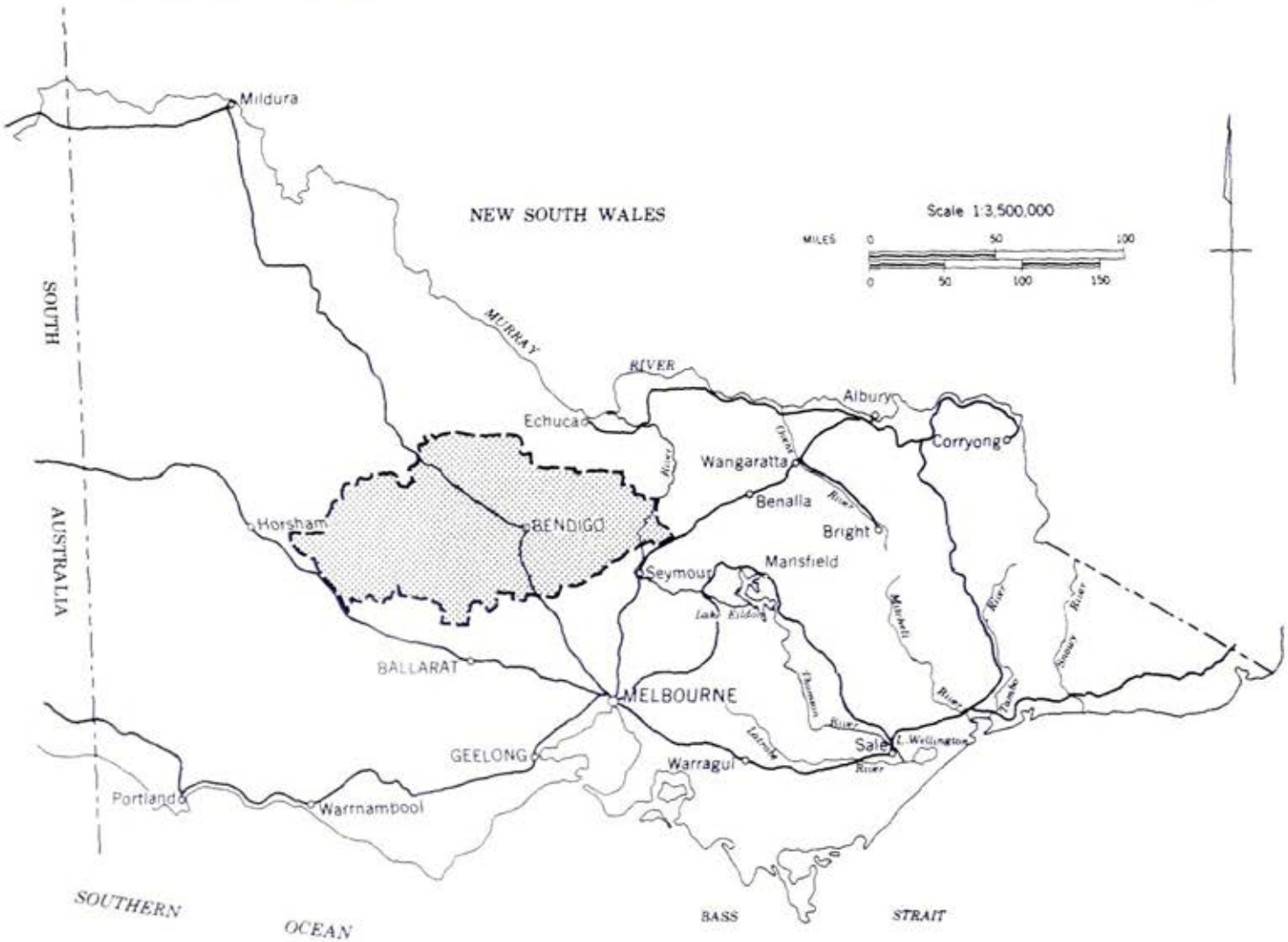
Land Conservation Council, Victoria

Melbourne : July, 1978

5571/78—PL

LAND CONSERVATION COUNCIL
VICTORIA
NORTH CENTRAL STUDY AREA

LOCALITY PLAN



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FOREWORD

The *Land Conservation Act* 1970, established the Land Conservation Council, whose function 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".

This report sets out to describe and assess the natural resources of the public land in the North Central study area and provides a factual basis on which members of the community may base their submissions to the Council. It ensures that all those persons and bodies who have an interest in the future use of public land in this area can obtain and study the basic information, which the Council itself will study, and so make informed and constructive suggestions to the Council for its consideration.

In making this report available, the government hopes that all interested parties will be able to participate in an informed fashion in the process of considering how public lands should be used. It is hoped that, in making submissions, members of the community will use as a basis the information provided by this study. The Council will make its recommendations only after due consideration of those submissions.

Demands for land for various purposes are many and varied, some of which are compatible and some conflicting or competitive. It is therefore important that decisions made are based on factual evidence, not on subjective criteria.

Submissions are now invited and should reach the Secretary of the Land Conservation Council within 60 days of the publication of this report, as notified in the Victorian Government Gazette.

S.G.McL. DIMMICK
Chairman

Land Conservation Council
464 St. Kilda Road
MELBOURNE 3004

LAND CONSERVATION ACT 1970

EXTRACT

Public land

Section 2.

(1) "Public land" means -

(a) land which is not within a city town or borough and is -

(i) unalienated land of the Crown including land permanently or temporarily reserved under section 14 of the *Land Act* 1958 and State forest;

(ii) vested in any public authority (other than a municipality or a sewerage authority within the meaning of the *Sewerage Districts Act* 1958); 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* 1958; and

(c) advise 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 of 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.

(3) Where the Council recommends the alienation of any land the recommendation shall include the Council's opinion as to tbe 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).

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 the 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 recommendations to -

(a) the Council of any municipality in the municipal 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 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 it 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 Government Printing Office, 7a Parliament Place, Melbourne, 3002.

ACKNOWLEDGEMENTS

This report covers so wide a field that its compilation would not have been possible without the generous assistance and co-operation of a great many individuals and organizations.

The Council acknowledges the assistance of the following organizations, which prepared basic information for maps and chapters of this report: Departments of Agriculture, Crown Lands and Survey, and Minerals and Energy; the National Museum, the Fisheries and Wildlife Division; the Forests Commission; the National Parks Service; the Soil Conservation Authority; the State Electricity Commission; and the State Rivers and Water Supply Commission.

Many other bodies also readily supplied information, checked drafts, or contributed valuable discussion and advice. They include other Victorian and Australian government bodies, local governments, universities, apiarists, members of fauna and flora study organizations, and many individuals with expert knowledge in fields such as botany or zoology. Their assistance is gratefully acknowledged.

This Council is indebted to many of the Government Departments mentioned above that made photographs available for the report, and to T. Pescott, M. Gottsch, R. Cooper and W.R. Wheeler for the use of their photographs.

PART I

INTRODUCTION

1. AIMS AND METHODS

This report brings together information that is relevant to decisions regarding the future use of public land in the study area.

It describes the physical nature of the land, examines the existing and likely forms of land use, and assesses the hazards associated with these uses. The report does not contain recommendations, but aims at providing a factual basis on which land use recommendations can be formulated.

Existing information collected from published reports, government departments, public authorities, private organizations, and individuals has been supplemented by short-term surveys of plants and animals. Although public land has been emphasized, the report considers relevant aspects of all land in the study area to place public land in perspective.

The text is divided into four main sections. Part I, an introductory section, sets out the aims of the study, and defines and briefly describes the study area and its history.

Part II describes the main features of the environment for the whole study area. Climate, geology, physiography, soils, vegetation, fauna, water resources, and land systems are described. Maps showing the geology, vegetation on public land, land systems, and topography and rainfall are included.

Part III deals with the main forms of land use that are likely to make demands on public land, and examines the present levels of activity. Hazards associated with these land uses, such as soil deterioration and fire, are also discussed. Primary production, minerals and stone, and recreation are depicted in maps for this section.

Part IV provides more detailed information and, for convenience, the study area has been divided into nine blocks. The information is set out in a consistent format of headings, so that specific information can be readily found and compared with its counterpart in other blocks or areas.

A number of appendices including lists of flora and fauna complete the report.

2. CONSERVATION PRINCIPLES

Conservation is concerned with Man's relation to his environment. It is often said to be the wise or balanced use of resources. Because "wisom" and "balance" are not absolute terms, the principles set out here attempt to explain this concept.

Conservation can be considered as an endeavour to anticipate and resolve conflicts between the individual and society about the present and future use of resources, and between competing uses of the same resource. The conservationist must be aware of long-term needs and recognize that a community requires land for recreation, scientific, and aesthetic purposes as well as for the production of food, timber, and minerals or for urban and industrial use.

Natural Resources

Two broad classes of natural resource may be distinguished, according to whether they are renewable.

Non-renewable resources

The quantity of these resources does not increase significantly with time, and use consumes them. In the last century the expansion of Victoria's economy was based on the exploitation of gold - a non-renewable resource. The oil and gas fields of Bass Strait provide another example.

Conservation of a non-renewable resource requires the best techniques for exploration, recovery, and processing, and the efficient use of the end product.

Renewable resources

The quantity of a renewable resource such as timber may increase or decrease with time. Animal and plant communities and landscape fall within this category. Abuse of these resources may reduce them to such a poor condition that the practical opportunity to restore them to a desired state is lost for many generations.

Conservation of renewable resources requires a thorough understanding of ecological principles and development of sound management techniques based on those principles. An ecosystem typically contains many interrelated components. A change in any one of these will have effects elsewhere in the system. In general, an ecosystem with a diverse

range of species will be better able to adapt and absorb the impact of sudden change - such as that caused by fire, disease, or Man's activities - than a simple ecosystem with few species.

Man is part of the ecosystem and, like every other organism, influences and is influenced by the other parts. The development of new techniques has increased his ability to modify the environment. Many new techniques have both advantages and disadvantages. Often the disadvantages are not obviously linked to the new techniques and only emerge in the long term - for example, the use of insecticides can increase production of food or fibre dramatically, but may also reduce the population of predatory birds and insects and so encourage the build-up of populations of other insect pests.

Relations Between Resource Uses

Many uses of a resource are compatible. They may be supplementary and add to each other, or complementary in that one use benefits from the other, but they may also be competitive when an increase in one leads to a decrease in the other.

For example, the relation between timber production and picnicking within a forest may be complementary in the sense that picnickers gain access along tracks and use open spaces created during timber operations. It may become competitive if logging makes the forest an unsuitable picnic area, and at other times picnickers may present a considerable fire risk.

In general, decisions on land use will involve selecting major land uses for a particular area, determining other uses compatible with these, and specifying the intensity of use above which they become incompatible.

The Principles of Land Use

In the past our society has grown (and the economic welfare of the people improved) through mining, farming, timber production, and industrial development. These industries have usually been given prime importance when deciding the use of natural resources. The present pattern of land use is, of course, a result of these past decisions.

Recently there has been greater public demand for a shift in emphasis towards nature conservation and recreation as the economic welfare of the bulk of society has improved, the need and opportunities for outdoor recreation have grown, and an appreciation of nature has become more apparent.

The concept of balance is fundamental to land use and is directly related to the values that society puts on the goods and services that the land can provide. It also involves consideration of the needs of all sections of society, on both regional and State bases, as well as those of this and future generations.

These needs should be clearly stated as aims.

The intangible values of recreation, aesthetics, and preservation should be recognized by providing land for these purposes, and by considering the impact of other land uses upon them. The preservation of outstanding natural features should be considered.

Where several land uses are compatible, land should be available for the most beneficial combination of such uses. To achieve this, it may be necessary to define major aims and to assess levels above which secondary uses are unacceptable.

Where land has been committed to a particular use, it should be managed so that its capability for that use is not impaired. Uncommitted land should be maintained in a condition that will allow the widest possible choice of future uses.

Review and reassessment of land will become necessary as society and technology change.

3. THE STUDY AREA

As its name implies, the area discussed in this report lies in the north-central part of Victoria (see the locality plan on page ii). It covers some 19,300 sq km (8.5% of the area of Victoria), including the Shires of Avoca, Bet Bet, East Loddon, Huntly, Kara Kara, Korong, Maldon, Marong, Metcalfe, McIvor, Newstead, Strathfieldsaye, Talbot and Clunes, Tullaroop, and Waranga and parts of Stawell and Goulburn Shires. These figures do not, however, include the Cities of Bendigo, Maryborough, and Castlemaine, the towns of Stawell and St. Arnaud, or the Borough of Eaglehawk, which together cover 132 sq km. The study excludes these urban districts.

The boundary follows shire boundaries except where it passes through the Shires of Stawell and Goulburn.

While mostly hilly or undulating, the study area does include extensive plains in the north.

Its public land is mainly forested or, in the north, covered with mallee vegetation. By contrast, virtually all the private land is cleared and under pasture or crops.

Public land

Public land occupies some 2,900 sq km (15% of the study area). Although concentrated on the wooded hilly areas, much of it is extremely fragmented, and only a few large consolidated blocks remain - the Pyrenees and the Whroo--Redcastle blocks are among the largest.

Most of it is reserved forest, with some areas of protected forest. Approximately 0.5% is covered by water, predominantly in storages on the Loddon, Campaspe, and Goulburn systems.

Land use

Primary production has not changed significantly in the last 30 years, apart from a marked increase in productivity with improved technology. Its main forms in the study area are mixed farming and grazing on dryland farms.

The value of rural land in many areas has been raised well above its agricultural value by an increasing number of urban residents, both local and from outside the area, buying rural land for leisure, hobby, or speculative purposes.

Public land is used mainly for timber and euclayptus oil production, apiculture, forest grazing, and recreation.

Despite the important role played by gold-mining in the development of the region, mining here today is negligible. However, quarrying and gravel extraction by State departments, municipal Councils, and private operators occur in scattered locations throughout the area.

Six main water storages within the study area supply water for domestic purposes and irrigation and are also used for recreation.

Transport

Bendigo has become an important transport centre, with links to other major Victorian centres and to the Riverina district in southern New South Wales. It now forms the hub of a network of arterial roads, including the Calder, Loddon Valley, Midland, and McIvor Highways. Bendigo is also a major junction in the State's railway network, with a heavy-duty double rail link with Melbourne, and a number of radiating lines to the north and north-west for freight and passenger services.

The North-west Highway, through Avoca and St. Arnaud, and the Western Highway through Stawell serve the western part of the study area. Other major connecting routes include the Northern, Wimmera, and Pyrenees Highways.

Aerodromes suitable for light commercial aircraft are located at Bendigo, Maryborough, and St. Arnaud, and the area also contains several private landing grounds.

Power

Most of the power comes from the State's electricity network, although a small 2-MW hydroelectric station at the Cairn Curran Reservoir generates some power. Bendigo is a major "terminal" station in the 220-kV network, while both Castlemaine and Maryborough are linked in with a 66-kV sub-transmission line. A substantial network of low- and medium-voltage lines supplies smaller centres.

Population

In 1976, the study area had a population of approximately 107,000, or 2.95% of that of Victoria (see Table 1). This figure includes the populations of six urban centres (Bendigo, Maryborough, Castlemaine, Stawell, St. Arnaud, and Eaglehawk - total 59,900), although technically they are not part of the study area.

The 1976 total represents an increase of 0.6% over the 1966 total, but forms a lower proportion of the State's population. The effects of the rural recession of the late 1960s have passed, however, and both the rural and urban populations exceed the 1971 figures, which indicated a slump.

Table 1

DEMOGRAPHY

Local-government area	Population			Average annual increase or decrease 1966--76 (%)	Area[D] (sq km)	Approximate population density (per sq km)
	1966[A]	1971[B]	1976[C]			
Avoca (Shire)	2,133	1,962	2,022	- 0.5	1,124	1.8
Bet Bet (Shire)	1,975	1,717	1,686	- 1.5	927	1.8
East Loddon (Shire)	1,722	1,598	1,542	- 1.0	1,194	1.3
Huntly (Shire)	2,323	2,242	2,400	+ 0.3	878	2.7
Kara Kara (Shire)	1,360	1,193	1,099	- 1.9	2,293	0.5
Korong (Shire)	3,663	3,203	3,098	- 1.5	2,385	1.3
McIvor (Shire)	1,896	1,789	1,858	- 0.2	1,453	1.3
Maldon (Shire)	1,953	1,759	1,864	- 0.4	559	3.3
Marong (Shire)	6,488	6,905	8,168	+ 2.6	1,489	5.5
Metcalfe (Shire)	2,163	1,983	2,041	- 0.6	590	3.4
Newstead (Shire)	1,781	1,622	1,719	- 0.3	409	4.2
Strathfieldsaye (Shire)	6,703	7,711	10,256	+ 5.3	619	16.6
Talbot & Clunes (Shire)	1,514	1,445	1,396	- 0.8	534	2.6
Tullaroop (Shire)	1,277	1,193	1,338	+ 0.5	637	2.1
Waranga (Shire)	4,506	4,333	4,187	- 0.7	1,645	2.5
Part of Stawell (Shire)	1,430	1,240	1,405	- 0.2	1,797	0.8
Part of Goulburn (Shire)	1,560	1,700	1,750	+ 1.2	802	2.2
Total (actual study area)	44,447	43,595	47,829	+ 0.7	19,335*	2.5
Bendigo (City) *	30,806	32,007	32,573	+ 0.6	32.5	1,002.2
Castlemaine (City) *	7,103	6,915	6,675	- 0.6	23.3	286.4
Maryborough (City) *	7,707	7,472	7,569	- 0.2	23.3	324.8
Stawell (Town) *	5,909	5,800	6,150	+ 0.4	23.7	259.5
St. Arnaud (Town) *	3,004	2,779	2,786	- 0.7	25.4	109.7
Eaglehawk (Borough) *	5,230	5,383	6,447	+ 2.3	14.5	444.6
	59,759	60,356	62,200	+ 0.4	142.7	452.5
Total (including main urban areas)	104,206	103,951	110,029 (2.95% of the population of Victoria)	Av. + 0.6	19,477.7	Av. 5.5

* Not part of the study area; A Census 1966; B Census 1971; C Census 1976 (Preliminary); D Aust. Bureau of Statistics 1974

"Urban Bendigo" is defined in the "Victorian Yearbook" (1973) as:

Bendigo City	(part)
Eaglehawk Borough	(part)
Marong Shire	(part)
Strathfieldsaye Shire	(part)

It remains the fourth-largest urban centre in Victoria (after Melbourne, Geelong, and Ballarat). While the population of Bendigo city has not grown markedly, several adjacent areas have shown major increases in population. Strathfieldsaye Shire has had a 5.3% increase between 1966 and 1976, while the Shire of Marong and Eaglehawk Borough both show an increase of approximately 2.5% for the same period.

Outside Urban Bendigo and the other major centres, the population density is relatively low. Large towns include Heathcote, Rushworth, Avoca, and Nagambie.

Decentralization and Industrial Development

Decentralization has not contributed greatly to the growth of cities and towns in the study area, but the potential is significant, particularly in Bendigo, Castlemaine, and Maryborough. Public land, as well as private property, is likely to be required for new residential and industrial development.

Decentralization of the population depends on the availability of employment, which is provided largely by industry. At the same time, industry is unlikely to move to a location where labour is not already plentiful. As a general rule, therefore, decentralization will affect only major centres.

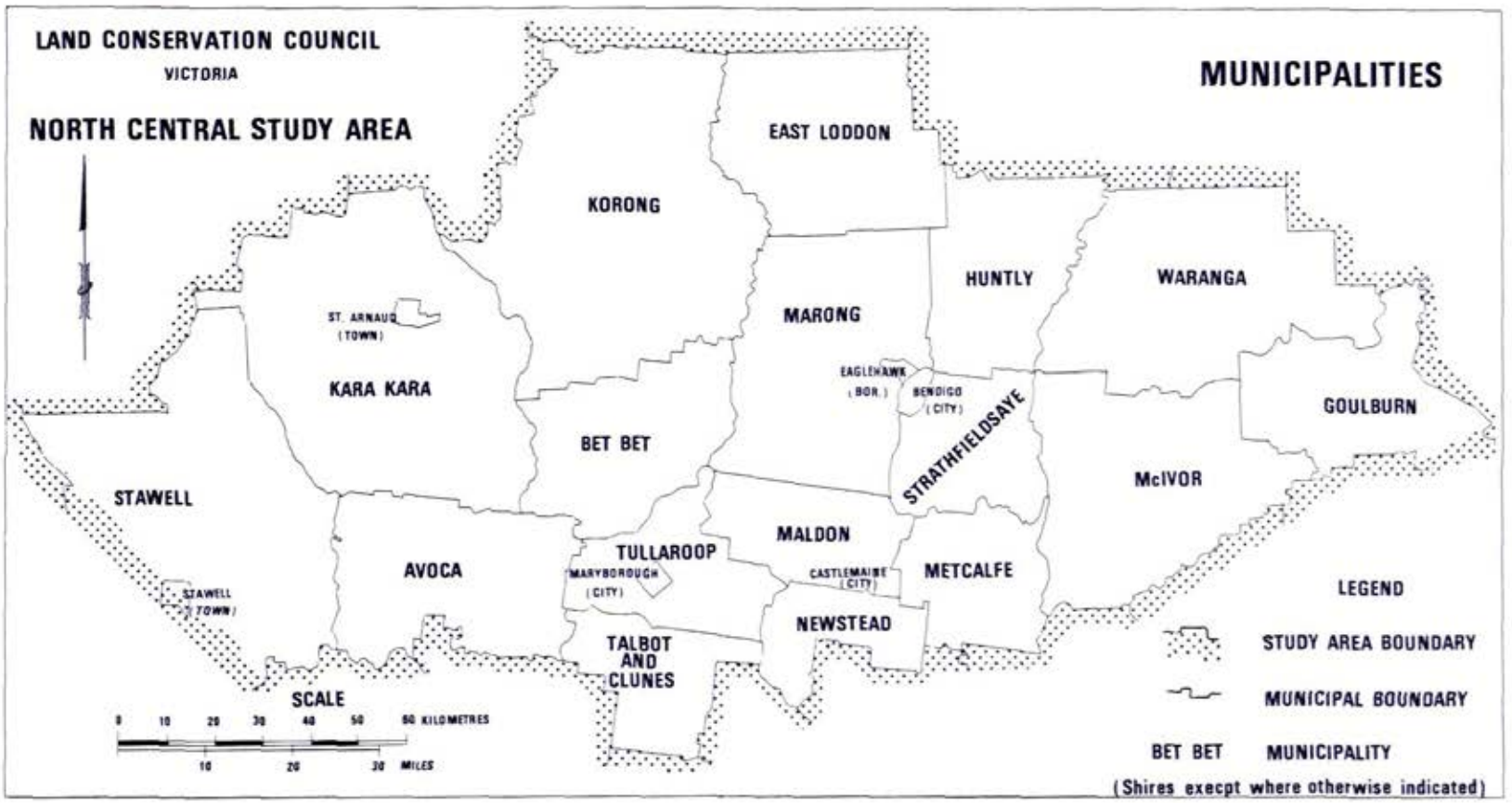
The following factors are important:

* government incentives for decentralization
* availability of land and/or buildings
* availability of appropriate labour
* availability of finance
* transport costs
* environmental considerations
* availability of raw materials

As the largest city in the study area, and the third-largest population centre in rural Victoria, Bendigo has considerable potential for decentralization. The Calder, Midland, McIvor, and Loddon Valley Highways converge there. It is also a major rail centre, with lines radiating to the north-west, north, and north-east, as well as the main Bendigo --Melbourne line to the south.

Although Castlemaine is conveniently situated at the junction of the Pyrenees and Midland Highways, and on the Bendigo--Melbourne railway line, its potential is somewhat restricted by its proximity to the city of Bendigo.

Maryborough is situated at the junction of the Melbourne--Mildura and Castle-


LAND CONSERVATION COUNCIL
VICTORIA
NORTH CENTRAL STUDY AREA
MUNICIPALITIES
EAST LODDON
KORONG
HUNTLY
WARANGA
MARONG
ST. ARNAUD (TOWN)
KARA KARA
EAGLEHAWK (BOR.)
BENDIGO (CITY)
GOULBURN
BET BET
STRATHFIELDSAYE
McIVOR
STAWELL
MALDON
TULLAROOP
AVOCA
MARYBOROUGH (CITY)
CASTLEMAINE (CITY)
METCALFE
STAWELL (TOWN)
NEWSTEAD
TALBOT AND CLUNES
SCALE
0 10 20 30 40 50 60 KILOMETRES
10 20 30 MILES
LEGEND
STUDY AREA BOUNDARY
MUNICIPAL BOUNDARY
BET BET MUNICIPALITY
(Shires execpt where otherwise indicated)

maine--Ararat railway lines, and on the Pyrenees Highway.

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Australian Bureau of Statistics, Victoria. "Demography, 1974.) (Government Printer: Melbourne 1976.)

Australian Bureau of Statistics, Victoria. "Census of Population and Housing, 30 June 1976, Preliminary Statistics." (Government Printer: Melbourne 1977.)

Commonwealth Bureau of Census and Statistics. "Victorian Year Book 1973 - Centenary Edition." (Government Printer: Melbourne 1973.)

4. HISTORY

The Aborigines

Two Aboriginal tribes are reported to have formerly occupied the land that now comprises the study area. To the west, the Jaara tribe had a territory of some 15,600 sq km, extending from Stawell, east along the Dividing Range to Kyneton, north to Bald Rock (near Gunbower), and west towards Donald.

The Ngurelban tribe occupied a triangle-shaped area of approximately 7,800 sq km to the east (one side of the triangle formed the Jaara tribe boundary, and the apex was around Euroa).

Both tribes were hunters and gatherers, but they stayed close to permanent water supplies. Their first contacts with white colonists were tragic, although friendly relations were established with some early squatters. At the time of European settlement, the Jaara tribe had an estimated population somewhere between 1,000 and 1,300 people.

Aborigines continued to clash with the colonists, and the effects of disease and alcohol, combined with the general destruction of their way of life, caused a marked reduction in their numbers.

Today, only a few known Aboriginal relics have survived the troublesome colonizing days and the feverish search for gold that immediately followed. Examples include the rock wells at Maryborough and Whroo, the ceremonial stone arrangements at Carisbrook, stone axe quarries at Mount Camel, canoe-trees and shield trees at Barnadown, and numerous Aboriginal middens, particularly in the Boort area. Stone chips in the Fryers Ridge, Cope Cope, and Mount Tarrengower areas.

Exploration

The first Europeans to visit the area were Hume and Hovell, who in 1824 travelled from Lake George in New South Wales to Corio Bay, passing to the east of the study area, and returned along the route of the present Hume Highway. Although they reported very favourably on the land, it was not until 1836 that another party, led by Major Sir Thomas Mitchell, entered the area.

Mitchell crossed the Murray and camped at Swan Hill in June 1836. He then travelled to Portland, passing close to the sites of Wedderburn, St. Arnaud, and Callawadda. His return route took him

Scar on a tree near Carisbrook caused when Aborigines removed bark for a canoe

near the sites of Talbot, Newstead, Castlemaine, Heathcote, and Nagambie. Mitchell named the Loddon, Avoca, and Avon Rivers after streams in England and Ireland. He also named the Wimmera, using a native name, and the Campaspe and the Barnard (now known as the Coliban).

In 1860 the Burke and Wills expedition passed through the area, which was by then extensively settled. Previously, Burke had been the Administrator of Castlemaine, and Wills had surveyed and named Wedderburn.

Agricultural Settlement

The squatters

Following Major Mitchell's report, squatters moved into the area. In 1837, they established runs in the Goulburn Valley, as far south as Seymour. By 1838 they had spread to the Campaspe, and within 2 years had taken up country as far west as the Pyrenees.

At this time each squatter was allowed to occupy as much land as he could obtain for a yearly payment of £10. This meant that he did not own the land, but occupied it under licence - it remained Crown land.

These early squatters lived in crude bark huts. Runs were unfenced and sheep were tended during the day in flocks of

some hundreds by shepherds - usually ex-convicts or "ticket-of-leave" men. At night the sheep were guarded in yards to protect them from attacks by Aborigines and wild dogs.

During the 1840s the pastoral industry developed despite problems of fire, disease, and a shortage of feed. Wool cuts averaged about 2½ lb (1.1 kg) per head, and the wool was taken to Melbourne by bullock wagon. At this time labour was plentiful.

When the gold rush began in 1851, many shepherds left for the gold-fields, and the squatters suffered an acute shortage of labour. Problems with livestock were aggravated by thieving and the disease scab.

The increased mining population required food, but this could not be fully supplied by the squatters. Although they could graze stock, squatters were not permitted to cultivate the land, so they could not grow crops or vegetables. A system of selling surveyed land was needed, and the first land (near Bendigo) was auctioned in 1854.

Most of this land was bought by wealthy squatters for grazing, but small farmers also bought land and began to grow fruit and vegetables, grain crops, dairy produce, poultry, etc. These early farms were near the Campaspe, Loddon, and Goulburn Rivers, and their tributaries.

The land rush

By the late 1850s, the alluvial gold deposits were becoming exhausted and the miners were seeking other work; the majority wanted to become owners of land.

The auctioning system favoured the wealthy squatters, and in 1869 Grant's *Land Act* was introduced to enable less-wealthy individuals to select and purchase up to 320 acres (130 ha) of land - at a price of £1 per acre (approximately $5 per ha) over a 10-year period. This led to a land rush, with 4.4 million acres (1.8 million ha) being selected in Victoria in the next 5 years.

Agricultural methods were primitive at this stage. Fences were made of timber, brush, or stone. Farmers ploughed with a single-furrow implement, and rolled logs to level the land. They broadcast seed by hand, and reaped with hand sickles. Then they winnowed the grain by throwing it in the air, letting the wind separate seed and chaff.

The combined effects of poor soils and dry seasons made it obvious that many of the small holdings were too small, and many of the original selections were amalgamated. Much of the poorer land reverted to grazing.

Irrigation and Water Conservation

The first water supply system in the study area was the Coliban, which was

started in 1858 to supply the Bendigo and Castlemaine gold-fields.

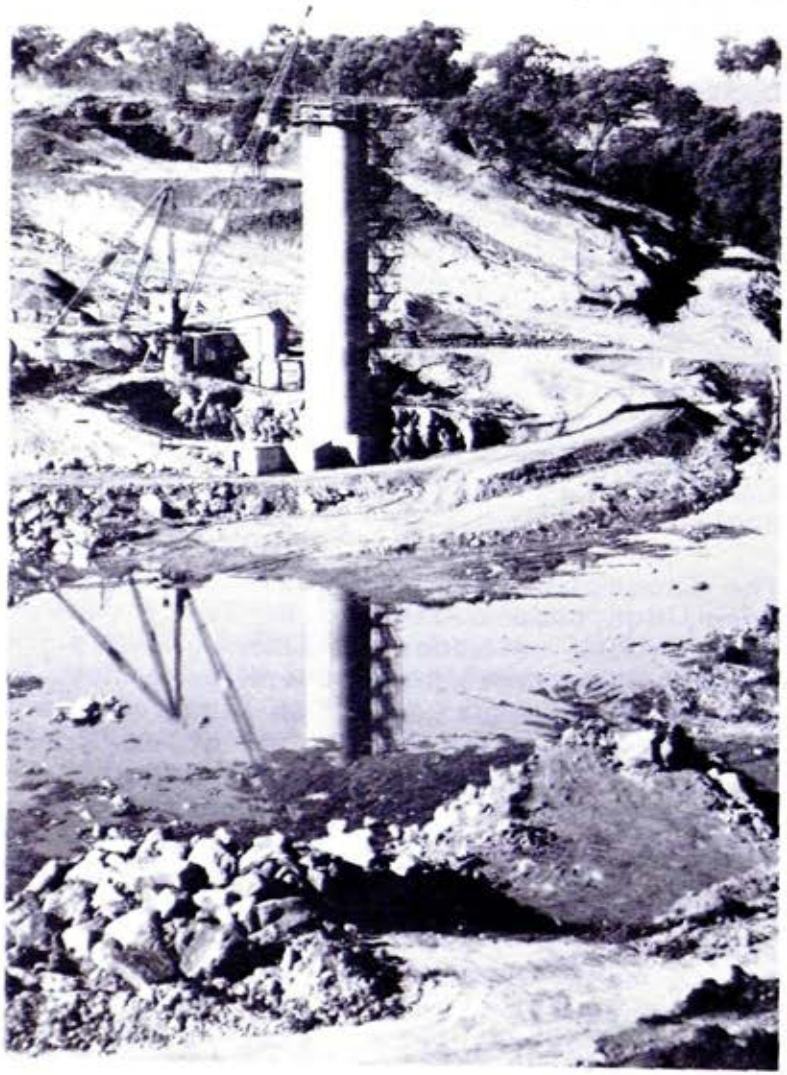
The introduction of the *Land Act* in 1869 opened new areas for selection and stimulated interest in water conservation.

The severe drought of 1877-81 prompted a governmental inquiry, which led to the establishment of the first of a series of Waterworks Trusts in 1881. These trusts were empowered to carry out schemes for domestic, stock, and town water supplied.

As a result of a Royal Commission, the *Irrigation Act* of 1886 vested the right to control and use surface water resources in the Crown, defined and limited riparian rights, and authorized the funding and construction of "National" works for water supply. The first construction under the National scheme was the Goulburn Weir in 1887, followed by the Laanecoorie Weir in 1889.

By 1900 Victoria contained almost 90 Irrigation and Waterworks Trusts - on the Loddon River alone there were seven Irrigation Trusts and two Waterworks Trusts. Many of the Trusts, particularly Irrigation Trusts, experienced difficulties, however. As a result the *Water Act* 1905 centralized control under a new body, the State Rivers and Water Supply Commission.

The irrigation industry has since developed considerably and today supports a



An early stage in the construction of Eppalock Dam (1961)

large sector of the rural economy of the study area.

Gold-mining

Discovery

Undoubtedly the settlers knew of the existence of gold in Central Victoria in the early 1840s. Discoveries were recorded near Navarre and Maryborough in 1848, but the settlers, fearful of what mining would do to their land, suppressed such information.

Subsequently, however, gold discoveries elsewhere in New South Wales (Victoria was then not a separate colony) caused such an exodus of gold-seekers that the local authorities became alarmed and offered a reward for anybody finding a gold-field within 200 miles of Melbourne.

One of the officially recognized discoveries was made by James Esmond at Clunes in July 1851.

Alluvial mining

Following Esmond's discovery, rich alluvial ground was opened at Clunes and also at Castlemaine (Mount Alexander) along Forest Creek. By the end of November 1851, 10,000 diggers had congregated on the rich surface and shallow deposits of Forest Creek. Other discoveries in the Castlemaine area were made at Barkers, Campbells, and Fryers Creeks. Castlemaine was the first of the gold-fields to achieve sensational success, and for a time surpassed its two rivals in Ballarat and Bendigo.

Gold had been found at Golden Point (Bendigo) in August 1861, and by January 1852 these alluvial deposits had yielded 200,000 oz (5,700 kg) of gold.

Further discoveries and subsequent rushes throughout the study area followed soon after. Alluvial gold was discovered at Amherst, Wedderburn, Moliagul, and Tarnagulla in 1852, at Stawell, Avoca, Maryborough, Dunolly, Kingower, Costerrield, and Rushworth in 1853, and at Alma and Maldon in 1854. The gold-fields west of the Loddon and north of Dunolly were particularly famous for the number of nuggets produced.

Alluvial deposits usually had a short economic life. Generally the fields soon became deserted, although fresh discoveries and re-rushes occurred in some areas, as happened at Dunolly on many occasions. Alluvial gold production reached its peak in 1856. In subsequent years it gradually declined, until by 1878 production from quartz reefs exceeded it.

Reef mining

At Bendigo, large blocks of quartz stood as much as 12 m above the surface. Some showed gold, and by 1853 the first quartz-reef mine opened at Specimen Hill

and Victoria Hill. First attempts at reef mining used hammers and other primitive tools to crush the quartz and secure the gold. Then "dollies" or light stampers, worked by hand, were used.

Working of the reefs commenced in earnest in 1854, when the first public battery with iron stampers was installed at Bendigo.

At other localities the pattern was the same, with numerous reefs being discovered during and after the main rushes for alluvial gold. At Clunes in 1857, the Port Phillip Co. made the first successful attempt at the deep mining of a quartz reef.

Quartz bodies at many localities were rapidly exhausted, but at Bendigo it was realized that the auriferous quartz reefs recurred as saddle reefs at random, one below the other. This discovery led to the sinking of thousands of shafts - the deepest to 1,407 m - by hundred of mining companies, and the construction of hundreds of kilometres of levels and crosscuts.

For 100 years Bendigo was the principal quartz-reef mining centre in Victoria, but the last mine there closed in 1954.

Other important reef mining centres in the study area were Castlemaine--Chewton, Stawell, Maldon, Maryborough, St. Arnaud, Tarnagulla, Rushworth, and Inglewood.

Deep leads

In 1856 the "Perseverance Mine" became the first in the study area to systematically work buried channel deposits or "deep leads". This ancient drainage system lay beneath the valley of Chinaman's Flat Creek.

Other north-trending leads (Alma, Timor, Maryborough, and Lucknow) were located in valleys beneath alluvium or basalt, or both. Often the leads were up to 300 m wide, and specialized equipment was required to deal with the weak ground, and with the enormous quantities of water passing through the coarse gravels.

Dredging

From early this century, up to the 1950s, many of the old alluvial areas were reworked by large dredges. Operations were concentrated along the Loddon valley in the Fryerstown--Guildford--Newstead area, and along the Avoca River north of the Amphitheatre. The last major dredging operation in the study area ceased in 1956, although a small dredge still operates at Maldon.

Decline

The period 1890--1910 was characterized by excessive payments of dividends by successful companies, leaving insufficient funds for adequate prospecting. When the known ore bodies were depleted,

Bendigo at the height of the reef-mining era

premature closure of the mines resulted. After 1910, gold production from all sources declined rapidly - due partly to the exhausting of reserves, but hastened by the lack of manpower brought on by World War I. The last of the major deep-lead mines in the study area closed in 1919, although a reef mine at Bendigo continued production until 1954.

In 1976 the last commercial gold-mine working in the study area, the Wattle Gully Mine at Chewton (1975 production - 104 kg), ceased mining operations.

Timber Production

During the gold rush, much of the forested land adjacent to mining areas became dotted with tents, huts, and shanties. Virgin stands of timber within range of mining activities were ruthlessly exploited to provide fuel and mining timber. Subsequent regeneration of seedling and coppice origin was also felled as soon as it reached usable size.

In the 1880s, the rapid expansion of the railway system into rural Victoria created a demand for sleeper and heavy construction timbers. Until 1885, when a licence system was introduced, there was no control on exploitation of the box--ironbark forests. During the 1890s, regulations introduced under the *Land Act* set minimum diameters for each species to be felled, fixed royalty rates, and required forest produce to be measured at the stump. Licensees began thinning to favour selected trees in 1901. After the constitution of a State Forests Department in 1908, departmental employees continued this practice.

In 1918 a new *Forests Act* (which formed the basis of current legislation) was passed, constituting the Forests Commission and providing for the further improvement and development of State forests. Between 1928 and 1935, working plans for forest management were prepared for 80% of the box--ironbark forest. During these depression years, thousands of unemployed men undertook forest work, paid for from government funds. Thousands of acres of forest thus benefitted from silvicultural treatment at low cost. The depression also brought a partial revival of mining, with a renewed demand for mining timbers, but utilization was strictly controlled.

During World War II, fuel-wood again became a source of power for industry and transport. The armed services required liquid fuels, so private and commercial vehicles were converted for gas-operation. Charcoal was prepared, using wood from standing ring-barked trees and from thinning operations. Vast areas of over-stocked forests were also thinned for fuel-wood by licensees, interned aliens, and prisoners of war.

After the war, many European immigrants to Australia on assisted passages were required upon arrival to work for the government for 2 years. This enabled further forest improvement works and fuel-wood production to be carried out.

In the last 20 years, the market for firewood and other forest products, such as poles and fencing material, has declined as alternatives have become available.

Communication and Transport

The early settlers faced many problems of transport and communication. Routes originally navigable only by foot or horse soon, however, became rough tracks

for drays and bullock wagons. Packhorse mail and the famous Cobb and Co. coaches played important roles in early communication across the area.

The expansion of mining areas provided the impetus for the construction of many railway lines. The Melbourne--Bendigo line was one of the earliest in the State, being completed as far north as Echuca by 1864. In the 1870s, the Maryborough--St. Arnaud line was built.

Agricultural settlement further to the north-west, followed by development of the Mallee country, led to further extensions of the railway system. In the early 1880s the lines from St. Arnaud to Donald, Inglewood to Wycheproof, and Bendigo to Kerang were completed. Soon afterwards, a cross line was built from Inglewood to Dunolly. The Bendigo--Heathcote link formed early in the 1890s and the connection made to the main Melbourne--Albury line resulted in Bendigo becoming a major railway centre.

Although the railroads remained significant in the area, motor transport grew in importance during the 1930s. Further roads were developed throughout the area to link the various railway lines.

Local Government

Most of the local government areas within the study area today were created as districts in the early 1860s. This resulted from an *Act* passed in 1853, which allowed land-owners in any locality to elect a District Roads Board.

Between 1864 and 1871, the proclamation of shires eliminated road districts. At the same time, several urban municipalities were proclaimed in the more established areas. Some, such as Bendigo, have remained and have continued to grow, but others have subsequently had to change their status. Graytown, a former gold-fields borough in the present Shire of McIvor, now has only a dozen inhabitants.

Many of the areas currently proclaimed as Waterworks Trusts, or water supply districts under the control of local government bodies, were proclaimed between 1870 and the 1900s.

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PART II

NATURE OF THE LAND

5. CLIMATE

Compared with many other parts of the State, the study area has a relatively uniform climate. Apart from the Pyrenees, it has few major topographic variations to cause marked climatic differences between nearby sites. Nevertheless, even fairly minor topographic features do produce differences. For example, elevated ridges and ranges often receive greater rainfall than surrounding lower areas; on the other hand the low-lying areas are frequently more prone to frost - in this case a difference in elevation of only a few metres can make a significant difference. The influence of latitude on climate is superimposed on the local effects of topography.

Because of the gentle climatic variation here, a small number of representative sites may be used to compare the climates of different parts of the study area. The information in this chapter is based mainly on eight climatological recording stations. Boort and Charlton represent the northern parts - these two stations just outside its northern boundary have been selected in the absence of comprehensive recording stations within this part of the study area. St. Arnaud, Bendigo, and Murchison represent the central latitudes, while Stawell, Avoca, and Castlemaine provide examples of the southern parts. Meteorological records are no longer kept at Murchison, so figures listed for this station are old; however, this information remains the best available for the eastern part of the area.

Temperature

Table 2 shows the average maximum, minimum, and mean temperatures for the eight representative recording stations.

January and February are the warmest months, with temperatures being highest in the north - the average maximum of 31°C at Boort compares with one of 28°C at Castlemaine.

Temperatures are lowest in July, with average daily maxima for Boort and Castlemaine respectively of 14°C and 12°C, and average minima of 4°C and 2°C.

Frost

The occurrence of frost depends not only on the temperature and humidity of the

air, wind speed, and cloudiness, but also on the characteristics of the particular site - its vegetation cover, its slope, and the slope of the surrounding land. Susceptibility of a particular piece of ground to frost is a peculiarity of site; nevertheless some general observations are useful.

Damage to forest near Sandon caused by a tornado in 1976

At very low temperatures, frost causes damage to plants and may even kill them. The temperature at which damage occurs depends on the plant species and the stage of growth. For example, small green fruit of apricots and grapes may be damaged by less than 30 minutes' exposure to temperatures of -0.5°, where flower buds of apricots would be undamaged by such exposure to temperatures down to about -4° and flower buds of grapes could tolerate short exposure to temperatures as low as -6.5°.

Severe frosts have also caused deaths of young lambs in the study area.

Furthermore, the temperature at ground level may be low enough to cause severe damage, while only a metre above the ground no damage occurs (in frosty conditions ground temperatures are usually several degrees below screen temperatures - the actual difference varies considerably). Consequently it is very difficult to define a single measurement that reliably indicates when frost damage will occur. Screen temperature is a widely available measurement, and on of 0°C is widely accepted as indicating a heavy ground frost and some frost effect at one metre above the ground. Table 3 shows the average number of occasions of screen temperature of 0°C or less for the eight representative recording stations.

Table 2

AVERAGE MAXIMUM, MINIMUM, and MEAN DAILY TEMPERATURES (^{o}C)

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Boort*	Max.	31.2	30.3	26.8	22.7	17.0	14.2	13.5	15.2	17.8	22.4	25.1	28.3	22.0
	Min.	15.4	16.3	13.2	10.1	6.6	4.2	3.6	4.7	6.2	8.6	10.5	13.1	9.4
	Mean	23.3	23.3	20.0	16.4	11.8	9.2	8.6	10.0	12.0	15.5	17.8	20.7	15.7
Charlton*	Max.	31.1	31.0	27.0	22.4	16.8	14.1	13.2	14.8	17.0	22.5	25.0	27.9	21.9
	Min.	14.2	15.1	12.5	9.1	6.0	3.9	3.3	3.9	5.2	7.6	9.6	12.4	8.6
	Mean	22.7	23.1	19.8	15.8	11.4	9.0	8.3	9.4	11.1	15.1	17.3	20.2	15.3
St. Arnaud	Max.	29.9	29.5	25.8	21.6	15.9	13.1	12.2	13.8	16.2	20.7	23.4	26.3	20.7
	Min.	13.6	14.3	11.7	8.8	5.5	3.5	3.0	3.9	5.4	7.4	9.3	11.3	8.1
	Mean	21.8	21.9	18.8	15.2	10.7	8.3	7.6	8.9	10.8	14.1	16.4	18.8	14.4
Bendigo	Max.	29.2	28.1	25.3	20.7	15.5	13.2	11.9	13.5	16.2	19.9	23.4	26.2	20.3
	Min.	14.4	14.3	12.1	9.0	6.0	4.4	3.5	4.5	5.7	8.0	10.2	12.3	8.7
	Mean	21.8	21.2	18.7	14.9	10.8	8.8	7.7	9.0	11.0	14.0	16.8	19.3	14.5
Murchison	Max.	31.9	31.6	27.4	23.1	18.2	15.3	14.8	15.5	18.4	22.3	26.9	30.2	23.0
	Min.	14.3	14.4	11.8	9.0	6.2	4.3	3.6	4.1	5.7	7.6	9.9	12.6	8.6
	Mean	23.1	23.0	19.7	16.0	12.2	9.8	9.2	9.8	12.1	14.9	18.3	21.4	15.8
Stawell	Max.	29.9	28.8	25.6	20.5	15.7	13.4	11.6	13.3	16.5	20.8	23.1	25.2	20.4
	Min.	13.3	14.3	11.8	9.3	7.2	5.0	4.2	5.1	6.9	8.6	10.0	11.4	8.9
	Mean	21.6	21.6	18.7	14.9	11.5	9.2	7.9	9.2	11.7	14.7	16.6	18.3	14.7
Avoca	Max.	29.1	28.4	25.0	20.6	15.3	12.8	12.0	13.5	16.1	20.2	22.6	25.9	20.1
	Min.	12.7	13.7	10.5	7.4	5.1	2.9	2.4	3.5	4.5	6.2	8.5	10.6	7.3
	Mean	20.9	21.1	17.8	14.0	10.2	7.9	7.2	8.5	10.3	13.2	15.6	18.3	13.7
Castlemaine	Max.	28.8	28.9	24.9	20.9	15.4	13.1	12.0	13.4	15.6	19.5	22.8	25.6	20.1
	Min.	12.7	13.7	10.0	7.4	4.1	2.0	2.0	3.0	4.2	6.0	8.0	10.0	6.9
	Mean	20.8	21.3	17.5	13.7	9.8	7.6	7.0	8.2	9.9	12.8	15.4	17.8	13.5

* Outside the study area

Table 3

AVERAGE NUMBER OF SEVERE FROSTS (SCREEN TEMPERATURES OF 0°C OR LESS)

	No. of years	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Boort*	12	0	0	0	0	0.1	1.7	1.8	0.7	0.3	0.1	0	0	4.7
Charlton*	7	0	0	0	0	0.7	4.3	4.6	3.6	1.9	0.7	0	0	15.7
St. Arnaud	12	0	0	0	0	0.4	5.1	4.4	2.9	0.7	0.1	0	0	13.6
Bendigo	20	0	0	0	0	0.2	2.1	3.1	1.4	0.2	0.1	0	0	6.9
Murchison	<10	0	0	0	0	0.8	1.5	3.3	2.7	0.2	0	0	0	8.5
Stawell	3	0	0	0	0	0	1.7	1.0	0.3	0	0	0	0	3.0
Avoca	11	0	0	0	0.3	1.4	5.5	5.8	3.5	1.6	0.5	0	0	18.6
Castlemaine	11	0	0	0	0.7	4.5	10.3	10.2	6.6	3.6	1.1	0.1	0	38.1

* Outside the study area

Table 4

MEAN RAINFALL (mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Boort*	22	28	27	26	40	41	39	39	37	37	29	26	389
Charlton*	23	27	28	32	42	49	43	45	41	39	29	27	422
St. Arnaud	25	30	28	38	53	59	55	56	48	47	34	29	499
Bendigo	33	35	36	40	53	61	55	56	53	51	38	33	541
Murchison	34	32	40	40	51	65	56	55	51	55	38	34	551
Stawell	26	30	30	38	54	64	57	59	54	50	39	32	533
Avoca	26	38	30	40	50	61	59	60	52	48	38	36	537
Castlemaine	27	39	33	37	55	56	60	62	57	55	40	37	554

* Outside the study area

Some frosts normally occur each year in all parts of the study area, although their frequency varies greatly from place to place (for example, Boort has an annual average of 4.7 frosts, compared with 38.1 at Castlemaine). It is clear from Table 3 that, unlike average temperatures, frequency of frost is not determined mainly by latitude (compare Boort with Charlton in the north, and Stawell with Castlemaine in the south).

Another important factor is the period over which frost occurs, since this may restrict the suitability of an area for growing frost-sensitive crops. Castlemaine usually suffers frost on at least one day a month for 6 months, whereas at Boort frost occurs with this frequency only for 2 months.

Rainfall

Throughout the study area rainfall is greatest in winter (with June generally being the wettest month) and least in summer (the driest month usually being January).

Average yearly rainfall ranges from approximately 400 mm in the north to an estimated 750 mm or more on the higher parts of the Pyrenees (see Table 4 and Map 2). For most of the study area it varies between 400 mm and 500 mm, but much of the public land, being higher than surrounding private land, receives greater rainfall than nearby locations. In the absence of rainfall records within the public land, it is difficult to estimate the magnitude of this effect.

Climate and plant growth

When discussing climate in relation to land use it is necessary to consider the influence of climate on plant growth, since this has a direct bearing on land use.

Cold significantly reduces plant growth; a mean monthly temperature of 10°C is commonly accepted as the temperature below which it is substantially reduced and, in general, species of the temperate zone produce little appreciable growth when temperatures fall to about 5°C.

The effect of temperature on plant growth is buffered to some extent by the soil, which - being slow to cool or warm up - lags behind temperature changes and is little affected by such changes from day to day.

From Table 2 it may be seen that the mean monthly temperature is less than 10°C for 3 months (June, July, and August) at most stations. At Boort it falls below 10°C only for June and July, whereas at Castlemaine 5 months have mean temperatures less than 10°C. Thus, cold restricts plant growth in winter throughout the study area.

Frost is also important. Different plant species differ in their suscep-

tibility to frost and many grown in this area are unlikely to suffer damage. Some, however, such as fruit trees and grape vines, are susceptible. Spring frosts, occurring at a growth stage when plants are most sensitive to frost, may cause serious damage to agricultural crops. Table 3 shows the extent to which frost incidence varies from place to place. It also indicates that spring frosts are most frequent at Castlemaine, Charlton, and Avoca.

Data on rainfall are readily available, and the area contains many rainfall-recording stations. Rainfall alone is not a reliable indicator of availability of water to plants, however, which also depends on water loss through evaporation and on site characteristics such as soil type, slope, and aspect.

"Effective rainfall" - a widely accepted measure of the availability of moisture to plants - is the minimum amount necessary to start and maintain plant growth, and can be calculated from data on precipitation and evaporation. Such calculations make no allowance for site characteristics, nor for water already contained in the soil following a period when rainfall exceeded evaporation. Estimates of effective rainfall provide a useful guide to crop and pasture

Table 5

PERCENTAGE FREQUENCY OF FALLS OF RAIN EQUAL TO OR GREATER THAN THE "EFFECTIVE" AMOUNT

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Boort*	8	14	19	31	69	87	83	76	46	36	19	12
Charlton*	9	12	25	37	69	89	86	87	67	36	16	12
St. Arnaud	12	13	25	48	77	93	94	91	79	50	22	14
Bendigo	18	21	35	55	81	95	92	91	85	57	29	19
Murchison	19	19	34	49	79	94	93	86	77	61	26	22
Stawell	14	19	26	59	80	94	96	93	87	64	31	18
Avoca	13	23	28	57	86	100	97	95	90	60	31	28
Castlemaine	8	18	33	58	81	92	99	93	85	62	24	22

* Outside the study area

growth, but are less-reliable indicators of conditions affecting other plant species, particularly deep-rooted perennials.

Table 5 lists the probabilities of the actual monthly rainfall equalling or exceeding the calculated effective rainfall at the eight representative stations. A probability of 50% indicates an equal chance of receiving or not receiving rainfall at least as great as the "effective" amount during that month; one of 25% reduces that to only a one-in-four chance.

The table shows that all the stations have less than an even chance of receiving effective rain in the months November to March, and that this also applies at Boort, Charlton, St. Arnaud, and Murchison in April, at the first two places in October, and at Boort in September.

Thus it is clear that throughout the study area lack of rain will severely restrict plant growth for substantial periods.

As mentioned earlier, the effects of climate are modified by the characteristics of a particular site. Water availability depends on slope and aspect, and on soil type. Different soils vary considerably in the amount of water they hold, and in their rates of water absorption and loss.

A short growing season can be lengthened artificially. Irrigation during the dry period, when warm temperatures favour plant growth, enables growth of agricultural crops to continue.

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6. GEOLOGY

Geologists divide the Earth's history of more than 4,000 million years into four major time units called eras - the Precambrian, the Palaeozoic, the Mesozoic, and the Cainozoic.

Events in the geological history of the study area occurred predominantly in the Palaeozoic and Cainozoic eras. Table 6 depicts their sequential order of events and the geological time scale.

Early in the Palaeozoic era, marine sediments were laid down in a series of fault-controlled troughs in the Tasman Geosyncline, a large sedimentary basin that had formed along the eastern margin of Australia. The sediments deposited in these troughs were progressively folded, faulted, and intruded by granite, culminating in the middle Devonian period. It is these rocks that now form the bulk of the highlands in the study area.

Apart from glacial activity during the Permian, and the intrusion of dykes in the Jurassic, the study area underwent prolonged erosion from the middle Devonian to the early Tertiary - a time span of more than 300 million years. Many thousands of metres of sediment and granite were stripped away, and remnants of old erosion surfaces left scattered throughout the highlands.

Towards the end of the Tertiary period, large streams dissected the highlands, and laid down gravels (deep leads) along their valleys and into the Murray Basin to the north.

During the Pliocene epoch the sea, inundating the Murray Basin, penetrated the study area near Stawell and lapped the highlands around to Raywood. During and after the retreat of the sea, streams again flowed north, laying down extensive alluvial deposits that built up the Wimmera and Riverine Plains.

This was followed by Newer Volcanic activity, with basaltic lava forming broad plains and flowing along ancestral river valleys.

At least four climatically controlled depositional cycles are thought to have occurred during the Quaternary. The most recent cycle includes the deposition of alluvial sediments up until the present. The surface geology of the

study area is shown on the map at the end of the report.

Stratigraphy

Cambrian

Rocks of Cambrian age are the oldest in Victoria, and represent the initial phase of development of the Tasman Geosyncline. This occurred when extensive volcanic activity, early in the period, caused accumulation of at least 1,500 m of basic lava, ash, tuff, agglomerates, and minor intrusives called the Heathcote Greenstones. Within the study area these rocks occur along a narrow belt from Tooborac to Corop, known as the Heathcote Axis.

By the middle Cambrian, igneous activity had effectively ceased. At a later date these rocks were metamorphosed by deep burial. To the north of Heathcote township, the Heathcote Greenstone is conformably overlain by the Knowsley East formation, comprising shales interbedded with thin ash beds and some tuff.

The Goldie Shale (600 m of finely bedded black shale and mudstone) conformably overlies the Knowsley East formation to the north of Heathcote, but elsewhere it unconformably overlies the Heathcote Greenstones. In outcrop these shales are usually bleached and silicified and form a line of low hills making up the western part of the Colbinabbin (or Mount Camel) Range.

The Heathcote Axis is bounded by high-angle reverse faults. To the east the

Tight folding in Cambrian chert, Ladys Pass near Heathcote

McIvor and Mount Ida Faults bring the Cambrian rocks into contact with Upper Silurian--Lower Devonian rocks; to the west the Knowsley East and Heathcote Faults bring Cambrian rocks into contact with Lower Ordovician slates. Faulting has also incorporated slices of Lower to Upper Ordovician rocks within the Cambrian belt.

Cambrian--Ordovician

The rocks in the belt from the western boundary of the study area to east of St. Arnaud and Avoca are bedded sandstones and shale. They are usually extremely weathered. Because no fossils have been found in them, their age is uncertain, and they are assigned a broad Cambrian--Ordovician age.

They are separated from rocks of known Ordovician age to the east by a wedge of granitic and metamorphic rocks between Charlton and Natte Yallock and by a valley flow of basalt between Natte Yallock and the southern boundary of the study area.

Ordovician

Within the study area, Ordovician rocks outcrop between Wedderburn and Burnbank in the west and the Heathcote Axis in the east.

Approximately 3,000 m of Ordovician sediments were deposited in a segment of the complex Tasman Geosyncline. The sediments (alternating slates, sandstones, and siltstones) are thought to be continental shelf deposits subsequently redeposited in subsiding geosynclinal troughs by turbidity currents.

Dark shaly layers accumulated in the quiescent periods, and a rich, almost complete sequence of graptolites (extinct colonial organisms now preserved as fossils) developed there. These fossils have made it possible to subdivide the Ordovician sediments - one of the most detailed zonal subdivisions in the world.

The western margin of sedimentation shifted progressively towards the east. Unfossiliferous sediments in the west may have provided some of the source material for the younger Ordovician sediments deposited in contracting troughs nearer the Heathcote Axis.

Soon after deposition, the sediments were tightly folded and converted into low-grade metamorphics, especially changing shale to slate.

Large-scale faults disrupted major folds and cut out zones in the fossil sequence. Some faults were active during sedimentation, and controlled the areas of deposition. The most important are the Muckleford, Whitelaw, Sebastian, and Campbelltown Faults. The Muckleford Fault has been traced for more than 130 km, from west of Bendigo southwards. It transects the Harcourt Batholith, where

Table 6

GEOLOGY OF THE NORTH - CENTRAL STUDY AREA:
RELATIONSHIP OF THE ROCK UNITS AND THE GEOLOGICAL TIME SCALE

ERA	PERIOD	EPOCH	AGE (m.y.)	West of Ballarat - Wedderburn line	Central area	East of Colbinabbin Range	MAJOR EVENTS
CAINOZOIC	QUATERNARY	RECENT	0·01	Coonambidgal Formation, *alluvial and lacustrine deposits*			
		PLEISTOCENE	1·8	Shepparton Formation, *alluvial and aeolian lunette deposits*		Wunghnu Group	River, lake and wind deposition; erosion in midlands Lateritization
	TERTIARY	PLIOCENE		Parilla Sand, *shallow marine sandstone, siltstone*	Newer volcanics, *basalt lavas and pyroclastics*	Calivil Formation, *alluvial lead deposits of pebbles, sands, silts and clays*	Volcanicity
			5				Marine incursion
		MIOCENE					Erosion, deposition along swift streams Faulting, uplift of midlands
			23	Murray Group, *clays*			Deep weathering (lateritization) *Marine incursion in far west*
		OLIGOCENE					
			39	Renmark Group, *non-marine sands and silts*			Lateritization River and lake deposition
		EOCENE					
		PALAEOCENE	55		*EROSION*		
MESOZOIC	CRETACEOUS		65				
			140				
	JURASSIC						Intrusion of monchiquite dykes
	TRIASSIC		195		*EROSION*		
			247				
PALAEOZOIC	PERMIAN			*Glacial sediments, tillites, sandstones, clay*			Glaciation on fault controlled topography
	CARBONIFEROUS		289		*EROSION*		
	DEVONIAN		367		*Granite intrusion; metamorphism of surrounding rocks to hornfels*		Folding, faulting, uplift of Cambrian - Lower Devonian rocks
			416	*Granite intrusion; metamorphism of surrounding rocks to schist and hornfels*			
	SILURIAN			*EROSION*		*Marine sediments*	
			446	*Culmination of folding of Cambrian to Mid Ordovician rocks*			Folding and faulting. Marine deposition contracts to east of Colbinabbin Range (Heathcote axis)
	ORDOVICIAN			*EROSION*	*Marine sediments, sandstone, greywacke, siltstone, mudstone; fossil graptolites allow detailed biostratigraphic division of sequence Outcrop only west of Colbinabbin Range*		Initiation of folding in far west
			509	*Marine sediments, sandstone, greywacke, siltstone, mudstone* ? ?	*Submarine volcanics (greenstones), shales and cherts*		Volcanicity and sedimentation
	CAMBRIAN		575				

it is marked by a zone of crushed granodiorite.

Silurian--Devonian

By the end of the Ordovician period, marine sedimentation proceeded only east of the Heathcote Axis.

Faulting along the Axis delineated the margin of a rapidly subsiding trough (Melbourne trough), in which 7,300 m of Lower Silurian to Lower Devonian sediments were deposited in the Heathcote--Costerfield area. This sequence consists of massive sandstone, quartzite, siltstone, mudstone, and some conglomerate. It contrasts markedly with thin-bedded, tightly folded, and strongly cleaved Ordovician sediments to the west.

One of the most complete and best-known Silurian--Lower Devonian sequences in the State is found between the Heathcote Axis and the Moormbool Fault, east of Costerfield. Correlation of this sequence with sediments east of the Moormbool Fault is hampered by the lack of fossil evidence, however, and different formation names have been given.

In the middle Devonian, these trough sediments were folded, faulted, and intruded by granite. These successive phases of tectonic activity progressively stabilized the study area.

Various dating methods have revealed two periods of intrusion by granitic rocks

Granite tors at Mount Egbert

and associated dykes (see Table 6). The plutons formed by these intrusions are predominantly granite or granodiorite, and vary in size from small pods 1 km across - for example, Mount Black - to more than 25 km in the Harcourt Batholith.

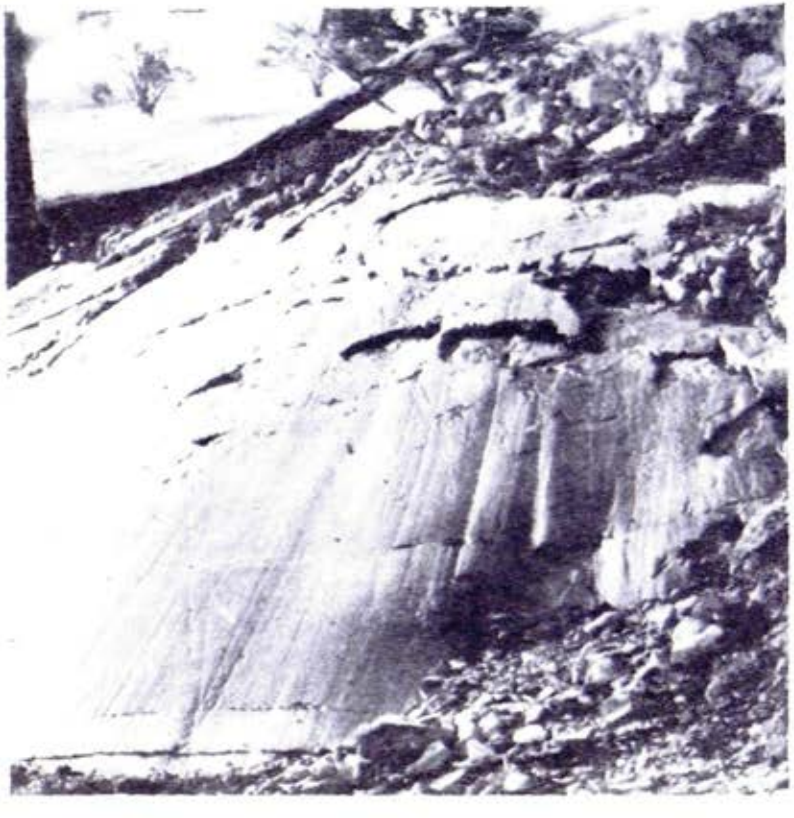
Permian

The interval between the folding of the Silurian--Devonian sediments and subsequent deposition in the Permian exceeds 100 million years. During this time extensive erosion took place, exposing several granitic masses.

During the Permian, frigid conditions developed over much of Australia. Continental glaciers moved from the south-

west and south-east into the study area along fault-controlled valleys in the Derrinal and Loddon River areas.

In the Derrinal area a glacier was confined to a valley between the Knowsley East and Meadows Valley Faults. Glacial deposits (tillites) up to 75 m thick were deposited, some of which are displayed in road cuttings on the McIvor Highway, and numerous glacial erratics



"Kellams Rock", showing striations formed by glacial action

are present (including "The Stranger", a large striated block of pink granite.

The thickest glacial rocks occur beneath basalt or gravels, along the Loddon Valley to Newbridge. Deep-lead mining revealed many occurrences, and one bore was abandoned after intersecting 93 m of tillite.

Jurassic

Dark-coloured fine-grained dykes of late Jurassic age intrude the Lower Palaeozoic basement rocks. These are best known on the Bendigo gold-field.

Tertiary

Following the brief period of glacial deposition in the Permian, erosion continued in the study area for more than 200 million years. The Pyrenees are remnants of an early Tertiary peneplain, which had elevations exceeding 900 m.

As a result, extensive deposition occurred on the alluvial plains and deltas in the Murray Basin (forming the Renmark group). Later, streams dissecting the highlands laid down coarse gravels and sands (the deep leads of the Calivil formation) in their valleys.

In the Pliocene epoch these valleys and their sediments were flooded by the sea inundating the Murray Basin. As the sea retreated, it laid down sands and silts called the Parilla Sands. Calivil form-

ation sediments continued to be deposited by streams flowing north, and these in turn covered the marine deposits.

Pliocene and Pleistocene Newer Volcanics

In the Pliocene and Pleistocene epochs, the Newer Volcanics (basalts, tuffs, and scoria) of the Western District volcanic province were extruded. This included the southern part of the study area around Clunes and Moolort, but lava flowed north, even as far as Avonmore, along ancestral river valleys (Bet Bet, Loddon, Coliban, and Campaspe). Around Moolort the basaltic flows filled the Tertiary "deep-lead" valleys, before overflowing and forming a broad plain.

Between Woodstock and Newbridge the basalt flows gave rise to the characteristic features of "stony rises" - a combination of original flow tops, steep flow edges, and collapsed lava tunnels. Bald Hill near Marong - a lava cone and the most northerly eruption point known in Victoria - was one of the sources for this lava.

Quaternary

Quaternary sediments form an almost continuous veneer over the older flat-lying Tertiary sediments of the Murray Basin. The Shepparton formation consists of all the older alluvial formations, which infill the highland valleys and coalesce at the highland front to form the Riverina and Wimmera plains. Four climatically controlled depositional cycles are thought to have occurred in this period. In the most recent cycle, modern streams have incised into the older deposits and laid down sediments of the Coonambidgal formation.

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7. PHYSIOGRAPHY

Broadly, the study area has three main physiographic divisions: the Western Highlands, covering most of it; parts of the Murray Basin plains to the north and west; and remnant areas of undulating plains on Newer Volcanics in the south and centre. These divisions largely depend on the geological parent materials, discussed in the previous chapter.

The highlands do not have readily definable boundaries with the plains, as, with a few exceptions, they rise less than 300 metres above sea level. The plains extend along several of the river valleys that cut north--south across the study area. The Loddon River, which bisects it, is one of the seven major north-flowing rivers there.

Topography does not vary greatly - the maximum relief being 660 metres from the highest point in the Pyrenees (Mount Avoca, 760 m) to the plains in the north (average elevation 100 m). The higher-altitude areas correspond to the more-resistant igneous and metamorphic rocks.

Murray Basin plains

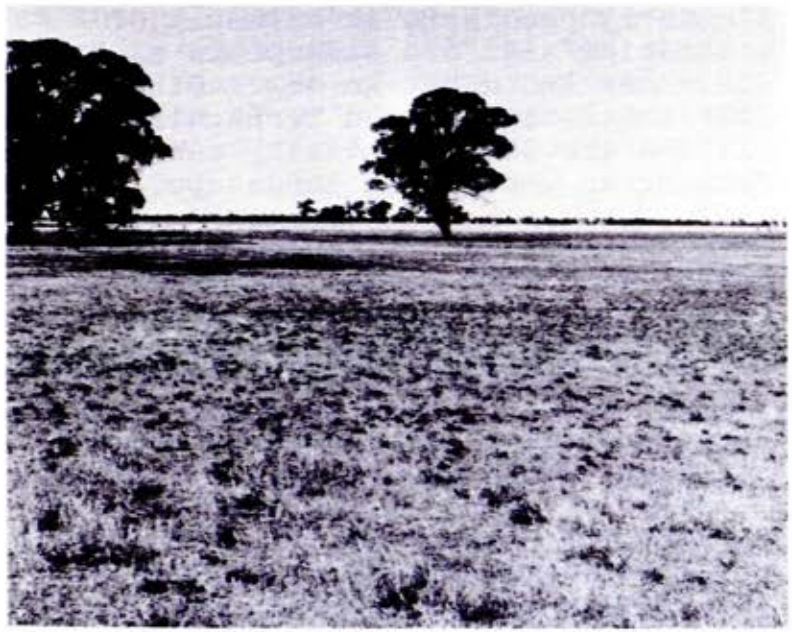
Broad plains of alluvium in the northern part of the study area were formed on older flat-lying Tertiary sediments of the Murray Basin. Eastern parts of these are known as the Riverine Plains, and in the study area extend north from Borung, Raywood, and Murchison. Also, southerly extensions of the Riverine Plains correspond to the Goulburn, Cornella, Campaspe, and Loddon alluvial plains. All of these were laid down in the Quaternary period by depositional cycles of north-flowing streams emptying into the Murray Basin.

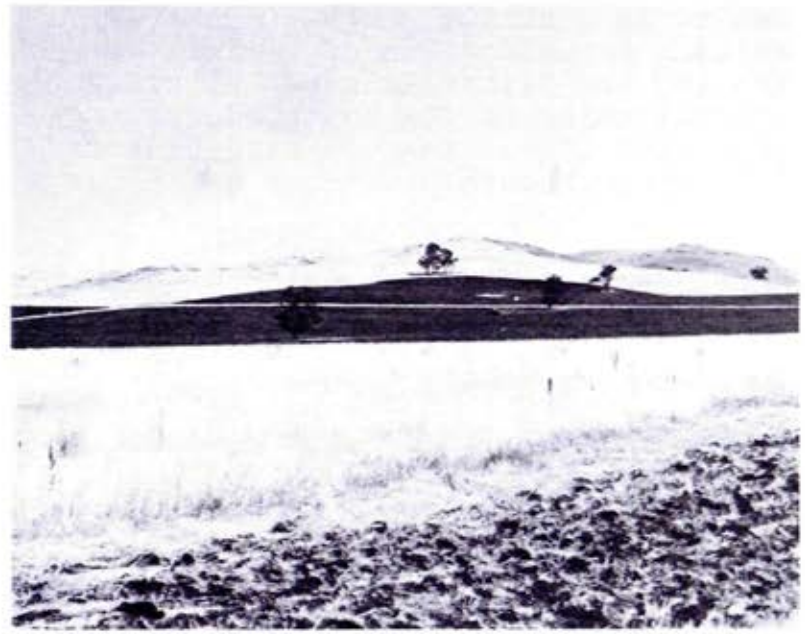
Modern streams, associated with the most recent cycle, have formed flood plains with terraces displaying entrenched meanders, scroll patterns, etc.

Lacustrine areas with up to three associated lunettes on their eastern margins are located east of Bailieston, in the Corop lakes area, at Cope Cope, and at Gre Gre North. Multiple lunettes are explained by receding shore lines, with the oldest lunette furthest from the lake.

The highlands

The highlands form part of the midlands subdivision of the Western Highlands. Topography here reflects rock type,





Quaternary alluvial plains near Serpentine and the Mount Camel Range near Colbinabbin

structural factors (faulting and folding), and old erosion surfaces.

The Pyrenees form the most rugged terrain, with the highest point being Mount Avoca (760 m), south-east of Landsborough. Comprising Cambrian to Lower Ordovician sediments, this range is a remnant of a Cainozoic peneplain that had elevations exceeding 900 m. The peneplain's development resulted from the uplift and dissection of a deeply weathered plateau during the mid Tertiary.

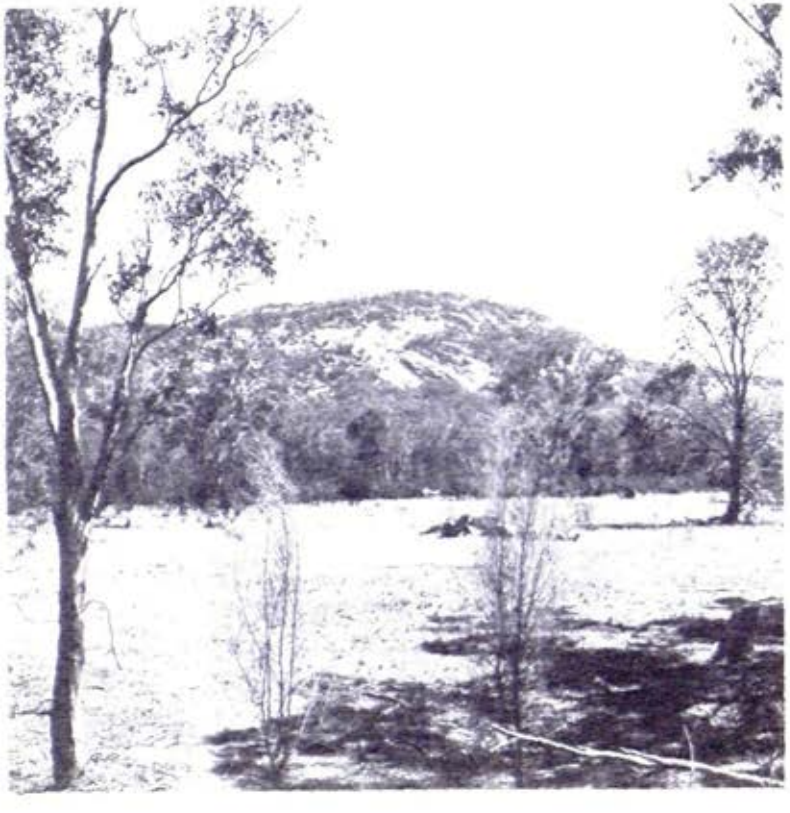
Reactivation of Palaeozoic strike faults at this time resulted in some blocks of the earth's crust being uplifted while others were downthrown. Bendigo is situated on one of several such blocks between the Leichardt and Whitelaw Faults.

East of the Heathcote Axis, a dissected plateau of Silurian and Devonian sediments resembles that developed on the Ordovician sediments to the west. Here broad folds in the sediments, combined with thick sandstone and conglomerate beds, have produced strike ridges such as at Bailieston and Whroo.

The Mount Camel Range, separating the Ordovician from Silurian--Devonian sedi-

ments, is a strike ridge of Cambrian rocks. A combination of resistance to erosion and Cainozoic movement along several major faults has produced this prominent linear feature extending from Tooborac, through Heathcote and Mount Camel, to Corop.

Various granitic masses within the study area cause variations in topography. The Harcourt, Mount Kooyoora, and Coonooer granite masses (plutons) are particularly prominent as a result of weathering and form such peaks as Mount Alexander and Mount Korong. Others, like the Carapooee and Tarnagulla plutons are topographically subdued - forming an undulating landscape.



Mount Kooyoora

Prominent contact ridges occur in association with some granitic masses and are particularly well developed around the Natte Yallock, Tarnagulla, and Harcourt plutons. Small resistant pods of granite and associated metamorphic aureoles often form high points, as at Mount Moliagul, Mount Egbert, and Mount Black.

Colluvial slope deposits, particularly in granitic areas, are widespread and well developed in the highlands.

The belt of soft Permian rocks around Lake Eppalock comprises a distinctive area in the highlands. The smoothly rounded slopes formed on this rock type contrast with the adjacent rugged Ordovician bedrock.

Newer Volcanics

At its northern edge, a large area of volcanic rocks known as the Western District volcanic province extends into the southern and central parts of the study area. Lava flows from its volcanoes have spread along the Bet Bet, Loddon, and Campaspe River valleys. Around Clunes, Moolort, and Eddington, the basaltic flows have formed a broad undulating plain.

Remnants of more recent flows around Newbridge--Woodstock exhibit the characteristic features of "stony rises" - a combination of original rough flow tops, steep flow edges, and collapsed lava tunnels.

Within the study area, 16 eruption points have been named, and remnant volcanoes range from 400 m high down to hillocks of less than 15 m. Two types of volcanic activity are represented:

* Lava volcanoes: repeated eruptions of basaltic flows with no apparent scoria have formed low-angle lava cones of moderate relief. Few show any sign of a crater; most are deeply weathered, and may appear nothing more than insignificant humps - for example, Mount Moolort, Bald Hill (Woodstock), and Two Mile Hill.

  In some areas, more-viscous extrusions have produced steep-sided hills or lava discs.

* Scoria cones: pyroclastic activity has constructed steep-sided scoria cones (for example, Mount Duntrulm or scoria cones lacking a crater (for example, Mount Cameron and McKinnan's Hill). Some, such as McIvor Hill and Mount Duntrulm, exhibit breached craters. The more coarse the material thorn out by the volcano, the steeper is the cone that results.

Mount Moolort, an ancient volcano

Mount Greenock is the only extinct volcano remaining on Crown land in the study area.

Drainage

Elevation of the highlands and retreat of the sea during the late Tertiary resulted in the rejuvenation and alteration of stream courses. Movement along faults has also produced narrow valleys on the upthrown blocks, such as that of Bendigo Creek upstream of the Whitelaw Fault. In addition, volcanic flows forced the late Tertiary Avoca River to abandon the Bet Bet valley and to take its present course north from Archdale.

East of the Mount Ida Fault, down-faulting by about 30 m during the Quaternary restricted drainage from Cornella Creek

and Wanalta Creek, resulting in an extensive system of lakes and marshes in the Corop area. These lakes often dry out during droughts, but Green's Lake now forms part of an irrigation system. Tilting near Bailieston is probably responsible for the formation of the Reedy Lake system. Cainozoic movement on the Whitelaw Fault has also led to the development of Tang Tang and Winghee swamps.

The metamorphic aureoles around granite intrusions resist erosion and form prominent ridges, and in many cases streams are confined to the contact zone. Carmanuel Creek in the Natte Yallock pluton is one example.

Basaltic flows of Newer Volcanics have exerted considerable influence on the drainage in the southern part of the study area by ponding and diverting streams. These areas are now marked by alluvium in which the drainage is poorly defined, with numerous swampy areas.

Some of the major rivers - the Loddon, Campaspe, and Coliban - still occupy their pre-basaltic valleys despite some damming by lava flows in the past. Active erosion by these rivers has left scattered remnants of basalt along their courses. Numerous lateral streams have developed, including the Loddon River between Newbridge and Bridgewater, Joyce's Creek north of Campbelltown, and Bet Bet Creek north of Lillicur. Twin lateral streams have developed south of Craigie.

Source-bordering dunes have developed along Majors Creek and the Campaspe River, from sand blown from stream-beds and bars.

North of Serpentine, the Loddon River fans out across a broad flood plain as anastomosing distributaries over a clay surface. Faulting along the Leichardt--Leagher Fault may have played a part in this phenomenon.

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8. SOILS

Complex interactions between climate, parent material, topography, and organisms determine the chemical and physical properties of most soils. The time span during which these factors act also affects the properties. In some environments, one or two of the soil-forming factors may have more influence than others.

Within the study area climatic variation is limited, and soil differences relate mainly to parent materials and topography. The most common parent materials are Palaeozoic slates and sandstones, granites, and granodiorites. These rocks, and the alluvial deposits derived from them, form soils of low to moderate fertility. The more fertile soils are limited to small areas of basalt and Cambrian greenstone.

Unfortunately, few detailed soil surveys have been undertaken in this area. Further north the Department of Agriculture has carried out detailed soil surveys on the Riverine plain in connection with irrigation use. These surveys extend into the study area in the Dingee--Mysia district and to the north-west of Rushworth. Small-scale regional soil maps with explanatory notes covering most of the area have been published by the Central Planning Authority.

The Soil Conservation Authority is presently conducting land system surveys in the area. As Table 7 shows, 17 local soil groups have been recognized, and extrapolated across the study area by photo-interpretation and limited field inspections.

In the absence of a comprehensive soils map, the land systems map does provide some indication of soil distribution. As indicated above, however, soils vary markedly, with differences in relief and drainage. Table 8 gives examples of soil catenas (or sequences) that develop at various topographic positions on different parent materials.

The soil group at a particular site can therefore be deduced by determining the likely geomorphic parent material there from the land systems map. Then, having determined the parent material (and knowing the approximate topographic position of the site), one can deduce the likely soil group from Table 8.

The features of each local soil group are discussed below. Many of the feat-

ures present problems; examples include the hard-setting surfaces and low permeabilities of the sodic duplex soils, or the low water-holding capabilities of stony soils and of the sand upper horizons on granitic rocks. These are further discussed in chapter 13 (Hazards) and in the land system descriptions.

A glossary on pages 46--7 explains some of the soil terms used in this chapter.

Local Soil Groups

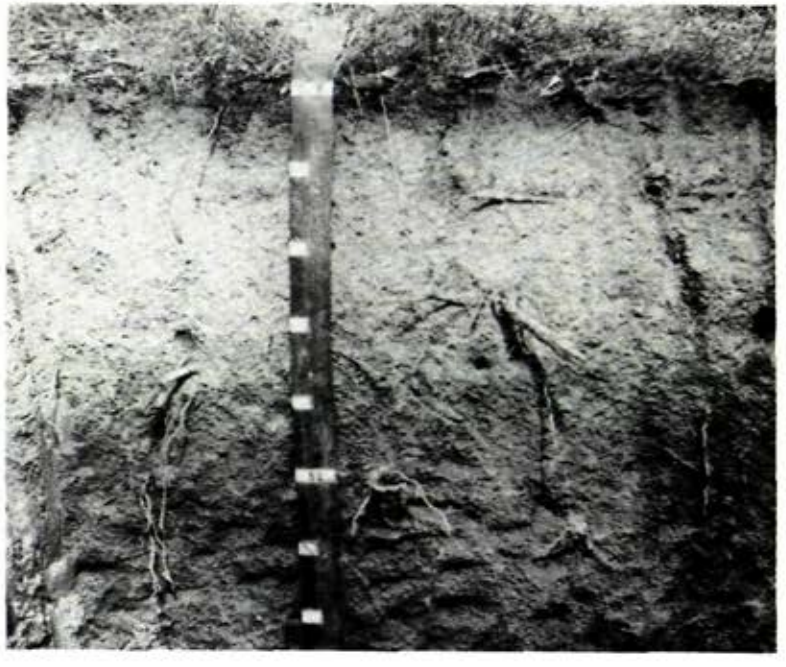
Uniform soils

Pale-brown coarse sands of uniform texture occupy the steeper slopes on granitic rocks, notably around Mount Alexander and Mount Tarrengower. The water-holding capacities of these loamy coarse sands are low and drainage is excessive. Most of the slopes with these acidic soils remain largely under timber, but cleared hills include Mount Buckrabunyule, Mount Yawong, and the Dunluce area.

Grey calcareous sodic clays of uniform texture and coarse structure occur on relatively broad basaltic plains such as those around Axedale and Baringhup. These soils can become markedly gilgaied with the hollows having loamy bleached profiles. The coarse blocky subsoils are slowly permeable, which causes waterlogging and excessive run-off during wet periods. Cracking is obvious when the clays dry out. Land use on these soils is chiefly grazing.

Grey-brown calcareous sodic clays of uniform texture have developed on the broad areas of clayey alluvium that make up the Murray Basin plains in the north of the study area, and in smaller areas between bedrock outcrops, such as the Kamarooka district and around Reedy Lake. The profiles are slowly permeable and usually gilgaied, and cause severe salinity problems when irrigated.

Red calcareous sodic clays of uniform texture occur widely on the Riverine plain (for example, around Wychitella) and on fans from greenstones along the



Profile of a coarse sand soil, uniform texture

Table 7

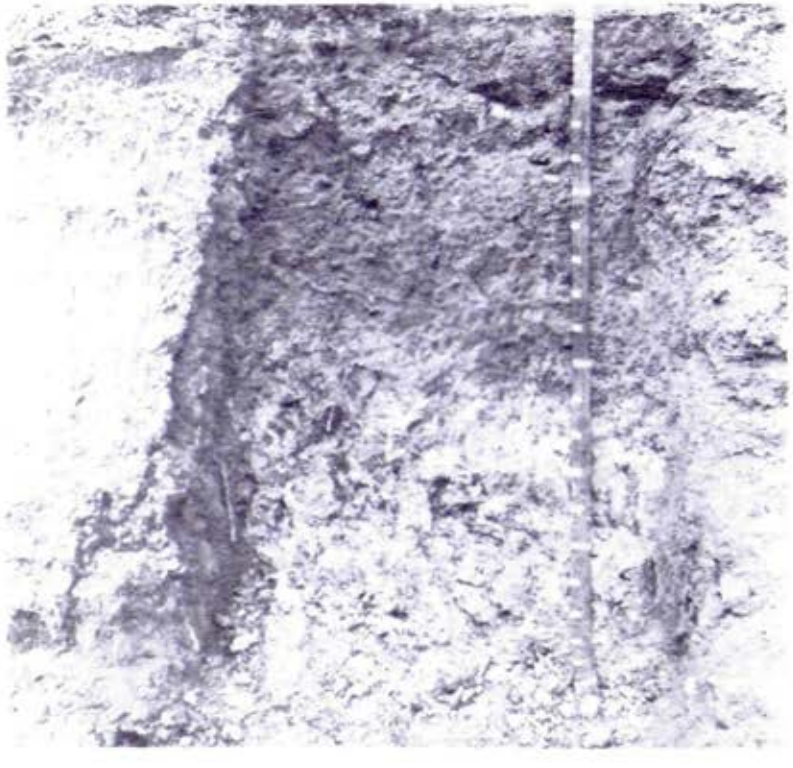
SOIL GROUPS IN THE NORTH CENTRAL AREA

Primary profile form	Great soil group*	Local soil group	Typical occurrence
Soils of uniform texture (soil profiles dominated by the mineral fraction, with only small differences in texture throughout	Brown podzolic soils	Pale-brown coarse sands	Mount Tarrengower, Mount Kooyoora, and the western face of Mount Bealiba. Cleared hills include Mount Buckrabanyule, Mount Yawong, and the Dunluce area
	Grey, brown, and red clays	Grey calcareous sodic clay soils, coarse structure	Rathscar, Baringhup, Axedale, Redesdale
	Grey, brown, and red clays	Grey-brown calcareous clay soils	Reedy Lake, Cope Cope
	Grey, brown, and red clays	Red calcareous sodic clay soils	Runnymede East, Whychitella
	Prairie soils	Black clay soils	Redesdale, Bung Bong
Gradational soils (soil profiles dominated by the mineral fraction, gradually becoming finer-textured (more clayey) with increasing depth)	Chocolate soils	Red-brown shallow stony gradational soils	Bridgewater, Woodstock North
	Krasnozems	Red stony gradational soils, fine structure	Mount Burramboot, Mount Camel
	Leptopodzols	Red stony gradational soils	No specific sites
	Leptopodzols	Yellow stony gradational soils	Metcalfe, Maldon, Pyalong
	Leptopodzols	Yellow-red shallow stony gradational soils	Whroo, Bendigo, Costerfield, Dunolly, St. Arnaud
	Leptopodzols	Yellow gradational soils	
Duplex soils (soil profiles dominated by the mineral fraction, with a pronounced and clearly defined contrast in texture between the A and B horizons)	Lateritic podzolic soils	Mottled red-yellow duplex soils with ironstone	Archdale West, Strathfieldsaye, Navarre
	Red-brown earths	Red calcareous sodic duplex soils	Bridgewater
	Solodized solonetz	Red sodic duplex soils	Whroo, Bendigo, Costerfield, Dunolly, St. Arnaud
	Solodic soils	Red sodic duplex soils, coarse structure	Tooleen, Bealiba, Wedderburn
	Solodic soils	Yellow sodic duplex soils, coarse structure	Knowsley, Lockwood
	Solodic soils	Yellow sodic duplex soils	Costerfield, Eppalock, Navarre

*According to Stace *et al* (1968), except for leptopodzols (Hallsworth *et al*, 1953).

Colbinabbin Range (for example, at Runnymede East). Although its permeability is low, the soil has moderate fertility and land use is predominantly cropping with alternate grazing. Cultivation on sloping fans poses a serious sheet erosion hazard, and severe salinity problems can develop following irrigation.

Black clay soils of uniform texture develop on alluvium from basalt, usually as narrow terraces beside drainage lines. They are only slowly permeable, which causes waterlogging and excessive run-off during wet periods. Examples occur at Redesdale and Bung Bong, and the land is used mainly for grazing.



A shallow stony gradational soil

Gradational soils

Red-brown shallow stony gradational soils occur on more-undulating parts of the basaltic plains, such as those south of Bridgewater. They are acidic and the colour varies from red through brown to grey, depending on drainage. Although they are fertile and permeable, stones and shallow profiles preclude cropping.

Red stony gradational soils with fine structure are restricted to the crest of the Colbinabbin Range, such as on Mount Burramboot or Mount Camel. They are acidic, permeable, and relatively fertile, but steepness and stoniness limit land use to grazing.

Red stony gradational soils form on fans below basaltic scarps. These are also acidic, permeable, and relatively fertile, but support cropping and grazing.

Yellow stony gradational soils have developed on fans below metamorphic ridges, such as at Metcalfe and Pyalong. Soil depth and permeability are satisfactory, but stone content limits the waterholding capacity. Forestry and grazing are the main land uses.

Yellow-red shallow stony gradational soils occur on the steeper slopes under-

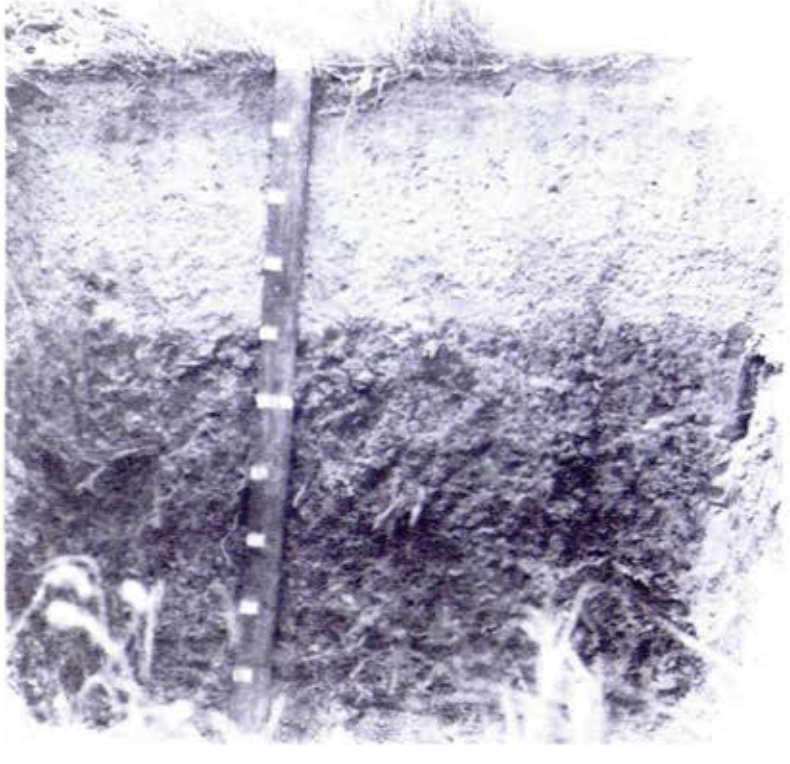
Table 8

SOIL CATENAS DEVELOPED ON DIFFERENT PARENT MATERIALS

Parent material	Topographic position	Local soil group	Hazards
Granite, granodiorite	Steep slopes	Pale-brown coarse sandy soils, uniform texture	Moderate sheet erosion
	Mid slopes	Mottled red-yellow duplex soils with ironstone	Low--moderate sheet erosion; low salting
	Lower slopes	Yellow sodic duplex soils, coarse structure	Moderate--high sheet erosion
	Alluvium from granite	Yellow sodic duplex soils	High gullying; low salting
Basalt	Steep slopes	Red-brown shallow stony gradational soils	Moderate sheet erosion
	Fans from basalt	Red stony gradational soils	Moderate sheet erosion
	Basaltic plains	Grey calcareous sodic clay soils, uniform texture, coarse structure	Low sheet erosion; low salting
	(Basaltic plains in the north)	(Red calcareous sodic duplex soils)	Deterioration of topsoil by overcultivation
	Alluvium from basalt	Black clay soils, uniform texture	Moderate gullying and streambank erosion; waterlogging; salting
Palaeozoic sediments	Steep slopes	Yellow-red shallow stony gradational soils	Moderate--high sheet erosion) Deterioration of adjacent land by siltation; salting
	Mid slopes	Red sodic duplex soils, coarse structure	High sheet erosion, moderate gullying
	Lower slopes	Yellow sodic duplex soils, coarse structure	
	Alluvium from Palaeozoic sediments	Yellow sodic duplex soils) Yellow gradational soils	Moderate--high gullying and streambank erosion; waterlogging; moderate salting
Diabase	Upper slopes	Red stony gradational soils, fine structure	High sheet erosion: high salting at junction with other land units
	Fans from diabase	Red calcareous sodic clay soils, uniform texture	
Permian tillites	Mid slopes	Red sodic duplex soils, coarse structure	Moderate sheet erosion
	Lower slopes	Yellow sodic duplex soils, coarse structure	Low sheet erosion
	Alluvium from Permian tillites	Yellow sodic duplex soils	High gullying; moderate salting
Metamorphic rocks	Mid slopes	Red stony gradational soils	Moderate--high sheet erosion
	Fans from metamorphic ridges	Yellow stony gradational soils	High sheet erosion and gullying
Tertiary sediments	Lower slopes	Mottled red-yellow duplex soils with ironstone	Low sheet erosion; extreme infertility
Variable	Riverine plains	Grey-brown calcareous sodic clay soils	Deterioration of topsoil due to over cultivation
		Red calcareous sodic clay soils	
		Red calcareous sodic duplex soils	
		Variable grey soils	Liable to flooding

lain by Palaeozoic slates and sandstones. Such localities include Whroo, Bendigo, Costerfield, Dunolly, and St. Arnaud. Soil depth averages about 0.5 m, but there are irregular areas of deeper soils where the bedrock is overlain by red finely structured clay that appears to represent part of an older soil.

These soils are acidic and the profiles are permeable, but they have a low water-holding capacity because of the stone content and shallowness. Most of them have been cleared for grazing, and this can lead to serious sheet erosion. However, pasture improvement has been particularly successful in recent years.



Soil profile of a mottled duplex soil with ironstone

Yellow gradational soils are found on Palaeozoic sediments in similar locations to the previous group, but in upper, narrow drainage lines. They are acidic with permeable profiles, but when cleared and grazed are susceptible to gully erosion.

Duplex soils

Mottled red-yellow duplex soils with ironstone are old soils preserved on Tertiary fluviatile deposits and on gently sloping areas of granitic rocks. Such soils are found at Strathfieldsaye, Navarre, and Archdale West. Their profiles are acidic, with relatively deep coarse sandy A horizons of low water-holding capacity. The B horizons have fine to moderate-sized aggregates and contain ironstone fragments, underlain by mottled red, grey, and white clays. Most areas on granitic rocks are cleared and used for grazing, with some cropping and orcharding. The higher areas on Tertiary sediments contain abundant quartz gravels, are relatively fertile, and remain largely forested or modified by gravel stripping.

Red calcareous sodic duplex soils occupy the prior stream sections of the River-

ine plain, streamside terraces within northern bedrock outcrops, and basaltic plains of the Bridgewater district. These soils are deep and contain little stone, but the loamy surfaces set hard when dry, particularly when over-cultivated. Land use is cropping and grazing.

Red sodic duplex soils occur on upper gentle slopes on Palaeozoic slates and sandstones where ironbark is (or was) a characteristic component of the vegetation. The surfaces are gravelly, hard-setting loams. These are sharply differentiated at irregular depths from red B horizons with a relatively fine structure and moderate permeability. On cleared areas, the land is used for cropping and grazing, and sheet erosion is a serious problem.

Red sodic duplex soils with coarse structure are found on the mid slopes of Palaeozoic sedimentary outcrops (such as at Bealiba), on the crests of gentle ridges where the bedrock rises merge with the Riverine plain (such as at Wedderburn), and on upper gentle slopes underlain by Permian tillites (such as at Tooleen). The gravelly loam surfaces are hard-setting, the coarse blocky B horizons have low permeability, and run-off is excessive, with consequent sheet erosion. Land uses are cropping and grazing.

Yellow sodic duplex soils with coarse structure occur on the lower slopes of ridges, notably on Palaeozoic sediments (such as at Lockwood) and on Permian tillites (such as at Knowsley). The features of the profiles are similar to those of the previous group, but the problems of land use are even more serious. The increased run-off across these lower slopes increases the hazards of tunnelling, gullying, and water-logging. The land use is mainly grazing.

Yellow sodic duplex soils have developed on alluvium from the various rock types in the lower drainage lines, which have been almost entirely cleared for agriculture. The subsoils are moderately to slowly permeable, but highly dispersible, resulting in severe gully erosion. The hazards of salting are also common with these soils.

Unclassified soils

Variable grey soils occur on the present alluvial flood-plain. These soils have little or no profile development, and have limited agricultural use because of the small area involved and the fact that they are seasonally flooded.

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Glossary of Soil Terms

blocky (or angular)	- a type of soil structure
calcareous	- containing a specific amount of free calcium salts
catena	- a sequence of soils of about the same age, derived from similar parent material and occurring under similar climatic conditions, but having different characteristics due to variation in relief and drainage
gilgai	- local micro-relief of mounds and depressions in calcareous clay soils
horizon (soil horizon)	- a soil layer differing from adjacent layers in physical, chemical, or biological properties, or characteristics such as colour, structure, texture, pH, etc.
ironstone	- concretions of clayey rock, with iron oxide
laterite	- a residual soil developed in areas of good drainage, leached of silica, and containing concentrations of iron and aluminium oxides
leptopodzol	- a soil that is less-leached than a normal podzol; normally grey-brown in colour and acidic throughout
podzol	- a highly bleached soil that is low in iron and lime, formed under moist, cool climatic conditions

soil profile	- a vertical section of the soil through all its soil horizons to the parent material
sodic	- a soil containing sufficient exchangeable sodium to interfere with the growth of most crop plants
solodized solonetz	- a group of soils with a very thin friable surface soil underlain by a dark hard layer, usually alkaline
texture	- an indication of the proportions of constituent particules in the soil (sand, silt, or clay)
water-holding capacity	- the ability to retain available water

9. VEGETATION

The natural vegetation of an area is determined by the environmental factors of the site, such as soils and their parent materials, topography, and climate. Preceding chapters have described these factors and noted the variation of each within the study area.

Vegetation is therefore particularly important when considering land use, as it reflects these factors and provides a convenient way of assessing the capability of a site for various uses.

Moreover, vegetation provides a multitude of Man's needs, including timber products, recreation sites, protection for values such as soil stability and water quality, habitats and food for animals, and a major part of what we regard as scenery or naturalness.

For these reasons, frequent reference is made to vegetation in the chapter on fauna, and in many of the chapters on land use (Part III).

Vegetation in the study area

Prior to settlement, much of the study area was wooded, with large areas of natural grassland on the plains. Mining and uncontrolled timber extraction in the past have dramatically affected the natural vegetation. Similarly, the alienation of large areas and subsequent clearing have affected the native flora and allowed the introduction of exotic species.

Practically all the native grassland has been developed for agriculture, and only small remnants survive in roadside reserves and similar areas. The remaining vegetation has been influenced to a lesser extent by Man's activities, including timber utilization, grazing, the introduction of weeds, and the changed incidence of fire.

In comparison with other areas in the State, the study area has a relatively homogenous vegetation. Of the 62 major vegetation alliances in Victoria (Frankenberg, 1971), only six occur here.

On a very broad scale the native vegetation can be described as being predominantly box--ironbark forests, with stringybark forests in the Pyrenees, southern St. Arnaud Range, and Castlemaine region and whipstick mallee in the

north of the study area. A few small stands of red gum are scattered throughout, and there are some very small plantations of native and exotic species. Those eucalypts that commonly occur, or are native to the area, are listed with their common names in Table 9.

The understoreys are extremely variable, ranging from sparse to dense, and many

Table 9

EUCALYPTUS SPECIES

Common name	Botanical name
black box	*E. largiflorens*
Blakely's red gum	*E. blakelyi*
blue gum	*E. st.-johnii*
blue mallee	*E. polybractea*
broad-leaf peppermint	*E. dives*
brown stringybark	*E. baxteri*
bull mallee	*E. behriana*
candlebark	*E. rubida*
green mallee	*E. viridis*
grey box	*E. microcarpa*
Kamarooka mallee	*E. froggattii*
long-leaf box	*E. goniocalyx*
manna gum	*E. viminalis*
messmate stringybark	*E. obliqua*
mountain grey gum	*E. cypellocarpa*
narrow-leaf peppermint	*E. radiata*
red box	*E. polyanthemos*
red ironbark	*E. sideroxylon*
red stringybark	*E. macrorhyncha*
river red gum	*E. camaldulensis*
scent-bark	*E. aromaphloia*
yellow box	*E. melliodora*
yellow gum	*E. leucoxylon*
white box	*E. albens*

species are xerophilous (adapted to dry conditions). Table 10 lists a number of understorey species that commonly occur on the public land.

Additional understorey species may be restricted to, or indicative of, a particular vegetation association; they are listed with the association descriptions

Table 10

UNDERSTOREY SPECIES COMMONLY OCCURRING ON PUBLIC LAND

Common name	Botanical name	*
spreading wattle	*Acacia genistifolia*	ls
golden wattle	*A. pycnantha*	ls
drooping cassinia	*Cassinia arcuata*	ls
bushy needlewood	*Hakea sericea*	ls
clustered everlasting	*Helichrysum semipapposum*	ss
smooth cat's ear	*Hypochoeris glabra*	dh
scaly buttons	*Leptorhyncos squamatus*	dh
cotton fireweed	*Senecio quadridentatus*	dh
solenogyne	*Solenogyne bellioides*	dh
scented sundew	*Drosera whittakeri*	dh
austral crane's-bill	*Geranium solanderi*	dh
common raspwort	*Halogoris tetragyne*	dh
dodder-laurel	*Cassytha melantha*	dh
wattle mat-rush	*Lomandra filiformis*	mh
early nancy	*Anguillaria dioica*	mh
black anther flax lily	*Dianella revoluta*	mh
chocolate lily	*Dichopogon strictus*	mh
twining fringe lily	*Thysanotus pattersonii*	mh
large quaking grass	*Briza maxima*	mh
silvertop wallaby-grass	*Danthonia pallida*	mh
spear grass	*Stipa* sp.	mh
toad rush	*Juncus bufonius*	mh
capitate rush	*J. capitatus*	mh

* ls - large shrub ss - small shrub dh - dicot. herb mh - monocot. herb

later in this chapter Appendix 1 gives a further, more complete, listing of the common vascular species.

Classification and Mapping

The vegetation has been classified into a number of floristic associations according to the commonly occurring dominant tree species. This floristic framework includes a number of structural forms, based on the height and form of the tallest stratum and the percentage of projective foliage cover. The most closely related associations can thus be grouped into alliances designated in terms of the most characteristic dominant species. For example, the messmate--gum alliance comprises four related associations. Table 11 lists 13 associations in six native alliances in the study area. (Plantations are not included.)

With few exceptions, the descriptions of the associations refer to vegetation on public land, as very little native vegetation remains on private land in the study area. In several places, stands of native trees remain in roadside reserves, and these provide valuable remnants of the original vegetation.

The distribution of the associations is depicted in the vegetation map at the end of this report. Two points need to be emphasized. Firstly, the scale of mapping (1:250,000) permits only the delineation of areas occupied predominantly, but not necessarily exclusively, by one particular association. Some small vegetation units have been combined for convenience. Secondly, adjacent vegetation types, although most of their boundaries are distinct or at least recognizable in the field, sometimes merge gradually from one to another. In vegetation mapping, however, some point must be selected as a disjunction, and a boundary drawn.

Vegetation Associations and Structural Forms

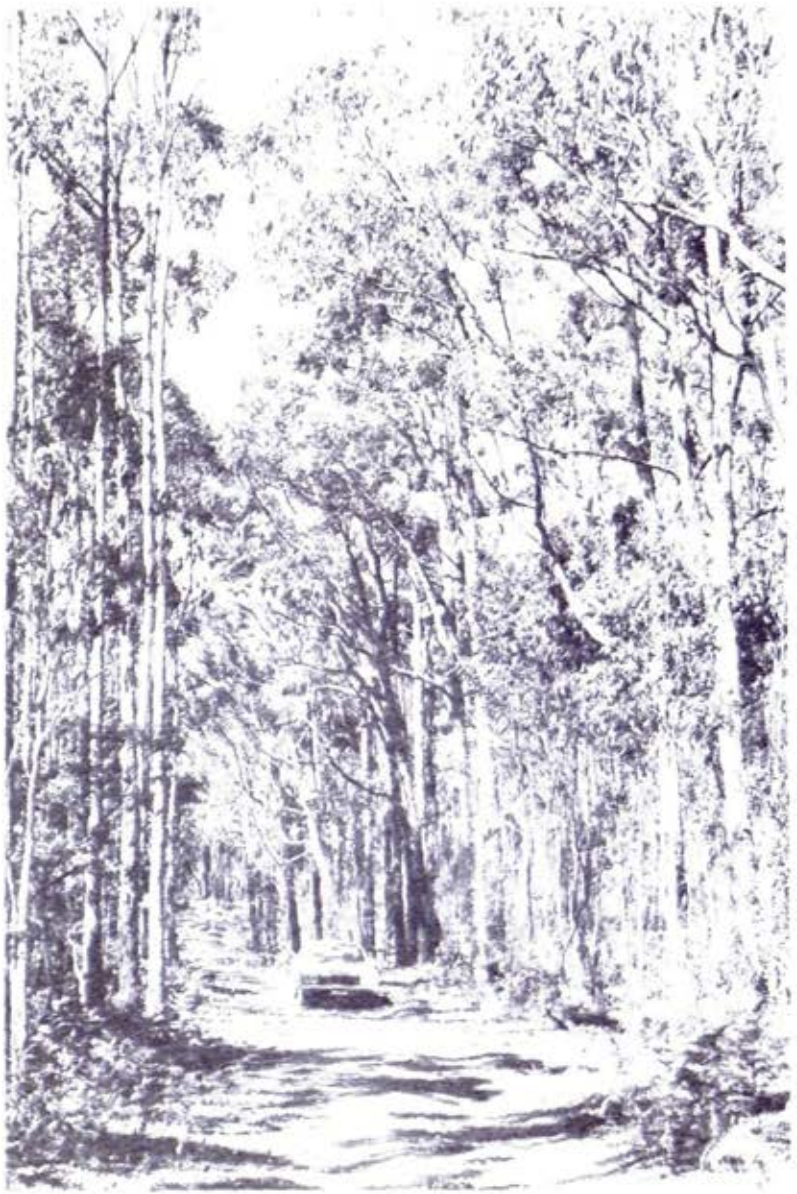
1a Messmate--blue gum open forest III--II

This alliance occupies higher elevations where significantly more rain falls than on the surrounding lower levels. Blue gum and messmate occur in a patchwork of small almost pure stands, and make up the tallest stratum.

Blue gum is found in mixture with mountain grey gum in the east of the Pyrenees, and with candlebark in the north and west.

On sites with shallow soil, and at lower altitudes, associated species include broad-leaf and narrow-leaf peppermint, red stringybark, scent-bark, and, in the south-east, brown stringybark.

Isolated ridgetop sites in the southern St. Arnaud Range, carry lower stand heights of the alliance.



Messmate--blue gum open forest III on the Pyrenees

Typical understorey species include wattles such as silver wattle *(Acacia dealbata)* and varnish wattle *(A. verniciflua)*, composites such as drooping cassinia *(Cassinia arcuata)* and fireweed *(Senecio minimus)*, common heath *(Epacris impressa)*, prickly starwort *(Stellaria pungens)*, bidgee-widgee *(Acaena anserinifolia)*, bracken *(Pteridium esculentum)*, tussock grass *(Poa australia)*, and ivy-leaf violet *(Viola hederacea)*.

1b Blue gum--candlebark--yellow box open forest II

This alliance is found at lower elevations in the Pyrenees and southern St. Arnaud Range, on the deeper soils near the base of the ranges, and extending up the gullies.

In the Pyrenees, associated species may include mountain grey gum or red box, or very narrow bands of river red gum along the major drainage lines.

Yellow gum may occur in mixture with the alliance in the southern St. Arnaud Range.

The understorey includes silver wattle, spreading wattle *(Acacia genistifolia)*, bushy needlewood *(Hakea sericea)*, twiggy daisy-bush *(Olearia ramulosa)*, pink bells *(Tetratheca ciliata)*, common heath, bracken, common maidenhair *(Adiantum aethiopicum)*, kidney weed *(Dichondra repens)*, thatch saw-sedge *(Gahnia radula)*, tussock grass, and ivy-leaf violet.

Table 11

VEGETATION CLASSIFICATION

Alliance	Map symbol	Typical structural form at maturity	Major species in the association	Associated tree species in tallest stratum	Common understorey species*	Typical occurrence
messmate--gum	1a	Open forest III Open forest II	messmate, blue gum	mountain grey gum, candlebark, red stringybark, brown stringybark, peppermints	wattles, bracken, composites *(Cassinia, Senecio)*	Pyrenees (higher elevations)
	1b	Open forest II	blue gum, candlebark, yellow box	mountain grey gum, red box river red gum, yellow gum	silver wattle, bracken, grasses, composites *(Olearia)*	Southern St. Arnaud Range and Pyrenees (lower elevations)
	1c	Woodland II Woodland I	messmate manna gum	manna gum, yellow box yellow box, long-leaf box, messmate	bracken, grasses, composites *(Cotula)*	Mt. Alexander Mt. Beckworth
red stringybark--red box--long-leaf box	2a	Open forest II	red stringybark, long-leaf box	brown stringybark, scent-bark, peppermints, yellow box in the west of the study area	thin-leaf wattle, composites *(Helichrysum)* and epacrids *(Brachyloma, Acrotriche)*	Fryers Ridge, Pyrenees (lower elevations)
	2b	Open forest I	red stringybark, red box, long-leaf box	yellow box in west of study area	variable; wattles, composites *(Helichrysum)*, peas *(Pultenea, Dillwynia)*, mint-bush	widespread in the study area on poor rocky ridges with shallow soils - e.g., Fryers Ridge
red ironbark	3a	Open forest I	red ironbark, red stringybark, red box	long-leaf box	more dense and diverse than 3b; wattles, mint-bush, grevilleas, *Boronia, Hibbertia*	widespread in the study area, frequently intermingled with 3b
	3b	Open forest II	red ironbark, grey box, yellow gum	-	wattles, *Xanthorrhea, Grevillea,* peas *(Pultenea)*	widespread in the study area, except for the Pyrenees and Fryers Ridge
grey box--yellow gum	4	Open forest II Woodland II	grey box, yellow gum	-	composites *(Cassinia, Brachycome, Craspedia)*, grasses, *Westringia*	widespread in the study area, on alluvial flats and gullies
red gum	5a	Open forest II	river red gum	grey box, yellow box	grasses, rushes *(Juncus, Eleocharis)* and other forbs	Goulburn River and along creeks throughout the study area
	5b	Woodland II	river red gum	-	As for 5a	Reedy Lake, Doctors Swamp, Carag Carag
		Woodland II Woodland I	river red gum	black box	As for 5a	Lake Cope Cope, Lake Batyo Catyo, Avon Plains
	5c	Woodland I	hill gum (Blakely's red gum)	yellow box, long-leaf box, grey box, yellow gum	wattles, pittosporum, rushes *(Juncus, Eleocharis)*, grasses, orchids *(Corybas, Pterostylis)*	Melville's Caves
whipstick mallee	6	Open forest I--open scrub	green mallee, blue mallee, bull mallee, Kamarooka mallee	acorn mallee, peppermint box	frequently sparse; wattles, *Baeckea,* paperbarks *(Melaleuca)*, mint-bush, *Casuarina*	Bendigo whipstick, Wedderburn, Inglewood, Rushworth, Dunolly
Plantation	7					Harcourt, Majorca, Dargile, Mount Beckworth

*Note: The column titled "Common understorey species" gives only an indication of some of the understorey present.

HEIGHT CLASSES (Mature forest)

I	Less than 15 metres	(less than 50 feet)
II	15--28 metres	(50--90 feet)
III	28--40 metres	(90--130 feet)

1c Messmate woodland and manna gum woodland II--I

Messmate and manna gum are typical of the higher-rainfall areas immediately south of the study area. Within it, they occur on the relatively fertile, fast-draining sandy topsoils on protruding granodiorites.

On Mount Beckworth, manna gum woodland (12--20 m) grows at higher elevations and on sheltered southerly aspects. In the north, it occurs in mixture with yellow box.

Messmate occurs in woodland formation (up to 25 m tall) on the deeper soils on the southerly and south-westerly aspects above 490 m in elevation.

The vegetation on Mount Alexander is similar. Manna gum woodlands dominate the central and southern sections, with messmate occurring on the deeper soils at higher elevations where rainfall is greater.

Understorey species include black wattle *(Acacia mearnsii)*, prickly starwort, bracken, blanket fern *(Pleurosorus rutifolius)*, pale vanilla lily *(Arthropodium milleflorum)*, variable spear-grass *(Stipa variabilis)*, brown-top bent *(Agrostis tenuis)*, hedgehog grass *(Echinopogon ovatus)*, Yorkshire fog *(Holcus lanatus)*, common cotula *(Cotula australis)*, and variable willow-herb *(Epilobium cinereum)*.

2a Red stringybark--long-leaf box open forest II

This association occupies poorer soils at lower elevations in the Pyrenees, in the southern St. Arnaud Range, and in very small stands south of Castlemaine.

Both species exceed 15 m in height, but only red stringybark also occurs in pure stands.

Red stringybark--long-leaf box open forest II

Associated species include brown stringybark in Fryers Ridge, Pyrenees, and southern St. Arnaud Range, and yellow box in the west of the study area.

The understorey includes thin-leaf wattle *(Acacia aculeatissima)*, kangaroo thorn *(A. armata)*, golden wattle *(A. pycnantha)*, button everlasting *(Helichrysum scorpioides)*, grey everlasting *(H. obcordatum)*, wire rapier sedge *(Lepidosperma semiteres)*, and epacrids such as daphne heath *(Brachyloma daphnoides)* and honey pots *(Acrotriche serrulata)*.

2b Red stringybark--red box--long-leaf box open forest I

This association occurs throughout the study area, mostly in small patches restricted to poor rocky ridges with very shallow soil. On the extremely rocky sites the trees scarcely attain a height of 3 m, but generally they are 8--15 m tall.

There are extensive patches at Fryers Ridge, and in the Pyrenees and southern St. Arnaud Range. Other than yellow box in the west, other species occur in mixture with the association only at very few locations in the study area.

The understorey of the association is variable, although wattles such as Bendigo wattle *(Acacia ausfeldii)*, thin-leaf wattle, woolly wattle *(A. lanigera)*, and Mitchell's wattle *(A. mitchellii)*, all commonly occur. Other species include silver wattle, golden wattle, kangaroo wattle, drooping cassinia, red parrot-pea *(Dillwynia hispida)*, fairy wax-flower *(Eriostemon verrucosus)*, mountain grevillea *(Grevillea alpina)*, silky hakea, button everlasting, bundled guinea flower *(Hibbertia fasciculata)*, pink beard-heath *(Leucopogon ericoides)*, slender mint-bush *(Prostanthera saxicola)*, large-leaf bush-pea *(Pultenaea daphnoides)*, and wire-rapier sedge.

3a Red ironbark--red stringybark--red box open forest I

This association occurs throughout the study area and is often intermingled in a patchwork with the better-quality red ironbark--grey box--yellow gum open forest II.

Red ironbark reaches 15 m on shallow soils, and soils with ironstone gravel in the surface horizon. It rarely grows in pure stands, commonly occurring with red stringybark in the east and with red box in the west.

In some places, long-leaf box also occurs with the association, particularly near Heathcote.

The understorey is variable, although often dense and heath-like. Species include woolly wattle, rough wattle, spike wattle *(Acacia oxycedrus)*, gold-dust wattle, kangaroo wattle, golden wattle, slender mint-bush, goldfields grevillea, variable prickly grevillea, mountain

grevillea, fairy wax-flower, gorse bitter-pea *(Daviesia ulicifolia)*, blue boronia *(Boronia caerulescens)*, finger-flower *(Cheiranthera linearis)*, Grampians guinea flower *(Hibbertia humifusa)*, rayless daisy *(Brachycome perpusilla)*, grey everlasting, salmon sun-orchid *(Thelymitra rubra)*, kangaroo grass *(Themeda australis)*, and a common bog sedge *(Schoenus apogon)*.

3b Red ironbark--grey box--yellow gum open forest II

Red ironbark is widespread throughout the study area; the only places where it is virtually absent are the Pyrenees and Fryers Ridge. It most commonly occurs in mixture with good-quality grey box, and on better sites can reach 15--24 m in height. Less commonly, pure red ironbark and mixtures of red ironbark--grey box--yellow gum are found; for example, on the flatter land near Rushworth, Wellsford forest (north of Bendigo), north of Eaglehawk, and near Dunolly.

As well as the normal winter-flowering form, an unusual summer-flowering form of red ironbark occupies limited areas, for example at Whipstick forest, Wellsford, Tarnagulla, and Whroo.

The understorey is usually sparse and shrubby, commonly including rough wattle *(Acacia aspera)*, gold-dust wattle (*A. acinacea)*, golden wattle, sweet bursaria *(Bursaria spinosa)*, drooping cassinia,

Intensively managed stand of red ironbark--grey box--yellow gum open forest II

austral grass-tree *(Xanthorrhoea australis)*, gold-fields grevillea *(Grevillea dryophylla)*, cherry ballart *(Exocarpos cupressiformis)*, leafless currant-bush *(Leptomeria aphylla)*, bush-pea *(Pultenaea largiflorens)*, small crowea *(Crowea exalata)*, wax-lip orchid *(Glossodia major)*, and bristly wallaby-grass *(Danthonia setacea)*.

4 Grey box--yellow gum open forest II/ woodland II

This association occurs on alluvial flats and in gullies throughout the box--ironbark forest, and varies in composition from pure grey box on the better soils to pure yellow gum on the poorer, shallow soils. The most common structural form is open forest II, but parts of the Kamarooka forest and most of the Dalyenong block near Bealiba are best described as woodland II.

Pure grey box stands are still common throughout the study area. Many of the forest blocks are fringed with a narrow strip of grey box adjacent to the cleared farmlands. Although grey box can grow to 24 m on alluvial soils, it also occurs north of Heathcote and around Dunolly as a tree of less than 15 m.

Grey box--yellow gum woodland II

Small patches of white box grow in pure stands or in mixture with grey box in typical grey box sites - for example near Heathcote Reservoir and at Colbinabbin West, Wehla, Mandurang, and Newbridge Flats.

Two subspecies of yellow gum occur. The west of the area supports the glaucous-leaved smaller-fruited *E. leucoxylon* var. *pauperita*, while the more-common *E. leucoxylon* var. *leucoxylon* grows in the east. Yellow gum rarely occurs in pure stands, but is frequently found in mixture with long-leaf box, red box, and red stringybark.

Understorey species in the alliance include kangaroo wattle, golden wattle, gold-dust wattle, drooping cassinia, slender westringia *(Westringia eremicola)*, nodding saltbush *(Rhagodia nutans)*, rayless daisy, flannel cudweed *(Actinoble uliginosum)*, billy buttons *(Craspedia glauca)*, cut-leaf goodenia *(Goodenia pinnatifida)*, raspwort *(Haloragis rubra)*, tiny star *(Hypoxis pusilla)*, soft millotia *(Millotia tenuifolia)*, bush-pea, kangaroo grass, dwarf arrow grass *(Triglochin centrocarpa)*, and tiny bow-flower *(Toxanthes perpusilla)*. The grey box stands of the Whipstick Forest have a particularly rich shrub flora.

5a River red gum open forest II

River red gum occurs along the major drainage lines in the study area. The main stands on public land occur along the Goulburn River near Murchison and Nagambie.

Patches of river red gum in pure stands or in mixture with grey box and yellow box occur in narrow strips, sometimes as narrow as 10 m each side of the bank, along many of the streams in the area. The trees attain a height of 15--24 m, and have a shrub-free understorey. Ground species include swamp wallaby-grass *(Amphibromus neesii)*, common spike rush *(Eleocharis acuta)*, swamp goodenia *(Goodenia humilis)*, swamp isotome *(Isotoma fluviatilis)*, joint-leaf rush *(Juncus holoschoenus)*, water milfoil *(Myriophyllum propinquum)*, tussock grass, and a sedge *(Carex tereticaulis)*.

5b River red gum woodland II

River red gum woodland 15--20 m tall occurs in three relatively large stands near Murchison--Reedy Lake, Doctors Swamp, and Wallenjoe Swamp.

Lakes such as Cope Cope and Batyo Catyo in the north-west of the study area are surrounded only by a narrow margin of red gum, with the occasional mixture of black box.

These river red gum areas are all regularly inundated and have similar understorey species to those listed for the open forest II formation.

River red gum woodland II, Wallenjoe Swamp

5c Hill gum woodland I

Hill gum or Blakely's red gum is found in the Melville's Caves and Mount Korong areas as a woodland on granitic sands. This is the southern-most extremity of its range, and its western limit in Victoria.

Open forest I of green mallee

Associated species in the tallest stratum include yellow box, long-leaf box, grey box, and yellow gum.

A well-developed understorey of wattle *(Acacia paucijuga)* frequently occurs, particularly where soil moisture is more abundant. Other species include lightwood *(Acacia implexa)*, weeping pittosporum *(Pittosporum phillyreoides)*, slender rice flower *(Pimelea linifolia)*, blunt greenhood *(Pterostylis curta)*, slaty helmet-orchid *(Corybas diemenicus)*, common spike-rush, wiry rush *(Juncus homalocaulis)*, common bog sedge, common love-grass *(Eragrostis brownii)*, tussock grass *(Poa australis)*, turret arrowgrass *(Triglochin turrifera)*, scaly buttons *(Leptorhynchos squamatus)*, austral carrot *(Daucus glochidiatus)*, and austral bear's-ear *(Cymbonotus preissanus)*.

6 Whipstick mallee open forest I

Whipstick mallee is found in extensive stands near Wedderburn and Inglewood, and north of St. Arnaud and north of Bendigo, with smaller patches around Rushworth, Whroo, and Tarnagulla. The term "mallee" is of Aboriginal origin and refers to eucalypt species, usually 2--8 m tall, with many stems arising from an underground root. "Whipstick" may have originated either from the use of springy stems for whips by the bullock-team drivers, or from the backlash resulting when settlers tried to roll, flatten, or cut the virgin stands.

The four main species of mallee in the study area are green mallee, blue mallee, bull mallee, and Kamarooka mallee and these may occur in either mixed or pure stands. The Whipstick Forest north of Bendigo contains all four species, while green mallee is more abundant and often occurs as pure stands near Rushworth and Dunolly. The area north of St. Arnaud is almost pure blue mallee. Two other mallee species occur infrequently in species mixtures - the acorn or oil mallee *(E. oleosa)* and peppermint-box *(E. odorata)*.

Whipstick mallee often has quite abrupt boundaries. They are usually contiguous with red ironbark stands, although in the Whipstick Forest they adjoin grey box.

Understoreys are frequently sparse, occurring principally in gaps within the stand and around stand margins. Typical species include wallowa *(Acacia calamifolia)*, Whirrakee wattle *(A. williamsonii)*, bent-leaf wattle *(A. flexifolia)*, dwarf nealie *(A. wilhelmiana)*, broom baeckea *(Baeckea behrii)*, slaty sheoak *(Casuarina muellerana)*, broombush *(Melaleuca uncinata)*, violet honey-myrtle *(M. wilsonii)*, twiggy heath myrtle *(Calytrix tetragona)*, cross-leaf paperbark *(M. decussata)*, scarlet mint-bush *(Prostanthera aspalathoides)*, flax-leaf logonia *(Logonia linifolia)*, guinea-flower *(Hibbertia virgata)*, sticky goodenia *(Goodenia varia)*, wax flower *(Eriostemon augustifolius)*, drooping cassinia, daphne heath, small crowea, grey everlasting, and variable plantain *(Plantago varia)*.

7 Plantations

Plantations in the study area occupy only a small portion of the public land.

Pine *(Pinus radiata)* is grown at Harcourt, Mount Beckworth, and Moonlight Flat near Castlemaine. A large plantation of sugar gum *(E. cladocalyx)* grows on granitic sands near Majorca, near Maryborough. Other smaller plantations, containing native and introduced trees are located at Dargile near Heathcote, Kingower, and Mount Beckworth.

Significance of the Flora

In a State-wide context, several of these vegetation alliances are regarded as being botanically significant.

The whipstick mallee areas are probably the most significant, and are almost wholly restricted to the study area. Unlike most other mallees in Australia, which grow on Cainozoic sands, these occur on clay and rocky soils derived from Ordovician sandstones. They are of considerable biogeographical and palaeoclimatic interest, and provide a strong contrast to the adjacent box--ironbark forests.

Also significant are the grey box--yellow gum stands. This association

occurs mainly within the study area, and other stands elsewhere in Victoria have been extensively alienated for agriculture. The pure stands of white box sometimes associated with grey box are also very restricted and significant.

Most stands of river red gum in the study area have been depleted for timber utilization. More significant are the small areas of hill gum (or Blakely's red gum) as these comprise the southernmost extremity of its range and its western limit in Victoria.

The distinct red ironbark stands have their distribution (in an Australian context) centred on the study area. These widespread forests also comprise the bulk of the State's representation of this forest type. The characteristic understorey includes a number of endemic plants.

Although stringybark--box forests are relatively widespread in Victoria, they are probably best represented in the North-central area.

Messmate--gum stands are also relatively widespread in the State, but their extent in the study area is quite small. The messmate--gum woodlands, however, are northern outliers of associations found more extensively further south. Consequently many of the understorey species occur at the northern limits of their ranges, and are not commonly found elsewhere in the study area.

Rare and Endangered Vascular Plants in the Study Area (Willis, 1971)

Monocotyledons

1. *Calochilus richae* (bald-tip beard orchid) - endemic to Victoria and extremely localized: recently rediscovered although previously known only by the type collection from Whroo.

2. *Pterostylis woollsii* (long-tail greenhood) - extremely localized and rare in Victoria, known only from a single collection near Rushworth (1928) on exposed ground in box--ironbark forest.

3. *Stipa breviglumis* (cane spear-grass) - rare and localized in Victoria; restricted to a few gorges and rocky streams in the west, including the St. Arnaud area.

4. *Thelymitra mackibbinii* (brilliant sun-orchid) - very localized and rare in Victoria, known only from a few collections from gravelly auriferous terrain, including the Maryborough district.

Dicotyledons

5. *Brasenia schreberi* (water shield) - an extremely localized species known only from a few locations, including the Goulburn Weir and Nagambie.

6. *Crassula tripartita* (Three-part crassula) - endemic to Victoria, this species is known from open grazing land at Graytown and therefore appears threatened with extinction.

7. *Eucalyptus froggattii* (Kamarooka mallee) - extremely localized and known only from a few locations, including Kamarooka East and Wedderburn.

8. *Kochia cheelii* (chariot wheels) - very rare; reported only from private property near Kamarooka (1947).

9. *Olearia pannosa* (velvet daisy-bush) - extremely localized and, in Victoria, known only from a few locations including Wedderburn and the Heathcote district.

10. *Pultenea graveolens* (scented bush-pea) - extremely localized; known from several locations including Bailieston near Nagambie.

11. *Phebalium obcordatum* (dainty phebalium) - extremely localized, and known from Kingower and the Bendigo Whipstick.

12. *Westringia crassifolia* (whipstick westringia) - endemic to Victoria and extremely localized; known from the Whipstick area, north of Bendigo.

13. *Zieria aspelathoides* (whorled sieria) - recorded from Mount Tarrengower and only recently rediscovered.

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10. FAUNA

The study area contains about one-half of the vertebrate species recorded in Victoria. Its records cover more than 240 bird, 35 mammal, 40 reptile, and 12 amphibian species.

Invertebrates make up about 95% of the total fauna here. They include worms, terrestrial and aquatic molluscs (slugs and snails), and innumerable species of arthropods, particularly insects.

A notable feature of this study area is the extent to which human occupation has altered the land. Burning by Aborigines may have affected animal habitats, but widespread clearing of forest during the gold rush and for agricultural development certainly caused dramatic changes to habitats. The present fauna of the study area therefore probably differs from that before settlement; it is not known how great the difference is.

Following an introductory section on habitats, this chapter briefly outlines the distribution of the major fauna groups within the study area. It discusses the species most characteristic of each type of habitat, but makes no attempt to include all the species that may occur in any habitat. More detailed information on individual species is provided in Appendices 2a--2g.

The information is based on surveys conducted by the Fisheries and Wildlife Division, on literature and archival searches by the National Museum, Victoria, on information provided by local naturalists, and on other published and unpublished data.

Habitats

As mentioned above, present habitats differ markedly from those before settlement. Large areas originally under woodland and forest have been cleared for agriculture, and so no longer support the species they once did.

Most of the remaining woodland and forest was severely disturbed last century, when virtually all mature trees were removed for timber or firewood. Timber production since then has prevented the forest from returning to its mature state, and has probably kept past woodlands more densely stocked as forest.

The lack of mature trees severely reduces the number of tree hollows, which are important as nest sites for many

species of birds and mammals. Unavailability of suitable nest sites may be a casual factor in the low population levels of these species. Certainly grazing by stock and rabbits has changed the habitats by reducing the ground vegetation. The effects of these habitat changes are unknown.

Animal communities frequently show a strong correlation with particular plant formations, being relatively homogenous throughout a specific formation. The reasons for this are numerous and varied, byt in most cases are related to the biological requirements of the animals comprising the community. These requirements - generally associated with feeding, breeding, or shelter - are supplied (either directly or indirectly) by particular vegetation structures present within the plant formations.

Thus, a classification of habitats based on vegetation structure appears to be the most meaningful approach to assessing the distribution of animals within a study area of this size. Six broad fauna habitats have been identified there. Of the five terrestrial ones, four are "natural" plant formations based on a simplification of the classification presented in the vegetation chapter. One habitat is aquatic.

Tall open forest

Small areas of tall open forest occur in the Pyrenees, on Mount Alexander, and on

Kookaburra at its nest in a tree hollow

a few other tall granite mountains. These areas, however, do not carry the dense undergrowth typical of most tall open forests elsewhere in Victoria. The habitat corresponds to the messmate--gum vegetation type described in chapter 9.

Open forest

This is the most common habitat on public land in the study area. Red stringybark--red box--long-leaf box open forest is widespread on the upper slopes of the ridges. Very little of this forest type has been changed by timber utilization.

Ironbark and yellow gum--grey box open forests occur extensively on public

land, mainly at lower altitudes than the stringybark--box complex. This habitat has been substantially altered by human influence: very few areas of mature forest remain, most now being coppice regrowth. This changes the fauna habitat in two main ways - the younger trees contain fewer nest hollows and tree density is greater than originally. It is probable that much of the yellow-gum--grey box forest was originally woodland.

Woodland

Woodlands were once extensive in the river valleys but most have been cleared, or partially cleared, to support pastures and crops, and populations of species mainly restricted to woodland are in danger of local extinction. Only a few small areas of relatively natural woodland now exist here. These are mainly river red gum woodland along water-courses and on flood plains.

Mallee

Some larger patches of mallee (locally known as whipstick) occur in the northern half. The dominant species are blue mallee, green mallee, and bull mallee.

Pasture--grassland--suburban

This habitat covers most of the study area. Some parts would have been naturally treeless, but most are the result of clearing. Many places, particularly roadside reserves, still carry reasonable samples of natural vegetation, which provide some habitat for wildlife species.

Aquatic

Five main rivers (the Avon, Avoca, Loddon, Campaspe, and Goulburn) flow northwards through the study area. Along these rivers and their tributaries are several large reservoirs (for example, Laanecoorie, Tullaroop, Cairn Curran, Lake Eppalock, and Waranga) and weirs (for example, Loddon, Serpentine, Fernihurst, and Goulburn), which usually contain deep open water and have river red gum margins.

Several lakes - such as Cope Cope, Grassy, and Batyo Catyo - occur along the north-western boundary between Cope Cope and the Avon River. These are 1--2 metres deep, with steep eastern banks and shallow western margins. River red gum, black box, lignum, and short reeds line the margins of the fresh-water lakes, and mud flats with salt grass surround the saline ones.

The north-east also contains several large lakes - Cooper, Salt, Fresh, Green, Stewart, and Horseshoe. Another large one, Reedy Lake, lies near Bailieston.

Other wetlands include the shallow seasonal swamps in depressions in the volcanic plains (Middle, Merin Merin,

Black, and Long Swamps); Tang Tang and Thunder Swamps north of Bendigo; and Gaynor, Mansfield, Wallenjoe, and One-tree Swamps in the north-east.

Birds

Recent records of birds regularly occurring within the study area cover more than 240 species, of which more than 200 are reported to breed here.

The following discussion is confined to the six broad habitats described earlier, with emphasis on species common on public land.

Tall open forest

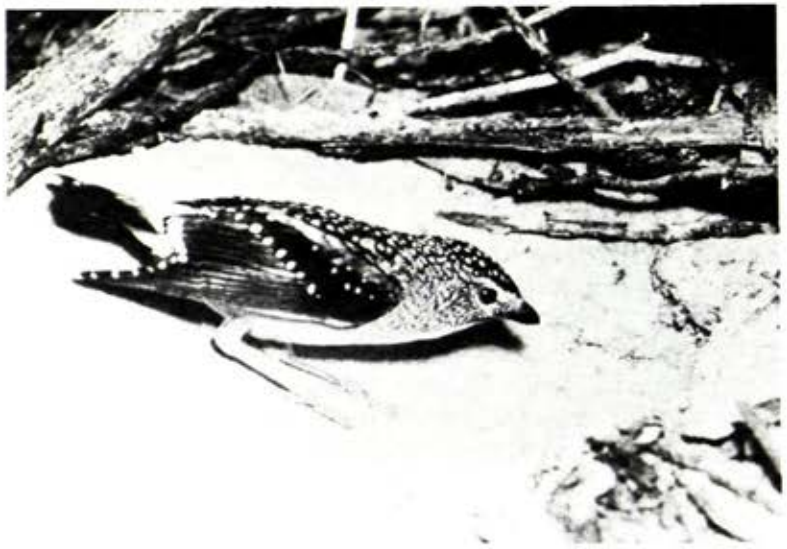
About 40 species of birds regularly occur in this habitat, where many nest in hollows in the large trees.

In this study area, few bird species are restricted to the habitat because it lacks the dense undergrowth typical of tall open forests elsewhere in Victoria. Consequently, most of the species also inhabit open forests or woodlands, which have a similar sparse undergrowth. Possibly species such as the grey goshawk, crimson rosella, powerful owl, and white-browed scrub-wren occur in the tall open forests in larger numbers than in any of the other habitats, mainly because of the tall trees, large hollows in the trees, and the dense austral bracken that occurs along some of the gullies.

Open forest

More than 100 bird species are regularly recorded in these forests. The areas of red ironbark are very important to the nectar-feeding species (lorikeets, honeyeaters, etc.), because these trees flower during winter and provide a valuable source of food at that time. Species such as the swift parrot migrate from Tasmania to spend the winter here. Thornbills and other bird species inhabiting low vegetation are also present, sometimes in large numbers.

The white-throated warbler inhabits open forest and woodland



The yellow-rumped pardalote nests in a tunnel excavated in the soil

Woodland

The deeper, more fertile soils of the now-alienated pasture and crop lands originally supported different native vegetation from that on the poorer soils of most of the blocks of public land now remaining.

The native vegetation on these more fertile soils - mainly woodland in structure - consisted of such trees as river red gum, grey box, and yellow gum. Today, little remains of what was once the major terrestrial habitat for birds in the study area - only roadside remnants and a few heavily grazed areas of river red gums on swamp and river margins. The loss of this habitat may result in local extinction of those bird species dependent on some of the specialized structures peculiar to woodland formations.

Nearly 100 species of birds are regularly recorded in these woodlands. Hollows in trunks and limbs of the mature woodland trees provide a particularly important nesting habitat for some parrots, lorikeets, rosellas, owls, kingfishers, martins, tree-creepers, and pardalotes. During the nesting season, large numbers of these species concentrate in the few remaining stands of large mature river red gums, and competition for nesting hollows appears to be intense.

Mallee

The mallee remaining in the north of the study area supports a diverse bird population. Although small in area compared with the open forests here, the mallee portions provide habitat for nearly as many bird species. Of the more than 90 regularly recorded in the mallee, about 18% are mainly restricted to this habitat in the study area. These include the mallee fowl, spotted nightjar, southern scrub robin, purple-backed wren, red-tailed thornbill, mallee heath-wren, crimson chat, yellow-rumped pardalote, black honeyeater, white-fronted honeyeater, tawny-crowned honeyeater, striped honeyeater, and spiny-cheeked honeyeater.

Pasture--grassland--suburban

More than 130 species of birds regularly occur in the open pastures, grasslands, and associated vegetation remaining along creeks and roads and in suburban gardens. Individually, the small pockets of trees and shrubs still remaining in these otherwise-cleared areas may not be ecologically viable, but collectively they are important to the continued success of many bird species in the study area. They provide shelter, protection, roosts, nesting sites, and food for both migratory and resident birds.

The open nature of the land makes it suitable for such dirunal predators as kites, eagles, harriers, and falcons to hunt over. Some members of the parrot-cockatoo family also forage in the pastures for bulbs and roots, while others occasionally occupy the denser vegetation associated with pastures. Several honeyeater species also frequent this habitat, some being regularly seen in suburban gardens.

Species that are particularly well adapted to survival in these open habitats include galahs, sulphur-crested cockatoos, some quails and larks, Australian pipits, yellow-rumped thornbills, white-fronted chats, jacky winters, house sparrows, goldfinches, magpie larks, and magpies. Suburban gardens and, occasionally, city streets and buildings provide habitat for a particular group of species, many of which are introduced. These include domestic pigeons, spotted turtle-doves, eastern rosellas, laughing kookaburras, blackbirds, song-thrushes, willie wagtails, white-plumed honeyeaters, eastern spinebills, red wattle birds, house and tree sparrows, starlings, indian mynas, and magpies.

Wetlands

The aquatic environment (including marshes and inundated pastures) in the study area contains more than 70 species of birds as regular inhabitants, more than 50 of which are recorded as breeding there. Most nest either on the ground or in tree branches, but a few of the ducks use tree hollows and the grebes build floating nests. These birds usually feed on aquatic animals.

A peregrine falcon

and some aquatic plants, although they sometimes take a variety of other food. Some ducks graze on terrestrial herbage, and some ibises, plovers, and dotterels consume substantial quantities of terrestrial insects.

Four of these species are intercontinental migrants that visit the study area during their non-breeding season. These birds breed in the following area: Japanese snipe - Japan; greenshank - northern Eurasia; sharp-tailed sandpiper - north-eastern Siberia; and red-necked stint - north-eastern Siberia and western Alaska.

While a number of bird species utilize wetlands such as impoundments and temporary situations in agricultural land, their main habitats in the study area are the natural fresh and saline waters and associated vegetation.

Mammals

Thirty-five species of mammals have been recorded in the study area within the last 15 years and at least three others have become extinct in recent times. The present mammal fauna consists of two monotremes, 14 marsupials, and 19 placental mammals, seven of which are introduced.

Prehistory and history

Knowledge of the prehistory of mammals in western Victoria, derived largely from subfossil cave deposits, has been summarized by Wakefield (1974). Significant changes in the composition of the mammal fauna have occurred since the end of the Pleistocene epoch (about 12,000 years ago). Many large marsupials became extinct at the end of Pleistocene, and since then climatic fluctuations have brought about changes in distribution.

The reasons for the disappearance from Victoria of species such as the bridled wallaby, boodie, Tasmanian devil, thylacine, plains rat, and white-footed rabbit-rat are not known. Climatic and hence habitat changes and the coming of the Aborigines with their fire and dingoes are possible causes of the general decline of the Victorian plains fauna.

This decline has hastened since European settlement because of habitat destruction and, in some cases, hunting. Three species - the quoll, tiger cat, and dingo - have become extinct in the study area during this century. The koala probably also disappeared, but has been reintroduced.

Present populations

Population levels of many mammals here are low. Whether this is the natural situation or is caused by past and present land disturbance is not known with certainty. Depletion of the understorey by grazing and the removal of

mature trees for timber production and firewood have probably drastically reduced the suitable habitat of many species, however. Lack of hollows may contribute to the low densities of almost all arboreal mammals in the survey area.

One such species, the squirrel glider, is rare throughout Victoria and has been recorded in two widely separated localities here - Rushworth State Forest and the Stawell--Glenorchy region. The latter population is threatened by habitat clearance, and the former has only one record (1961). The survival of this species in the study area is very uncertain.

Tuans are uncommon in Victoria and have been recorded in several localities in the study area, where they inhabit open forest and woodland. The absence of mature trees with hollows for nest sites may be significant in their apparent rarity.

Tall open forest

Excluding bats, 19 mammals have been recorded in the messmate--candlebark tall open forests. Arboreal species are koala, brush-tailed possum, ring-tailed possum, sugar glider, feather-tailed glider, and eastern pigmy possum.

Densities of all arboreal species are low except in areas of mature forest that contain numerous hollows, such as at Mount Alexander.

A more diverse and abundant ground mammal fauna occurs in this vegetation type than in others here. Dense growths of tussock grasses and austral bracken in gullies provide habitat for the brown antechinus, swamp rat, and black rat. Yellow-footed antechinus occur more commonly on the drier slopes. Large ground mammals are echidna, eastern grey kangaroo, black wallaby, and, in the Pyrenees, sambar deer. Rabbits occur in natural clearings or where disturbance has opened up the vegetation. Foxes and cats are also widespread.

Open forest

This habitat supports 20 species (excluding bats). The density and diversity of the arboreal fauna vary according to the availability of hollows for nest sites. Mature open forest provides numerous hollows and carries relatively high densities of a range of arboreal species. Brush-tailed possums, sugar gliders, feather-tailed gliders, tuan, brown antechinus, yellow-footed antechinus, and several species of bats use these hollows.

Most of the open forest, however, has been cut over for timber and is now immature coppice regrowth with few hollows. Only a few brush-tailed possums and occasional ring-tailed possums, sugar gliders, and yellow-footed antechinus occupy such regrowth. Koalas do not use hollows and occur wherever suitable food trees (long-leaf box, yellow

box, manna gum, red stringybark, and red ironbark) grow.

The ground mammal fauna is less diverse than that of tall open forest, probably because of the lack of low vegetation cover. The echidna and eastern grey kangaroo are common; the yellow-footed antechinus is uncommon although widespread; the brown antechinus occurs only in the Pyrenees; and the black wallaby occurs where suitable shrub cover grows. The introduced rabbit, European hare, black rat, house mouse, fox, and cat are all present.

Eastern grey kangaroos are common in the study area

Woodland

The woodlands contain 19 mammal species (excluding bats). This habitat has been considerably reduced in area since European settlement. Timber cutting in most of the remaining stands has reduced the availability of hollows, with consequences similar to those in open forest.

The arboreal mammal fauna here includes the squirrel glider and, otherwise, resembles that of the open forest.

The ground mammal fauna is generally sparse, probably because grazing and other activities prevent the establishment of dense undergrowth. The echidna, fat-tailed dunnart, yellow-footed antechinus, eastern grey kangaroo and, where some shrub cover exists, black wallaby are the only native ground-dwelling species known to be present, although the mouse dunnart may also occur. The introduced rabbit, black rat, house mouse, fox, and cat are generally common and widespread. The hare occurs in open grassy woodlands.

The mallee

Fewer mammal species occupy the mallee than the tall open forest, open forest, or woodland in the study area. Only the echidna, eastern grey kangaroo, and black wallaby are common. There are unconfirmed reports of western grey kangaroos from the Wychitella Forest, and the mouse dunnart and feather-tailed glider may be present, but no records exist.

Echidnas occur in forest, woodland, mallee, and grassland

A fat-tailed dunnart

The introduced rabbit, black rat, house mouse, fox, and cat are locally common.

These isolated, south-easterly extensions of mallee do not contain some mammal species (western pigmy possum, silky desert mouse, and Mitchell's hopping mouse) that are characteristic of the extensive mallee areas in north-western Victoria. The lack of a sandy substrate for burrowing is probably one factor excluding the latter two species, although there may be other reasons.

Pasture--grassland--suburban

Few areas of native grassland remain in the study area, but the extensive areas

of farm and pasture land provide habitat for ten mammal species, of which only four are native. The introduced species include the hare, rabbit, black rat, house mouse, fox, and cat, which are generally common and widespread. Of the native mammals, the fat-tailed dunnart is widespread, brush-tailed possums and echidnas are present in all but the most intensely farmed areas, and the eastern grey kangaroo feeds on pasture and farm lands adjacent to uncleared areas.

The black rat, house mouse, cat, brush-tailed possum, and ring-tailed possum occur in suburban areas.

Wetlands

Two aquatic mammals, the platypus and eastern water rat, are widespread; the latter is more common, but neither is considered to be threatened in the study area. The platypus requires permanent streams or lakes with banks of friable soil in which to construct nest tunnels. These may be up to 20 m long and are usually close to the soil surface, making them susceptible to caving-in if the banks are grazed or subjected to other heavy use. The eastern water rat occurs along most of the streams, lakes, reservoirs, permanent swamps, and irrigation channels.

Bats

Because of lack of information on the habitat requirements of the bats, they are discussed in this general section rather than under separate habitat headings. Of the ten species recorded here, two are fruit bats that are occasional visitors to Victoria and may occur in small numbers in late summer and autumn. They are usually associated with flowering eucalypts and orchards, where they feed on nectar and fruit.

The other eight species are small insectivorous forest bats, which roost and breed in tree hollows, behind slabs of bark, and in buildings. These include the little bat, Gould's wattled bat, and the lesser long-eared bat, which have been recorded in both open forests and woodlands; the Tasmanian pipistrelle, which has been recorded only in the tall open forest of the Pyrenees; and the little broad-nosed bat, which has been collected only once but probably favours the drier inland areas. The chocolate bat, white-striped bat, and little flat bat have been collected in a number of localities in the study area, but further work is necessary to determine their habitat requirements.

Reptiles

In relation to reptile geography, the study area is transitional between the Bassian fauna of the central highlands and the Eyrean fauna of the mallee and plains to the north and west. Hence 13 Bassian species have the northern extent of their range here, 17 Eyrean species occur no further south, and the ranges

of nine species enclose the study area. The 39 species recorded here are distributed among eight families as follows: tortoises (two species); dragons (two); geckoes (three); legless lizards (three); skinks (seventeen); goannas (two); snakes (seven); and blind snakes (three).

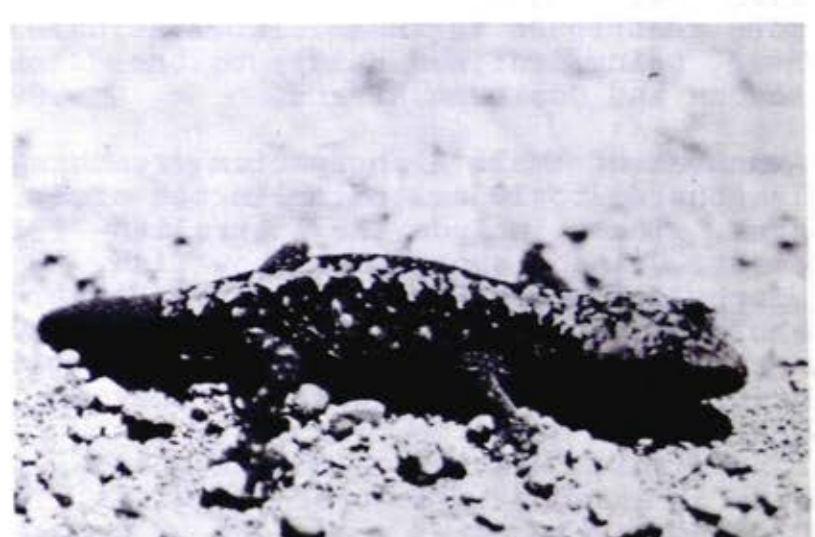
Changes in land use that alter the microclimate or the microhabitat of reptiles may influence their numbers and distribution. Arboreal species are particularly susceptible to present land use practices that have removed most mature trees. The tree goanna, which depends on such trees, is now rarely recorded in the study area. The marbled gecko may have benefitted from forestry practices that leave many stumps surrounded by bark - with a gap, due to shrinkage, that provides shelter for it. Abundance and distribution of species such as water, garden, and Boulenger's skinks are influenced by the relative abundance of decaying logs. This is largely determined by the amount of waste timber following logging and the frequency of fuel-reduction burns.

Fossorial species such as the bandy bandy and various blind snakes that occur in areas with deep soil would have their microhabitats destroyed by cultivation.

Amphibians

This study area contains 13 known amphibians. While all require water

A bearded dragon with its eggs



A stone gecko

(permanent or temporary), most display particular habitat preferences. For instance, only three species have been recorded in tall open forest, whereas 11 have been recorded in woodland. Details of abundance and distribution, habitat, and breeding are provided for each species in Appendix 2d.

Fish

About 22 fish species occur in the study area, of which eight were introduced. These introduced species include the most widespread and commonly caught sport or edible fish - redfin (European perch), brown trout, rainbow trout, tench, European carp, and crucian carp. The native sport or edible fish - Murray cod, golden perch, silver perch, blackfish, catfish, and bony bream - are much more restricted in their distribution here, being confined mainly to the Loddon and Goulburn Rivers.

A number of small fish species (reaching lengths up to 10 cm) occur in the study area. These include the Australian smelt, Crimson spotted rainbow fish, Mitchellian freshwater hardhead, western chandra perch, southern pigmy perch, western carp-gudgeon, purple spotted gudgeon, and big-headed gudgeon. They also include the mosquite fish (2--5 cm long), which was introduced in unsuccessful attempt to control mosquitos.

As with other animal groups, human interference has altered fish populations. Apart from the effects of the introduction of alien species, native populations have probably been affected by the construction of water storages - through alteration of both the flooding pattern and the water temperature. Murray cod and golden perch are two species that these changes are known to have adversely affected elsewhere.

Invertebrates

Invertebrates vastly outnumber (both in species and in individuals) the vertebrates in the study area. They include numerous species of insects and other arthropods, worms, and molluscs.

Although they form a vital part of any ecosystem, and despite the fact that some species have great economic importance, lack of information means that this report can do little more than draw attention to the group. The molluscs of the area, however, have been studied in some detail, so better information is available for these than for other invertebrates.

Molluscs

As listed in Appendix 2f, 22 species of molluscs are known to occur within the study area. Man's utilization of much of the area has encouraged the spread of introduced species, with the native molluscs being increasingly restricted to the remaining natural bush areas and unaffected streams.

Five species of slugs and two of snails are introduced, and most of these, particularly the common garden snail *Helix asperea*, can be considered as garden or farm pests.

Other land molluscs include Victoria's only native species of slug, *Cystopelta pettardi*, and three native species of snails.

The aquatic molluscs in the area are all native, and include snails (seven species), bivalves (two), a limpet, and a pea mussel. One species of snail, *Lymnaea tomentosa*, has great economic importance because it is the intermediate host for the sheep liver fluke. It is found throughout Victoria, and can spread quickly into flooded pastures.

Another fresh-water snail, *Glyptophys cosmeta*, was first recorded in Victoria in 1973 at Bridgewater on the Loddon River. This location is also the southernmost distribution limit to date of the snail *Plotiopsis balonnersis*.

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11. WATER RESOURCES

The study area comprises the middle reaches of five river basins that run from the northern slopes of the Great Dividing Range onto the northern plains. In general, the average annual run-off declines from about 70 mm in the mountainous south to almost nothing on the plains (for comparison, rainfall ranges from about 750 mm in the mountains to 400 mm on the northern plains).

Surface Water

Stream flow

Stream flow varies widely during the year and from year to year, depending on local weather conditions. Table 12 illustrates the extent of the variation for the seven rivers. Data on stream flow for the most important streams in the study area are listed in Appendix 4.

As may be seen from Table 12, the Goulburn River carries considerably more water (about 2,000,000 Ml annually) than any other stream in the study area. This is partly because of its much larger catchment area, and also because its upper catchment includes areas with greater rainfall. The Goulburn is the only river in the study area that has not been known to cease flowing.

Stream flow depends on seasonal weather conditions, and consequently flows are generally greatest in winter and spring, and least in late summer. Reservoirs on the Goulburn, Campaspe, and Loddon Rivers have changed the flow patterns, however.

Water quality

The suitability of water for domestic, industrial, or agricultural purposes is estimated by its salinity, or content of total dissolved solids (TDS) measured in mg per l.

Water quality in most streams is good (see Table 13 and Appendix 4), with mean salinity of less than 1,000 mg per l.

Only the Avoca and Wimmera Rivers have mean salinities between 1,000 and 3,000 mg per l. Salinity varies with changes in stream flow, however, usually increasing as flow decreases. Even so,

Table 12

VARIATION IN STREAM FLOW IN SELECTED STREAMS

Stream	Gauging station	Years of record	Annual discharge (10^3 Ml)			Daily flow (Ml)	
			Maximum	Minimum	Mean	Maximum	Minimum
Goulburn R	Murchison	88 1882--1970	7,390	146	2,145	195,760	35
Campaspe R	Axedale	18 1946--64	702	22.7	247	43,067	Nil (a)
Coliban R	Malmsbury	80 1890--1970	157	6.91	66	21,359	Nil (a)
Loddon R	Laanecoorie	75 1891--1966	743	9.25	231	153,157	Nil (c)
Avoca R	Coonooer	80 1890--1970	396	3.27	76	24,959	Nil (b)
Avon R	Wimmera Highway	7 1963--70	53.8	0.01	15	7,635	Nil (a)
Wimmera R	Glenorchy	20 1950--70	281	0.37	82	12,773	Nil (b)

(a) Nil yearly (b) Nil in dry years (c) Depends on valve operation

only the Avoca and Wimmera Rivers and Major Creek have recorded maximum salinities exceeding 3,000 mg per l. Even at these salinities these streams have still been suitable for most livestock and for some domestic and industrial uses.

The River Basins

Goulburn basin

About 2,645 km^2 of the study area lie within the catchment of the Goulburn. Of this, 1,450 km^2 drain directly to the

The Goulburn River at Mitchellstown

river, 220 km^2 surround the Waranga Reservoir, and 975 km^2 drain to the Corop Lakes. Approximately 60 km of the Goulburn River flows through the study area.

Regulation of Goulburn waters have modified the flow of the river.

Figure 1 illustrates the flow pattern of the Goulburn River since the completion of Eildon Reservoir. It depicts the mean flow at Trawool (above Goulburn Weir) and at Murchison (below the Weir). It also shows the calculated "natural" flow at Murchison, which includes amounts diverted at Goulburn Weir to the eastern and western channels and the volume and evaporation loss from both storages.

The graph shows that water is stored in Eildon Reservoir mainly in the period June to October, reducing flows downstream, and released mainly in the period December--April, augmenting flows above Goulburn Weir. Diversion of water at Goulburn reduces flows below the Weir.

Several swamps occur just west of the Goulburn River. Of the two largest ones, Reedy Lake covers about 300 ha and Doctors Swamp is considerably smaller. Both are filled by local run-off, and overflow after prolonged wet periods. Reedy Lake spills eastwards, reaching the backwaters of the Goulburn Weir near Bailieston East. Doctors Swamp spills northwards into the Dhurringile depression.

Several intermittent streams flow into Waranga basin.

Wanalta and Cornella Creeks drain land between Rushworth and the Mount Camel Range and flow into the Corop Lakes. Only in times of flood does flow from the lakes pass northwards down the Timmering depression to the Goulburn River.

Campaspe basin

Approximately 2,460 km^2 of the Campaspe basin lie within the study area. The principal tributaries are the Coliban River and Axe, McIvor, and Mount Pleasant Creeks.

The natural flow of the Campaspe River fluctuates greatly during the year, with mean monthly discharge at Axedale ranging from 617 Ml in January to 56,700 Ml in August.

Differences from year to year are also very large - total discharge recorded in 1944--45 was 752 Ml, compared with 663,354 Ml in 1956--57.

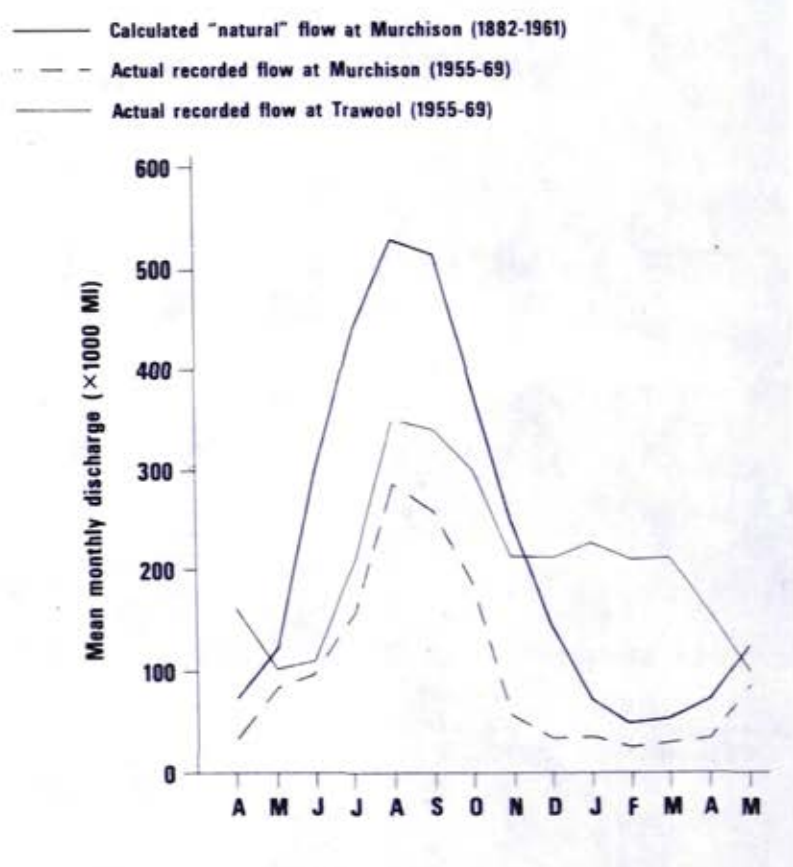
Loddon basin

Approximately 7,985 km^2 of the study area lie within the Loddon River basin. This area can be divided into three subcatchments. On the eastern side about 1,652 km^2, including most of the urban areas of Eaglehawk and Bendigo, drain to Bendigo Creek. Approximately 922 km^2 drain to Bullock Creek and, on the west, 5,380 km^2 drain driectly to the Loddon River.

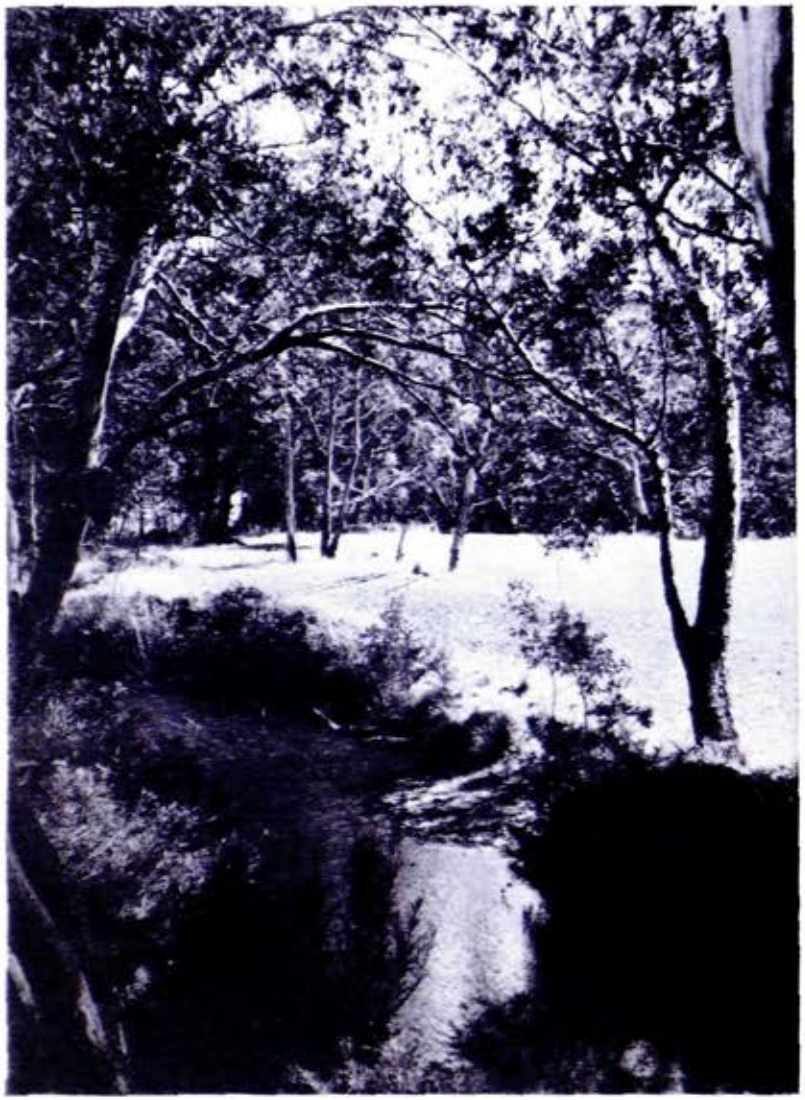
Important tributaries of the Loddon River include Bet Bet and Tullaroop Creeks. A few kilometres north of Bridgewater the river runs out onto the Loddon plain, which several effluent or distributory streams traverse. These include Serpentine and Bannagher Creeks.

Figure 1

GOULBURN RIVER FLOW PATTERNS



Mean monthly discharge of the Loddon at Laanecoorie ranges from 4,700 Ml in January to 48,000 Ml in August; the greatest monthly discharge recorded was 372,000 Ml in August 1909, while in very dry years the river may not flow at all for several months, depending on water released from Laanecoorie Reservoir.



The Loddon River at Glenluce

Avoca basin

The Avoca River rises on the Great Dividing Range at Mount Lonarch, just south of the study area. This part of the catchment covers about 180 km^2. The catchment within the study area comprises about 2,700 km^2. Tributaries include Sugarloaf, Cherry Tree, and Campbells Creeks.

The river at Coonooer has a mean discharge of 76,000 Ml a year, but the flow varies considerably between months and also between years. For example, the mean monthly discharge is 1,000 Ml for January but 16,800 Ml for August, and the total annual flow was only 3,270 Ml in 1967--68 compared with approximately 386,000 Ml in 1956--57. The Avoca has more saline water than other rivers in the study area (see Table 13).

Wimmera--Avon basin

In the study area the Wimmera--Avon basin occupies about 3,680 km^2. About 1,745 km^2 drain into the Wimmera River and 1,935 km^2 into the Avon.

Both rivers have very variable flows. The gauging data at Glenorchy on the Wimmera River for 1884 to 1913 rep-

Table 13

WATER SALINITY IN SELECTED STREAMS

Stream	Gauging station	No. of recordings	Salinity (mg TDS per l)		
			Minimum	Maximum	Mean
Goulburn R	Murchison	25	50	230	120
Campaspe R	Axedale	20	40	1,260	348
Coliban R	Malmsbury	14	80	190	117
Loddon R	Laanecoorie	102	75	1,940	504
Avoca R	Coonooer	35	135	5,300	2,375
Avon R	Wimmera Highway	20	100	775	259
Wimmera R	Glenorchy	43	150	3,150	785

resent natural flow, and during this period the mean annual discharge was 82,000 Ml, with monthly averages ranging from 370 Ml in April to 19,490 Ml in September. The lowest annual discharge in the period was only 3,947 Ml (1902--03) and the highest 245,586 Ml (1910--11). Monthly river flows were nil in dry years.

Flows in the Avon River are smaller, but just as variable. The mean annual discharge at the Wimmera Highway for the period 1963--70 is 15,000 Ml, with no flow in December, January, and February, and a peak flow of 4,453 Ml in October. Annual discharge varies over the period from 12 Ml in 1967 to 53,380 Ml in 1964--65.

Groundwater

Groundwater is water flowing below the surface, through aquifers. Water moves under the force of gravity or hydrostatic pressures through the pores in granular rocks, and along joints and fissures in non-porous rocks. A confined aquifer consists of a porous formation partly sealed by impervious formations.

Table 14

GROUNDWATER CHARACTERISTICS

Aquifer and area	Depth (m)	Salinity (mg TDS per l)	Hardness (mg $CaCO_3$ per l)	Yield (l per sec)
Shepparton Formation*	0--30	200--28,000	50--600	25
Calivil Formation				
Highlands	0--60	100--1,000	20--50	35
Plains	50--150	1,000--6,000	50--2,000	35
Basalt	0--30	120--5,000	290--1,600	20
Palaeozoics	10+	1,600--18,000	20--4,000	2--40

*Note: Surface shoestring sands contain better water than buried shoestring sands.

Recharge takes place where the porous formation outcrops, usually in higher land or alluviated valleys. Unconfined aquifers not only receive water in this way, but are also recharged by leakage from other aquifers or rainwater falling locally and infiltrating downwards.

Within the study area, groundwater saturates a number of aquifers, several of which are exploitable.

The Murray basin plains and Midland valleys contain flat-lying Cainozoic sediments resting on a relatively impermeable basement of Palaeozoic rocks. (The relative occurrence of these rocks is discussed in the geology chapter.)

Renmark group

Sand beds form a semi-confined to confined aquifer beneath the northern part of the Loddon plain in the study area, and also in the extreme west beneath the Wimmera plain. The water is generally salty.

Parilla sand

An unconfined aquifer of fine- to medium-grained sand outcrops north of the

highland front or lies buried beneath late Cainozoic deposits. Groundwater salinities show wide variation, but average around 15,000 mg T.D.S. per l.

Wunghnu group

Aquifers within this group (fluvial sediments and some lacustrine deposits) include the Shepparton Formation and the Calivil Formation.

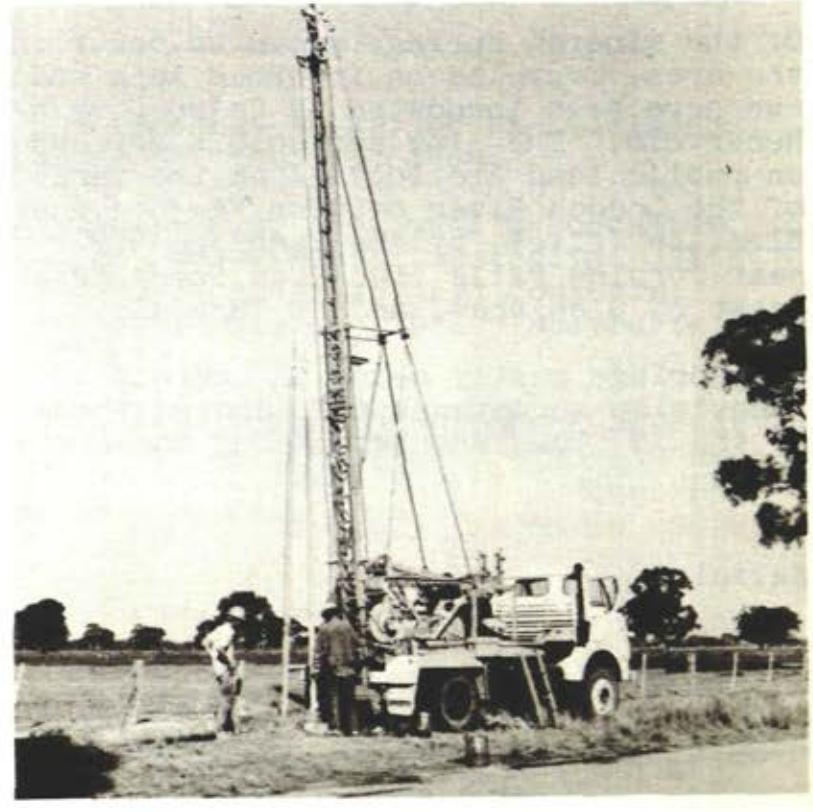
(a) Shepparton Formation. Groundwater salinities vary greatly in this formation, because of its variable lithology. Close to the highland front the narrow sinuous sand aquifers may yield salinities down to 500 mg per l, but salinity generally increases away from the highland front.

(b) The Calivil Formation. These buried fluvial deposits produce the best-quality water in the study area. They occur in the major alluvium-filled valleys (deep leads) such as the Goulburn, Campaspe, Loddon, Avoca, and Wimmera, as well as beneath tributary valleys such as those of Bet Bet and Burnt Creeks. The positions of these deep leads were accurately located between 1870 and 1920, when hundreds of bores were drilled for deep-lead gold-mining.

The best-documented lead systems are those of the Avoca and Loddon valleys.

In the Parish of Bridgewater, the aquifer produced by the confluence of these two leads is 75 m thick and 2.4--3.2 km wide, with salinities of the order of 1,000 mg T.D.S. per l.

At Elmore, groundwater within the Campaspe deep lead contains 300 mg T.D.S. per l. Within the Goulburn deep lead, groundwater yields may reach 50 l per sec, although the salinities are around 2,500 mg T.D.S. per l.



Drilling for groundwater

Newer volcanics

Basalts in the study area can yield good-quality water, although yields are not generally high.

Palaeozoic rocks

The Palaeozoic bedrocks of the midlands provide water suitable only for livestock, generally with low yields.

Mineral Springs

Of the mineral springs known to occur in the area, four lie on freehold land and two have been inundated by Cairn Curran Reservoir. The nine accessible springs on public land are located on the banks of the Loddon River between Vaughan and Glenluce (five), by the Campaspe River near Turpins Falls (two), on Stony Creek (east of Glenluce), and at Taradale.

The springs mostly occur in bedrock of Ordovician sandstones and slates; three of the 15 flow from basalt but these are all close to Ordovician rocks. Mineral water occupies fissures and fractures in the Ordovician sediments, which are best developed and most open in the sandstones and on fault planes. The bedrock is tightly folded and faulting is common. Springs usually rise where a stream has cut down across an anticlinal axis.

The mineral waters range in quality from 750 to 5,000 mg T.D.S. per l. Their characteristic feature is the presence of dissolved carbon dioxide, which effervesces at surface pressures. The amount of effervescence is commonly used as an indication of the quality of the mineral water. Two hypotheses have been proposed to explain the carbonation:

* reaction of percolating rain and stream waters with carbonaceous matter in the Ordovician sediments to produce carbon dioxide
* emanation, associated with Cainozoic volcanism, of carbon dioxide from great depth along fissures

Water Quality

Salinity

mg T.D.S. per l	
<1,000	Suitable for domestic and industrial uses, and for livestock and irrigation; use for irrigation restricted above 500 mg/l.
1,000--3,000	Brackish water: suitable for livestock, domestic, and industrial purposes, and for irrigation only under favourable conditions.
3,000--7,000	Brackish water: suitable for most livestock, and

	very limited domestic and and industrial use.
7,000--14,000	Salty water: suitable for sheep; beef cattle will tolerate up to 10,000 mg T.D.S. per l.
>14,000	Unsuitable for livestock,

Hardness

"Hardness in water refers to the difficulty in lathering soap, caused by the presence of calcium, magnesium, and iron compounds dissolved in it. The addition of soap produces an insoluble fatty scum.

Grades of hardness are as follows:

mg $CaCO_3$ per l	
0--60	Soft
61--120	Moderately hard
121--180	Hard
>180	Very hard

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12. LAND SYSTEMS

Preceding chapters have discussed individually the various environmental factors - climate, geology, physiography, soils, vegetation, fauna, and water. No one factor determines land use, however; it is their combined effect that controls the uses to which land may be put.

Land systems may be delineated and described as areas with uniform environmental factors within the limits considered significant for likely forms of land use. These arbitrary groupings can then be mapped to show areas of a specified degree of homogeneity. Land systems in the study area have been described and mapped by officers of the Soil Conservation Authority. Due to their complexity, however, those that are geomorphically similar have been grouped together for the purposes of this report.

Table 15 lists 11 discernible groups of land systems in the study area and these are discussed below.

Geomorphic Groups of Land Systems

Alluvial (A)

The alluvial group corresponds to the Murray basin plains, which predominate in the northern part of the study area. These broad plains are composed mainly of Recent alluvial deposits, with extensions along each of the river valleys. It is the most extensive group of land systems present (38% of the study area), but most of it has been alienated and cleared for agriculture.

Although arable, the soils vary greatly depending on the parent material. Sodic clay soils are widely distributed on the clayey alluvium; variable grey soils, which are liable to flooding, occur on the present flood plains; and calcareous sodic duplex soils form the prior stream levels.

The native vegetation remaining consists primarily of river red gum (open forest --woodland), although it may be associated with grey box, yellow box, or black box.

Present land use is predominantly dryland cropping and grazing. In irrigation areas sheep, beef, and dairy cattle are intensively grazed; some irrigation water is also used for crop and fruit production. Timber reserves are scarce, but some small stands remain along creeks and rivers.

Table 15

GEOMORPHIC GROUPS OF LAND SYSTEMS

Geomorphic groups of land systems		Area		Area remaining in public land (hectares)	Dominant features					Hazards	Typical occurrence
		hectares (approx.)	% of total study area		Geology	Topography	Average annual rainfall (mm)	Soils	Native vegetation		
A	Alluvial	731,900	38	11,400	Recent alluvium	Plains - almost level	375--625	Red calcareous sodic duplex soils; grey-brown calcareous sodic clay soils, uniform texture; variable grey soils liable to flooding	Woodland - grey box, yellow gum, red gum, black box	Destruction of topsoil by over-cultivation; flooding on present flood terraces	Serpentine, Elmore, Marong, Natte Yallock
TS	Tertiary sediments	210,200	11	15,000	Tertiary sediments - gravels, clays	Undulating plains	375--750	Mottled red-yellow duplex soils with ironstone	Whipstick mallee - blue, bull, and green mallee Woodland - grey box, yellow gum Open forest - grey box, yellow gum, red ironbark	Extreme infertility; unprotected fallows prone to wind and sheet erosion	Gooroc, Redbark, Painswick, Beazley's Bridge, Joel South
Tl	Tillites	9,700	< 1	685	Permian tillite	Undulating plains	475--575	Red sodic duplex soils, coarse structure; yellow sodic duplex soils, coarse structure; yellow sodic duplex soils	Open forest - grey box, yellow gum, white box	Sodic nature of soils causes salting; shrink--swell characteristics limit engineering works	Derrinal, Tooleen, Knowsley
B	Basalts	97,300	5	2,300	Recent basalt	Undulating plains	500--625	Grey calcareous sodic clay soils, uniform texture, coarse structure; red-brown shallow stony gradational soils; black clay soils, uniform texture; red stony gradational soils; red calcareous sodic duplex soils	Woodland - grey box, yellow gum, red gum	Low permeability and shrink--swell characteristics on plains and lower slopes; rocky terrain of upper slopes	Axedale, Redesdale, Moolort, Woodstock, Lillicur, Richmond, Park
PS1	Palaeozoic sediments 1	595,700	30	165,000	Palaeozoic sediments: interbedded slates, sandstone, quartz reefs	Gentle ridges	375--625	Yellow-red shallow stony gradational soils; red sodic duplex soils; red sodic duplex soils, coarse structure; yellow sodic duplex soils, coarse structure; yellow sodic duplex soils	Whipstick mallee - green, blue, bull, and kamarooka mallee Open forest - red ironbark, grey box yellow gum, red stringybark	Severe sheet erosion on upper slopes; gully erosion and salting on lower slopes; low permabilities and marked shrink--swell characteristics limit engineering works	Strathlea, Dunolly, Wedderburn, Rushworth, Maryborough, Redcastle
PS2	Palaeozoic sediments 2	91,500	5	26,900	Palaeozoic sediments: interbedded slates, sandstones, quartz reefs	Broken ridges	500--625	Yellow-red shallow stony gradational soils; yellow sodic duplex soils; yellow gradational soils	Open forest - stringybark, red box, long-leaf box, red ironbark, grey box, yellow gum	Same hazards as PS1, but a larger proportion of shallow soils prone to severe sheet erosion	Castlemaine, Mandurang, Mia Mia, west of Tooborac, south of Eaglehawk
PS3	Palaeozoic sediments 3	54,500	3	32,700	Regional metamorphics: interbedded slates, sandstones	Prominent ranges	500--625	Yellow-red shallow stony gradational soils; yellow gradational soils	Open forest - messmate, blue gum, candlebark, yellow box, red stringybark, red box, long-leaf box, grey box, yellow gum	Shallow soils; severe sheet erosion; silt deposition at lower levels; small landslips where profiles are deep	Pyrenees, Mount Avoca, St. Arnaud Range, Mount Ida, Mount Sugarloaf
M	Metamorphics	46,700	2	9,800	Contact metamorphics: interbedded slates, sandstones	Ridges	400--750	Yellow-red shallow stony gradational soils; yellow stony gradational soils	Open-forest - red stringybark, red box, long-leaf box, grey box, yellow gum	Steepness and stony surfaces cause high sheet erosion; severe gully erosion in drainage lines; salting on lower slopes below cleared areas	Shelbourne, Bealiba Range, Black Ranges, Tooborac, Mount Lofty
G1	Granite 1	74,000	4	3,000	Granite, granodiorite	Gentle hills	375--625	Yellow sodic duplex soils, coarse structure; mottled red-yellow duplex soils with ironstone; yellow sodic duplex soils	Woodland - red gum, yellow box, grey box, yellow gum Open forest - grey box, yellow gum, red stringybark, red box, long-leaf box	Impermeable hardpan restricts moisture storage; heavy rain saturates the profile impeding movement of machinery; sheet erosion on slopes and gully erosion if inadequate vegetation	Mount Tarrengower, Bradford, Harcourt North, east of Archdale Junction
G2	Granite 2	19,500	1	4,000	Granite, granodiorite	Steep hills	375--750	Pale-brown coarse sand soils, uniform texture; mottled red-yellow duplex soils with ironstone	Woodland - manna gum, messmate	Removal of vegetation can lead to massive landslips; severe gully erosion in drainage lines	Mount Alexander, Mount Kooyoora, Mount Yowang, west of Fyalong
CG	Cambrian greenstones	13,600	<1	10	Cambrian greenstones, chert, shale	Prominent range	425--500	Red stony gradational soils, fine structure; red calcareous sodic clay soils, uniform texture	Woodland - grey box, white box, yellow box	Clearing and cultivation cause high sheet erosion on slopes and the occurrence of saline springs in lower slopes	Mount Camel, Colbinabbin West, Mount Burramboot

Representation in public land is minimal and widely scattered, with the largest block being Reedy Lake, near Bailieston.

Hazards in the area include deterioration of topsoil due to overcultivation, and salinity problems in some areas developed for irrigation. Some of the grey and red soils are coarse-structured and form gilgais (humps and hollows). This causes soil movement and produces problems with drainage, foundations, underground pipelines, etc.

Tertiary sediments (TS)

Tertiary sediments cover 11% of the study area. They comprise gently dissected plateaux and are confined almost entirely to the undulating areas west of the Loddon River, although small areas occur east of Bendigo.

All these land systems have more or less similar and relatively infertile soils. These mottled duplex soils generally have a surface texture of gravelly loam, contain ironstone and rounded quartz gravel, and remain largely wooded except where gravel stripping has taken place.

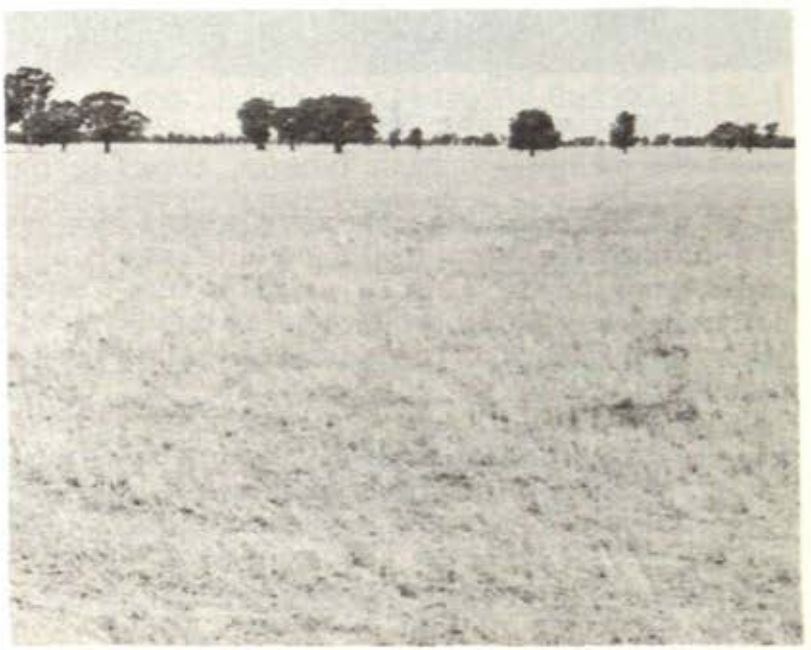
The native vegetation ranges from whipstick mallee in the drier areas, through red stringybark--red box--long-leaf box forests on the rocky ridges, to grey box --yellow gum areas on the better soils.

Present land use includes grazing, gravel stripping, and some cropping with timber production and apiculture in the wooded areas. The erosion hazard is relatively low in most areas, but is increased by the presence of bare gravel-stripped areas and cleared sandy soils.

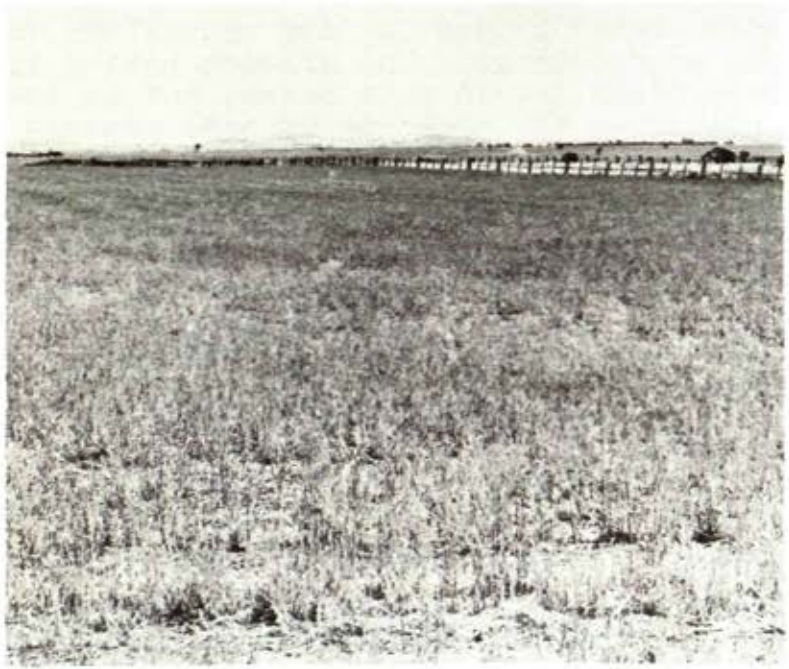
Representation in public land is confined mainly to a number of widely scattered small blocks between Inglewood and Stawell, with the largest consolidated area being Deep Lead, north of Stawell.

Tillites (Ti)

A small group of land systems cover a limited area of Permian tillites, north-



Alluvial plains near Serpentine



Basalt plains near Moolort

west of Heathcote. These glacial deposits occupy less than 1% of the study area, and their gentle undulating slopes contrast markedly with the ridges of adjoining Palaeozoic sediments land systems.

The solodic soils display a duplex profile, and support an open forest of grey box--yellow gum and white box. The sandy loam surfaces are generally hard-setting, and this produces moderate sheet erosion on the slopes. In the drainage lines, the hazards of gullying, waterlogging, and salting are high.

Most of the area supports grazing and cropping, except for a small area of forestry west of Toolleen.

Representation in public land is very small - the only areas are part of a block south of Derrinal and the forestry area west of Toolleen.

Basalts (B)

In the southern and central parts of the study area, a group of land systems corresponds to the undulating basaltic plains. These volcanic land forms occupy 5% of the study area, and are characterized by scoria cones, lava flows, and "stony rises".

Soils formed from these basaltic parent materials are extremely variable, ranging from shallow stony gradational soils on steep slopes, through the heavy grey clays on the open plains, to black cracking clay soils of uniform texture in creek flats. Similarly the problems caused vary, ranging from the shrink--swell characteristics of the heavy grey and black clays to the extremely rough (rocky) terrain of the red-brown gradational soils.

Most of the soils are relatively fertile, however, and the land is used primarily for grazing and dryland cropping. Timbered areas are rare, and the few stands that occur comprise woodlands of grey box--yellow gum, or red gum. Soil textures vary from clays to loams,

and the low permeability results in only moderate erosion hazards. In the lowland areas, over-cultivation can lead to deterioration of the topsoil, and stream-bank erosion, gullying, salting, and waterlogging are all known to occur.

Representation in public land is minimal, and includes only one isolated remnant volcano - Mount Greenock. The only sizeable area left unalienated is a block north of Clunes.

Palaeozoic sediments 1 (PS1)

This is the second-largest group of land systems present, covering some 30% of the land. It is also the most widely scattered group, extending to all parts of the study area and forming the bulk of the highlands.

A relatively large area of this group, unlike most land systems, remains in public land. The biggest single block of Crown land in the study area extends south from Rushworth almost to Costerfield, and most of it is composed of the PS1 group.

The PS1 land systems are composed of interbedded Palaeozoic slates and sandstones that have been extensively folded and faulted. These sediments have eroded to form gentle low ridges with a NW--SE trend.

Sodic duplex soils occur in most places - except for the steeper slopes, which carry shallow stony gradational soils. Surfaces are hard-setting gravelly or sandy loams, and the profiles generally have low water-holding capacities.

In the drier areas these soils support large stands of whipstick mallee, whereas the wetter areas and deeper soils support extensive box--ironbark open forests. Present land use is timber production, eucalyptus-oil production, recreation, grazing, and a few small nature conservation reserves.

Severe sheet erosion occurs on steeper components of this group when trees and forest litter are removed. This hazard increases if cultivation takes place. The inherent sodic nature of the duplex soils also makes them very prone to gully erosion and salting. Soils with a coarse structure have low permeabilities and possess marked shrink--swell characteristics. Both features are serious limitations for engineering works or the installation of septic systems.

In addition to the Rushworth--Costerfield block, extensive areas of this group occur around St. Arnaud, Maryborough, Dunolly, Inglewood, Wedderburn, Muckleford, Dellars Hill east of Heathcote, and the Whipstick and Wellsford forests near Bendigo.

Palaeozoic sediments 2 (PS2)

These land systems are very similar to those of the previous group, as both are

composed of the same Palaeozoic sediments. They cover much less (5%) of the study area, however, and are confined to the wetter south-eastern part.

Characteristic land forms are sharply dissected low ridges (also with a NW--SE trend) and the proportion of shallow gradational soils is larger. Soil surfaces range from hard-setting clay loams to gravelly loams, and the profiles have low water-holding capacities. More than half the PS2 group has been cleared for grazing, but the remaining areas of open forest (stringybark--red box) are used for timber production, apiculture, recreation, and nature conservation.

Hazards include severe sheet erosion on the shallow gradational soils, and deterioration of adjacent land and streams by siltation, erosion, and salting.

Good representation in public land remains - south of Castlemaine, and in scattered blocks between Kangaroo Flat (west of Bendigo) and Lake Eppalock.

Palaeozoic sediments 3 (PS3)

This group of land systems is characterized by several prominent NW--SE trending ridges, including the rugged Pyrenees. These regionally metamorphosed sediments occupy 3% of the study area, most of which lies in a belt extending south from St. Arnaud. In the east, a narrow strip runs south from the Mount Camel Range, through Heathcote, and another outcrop occurs around Mount Sugarloaf (north-east of Bendigo).

Soils on the upper slopes are predominantly shallow, stony, and gradational, producing severe sheet erosion, as well as flooding and silt deposition at lower levels. After rain small landslips can occur in steep cleared areas where soil profiles are deeper.

Because of the high elevations, rainfall interception in parts of the Pyrenees is significantly higher than in adjacent lower lands. The higher-rainfall areas support a distinct vegetation association of tall open forest (messmate--blue gum). At the lower elevations open forests of blue gum--candlebark--yellow box or stringybark--box occur.

Much of this group remains as forested public land. Present land uses include timber production, apiculture, recreation, and nature conservation. Several vantage points within the areas of reserved forest include Landsborough Hill and Mounts Avoca, Bolangum, Ida, Sugarloaf, and Warrenmang.

Metamorphics (M)

The metamorphic group of land systems comprises the aureoles formed by the contact metamorphism of Palaeozoic sediments. Covering 2% of the study area, these distinct ridges are obvious around the large igneous intrusions - for example, around the Harcourt Batholith -

and also completely surround some of the smaller plutons - for example around Mounts Black and Moliagul.

Most of the soils formed are stony and gradational, with a gravelly loam surface texture. Profiles are permeable, but of low water-holding capacity due to the stone content. Clearing of the steeper slopes results in severe sheet erosion, and salting in lower areas.

Much of this group has been cleared for grazing, but the remaining areas of native vegetation are predominantly open forest. In the drier areas the main association is grey box--yellow gum, while the wetter sites support stringybark--box. Land use in the timbered areas includes timber production, apiculture, and recreation.

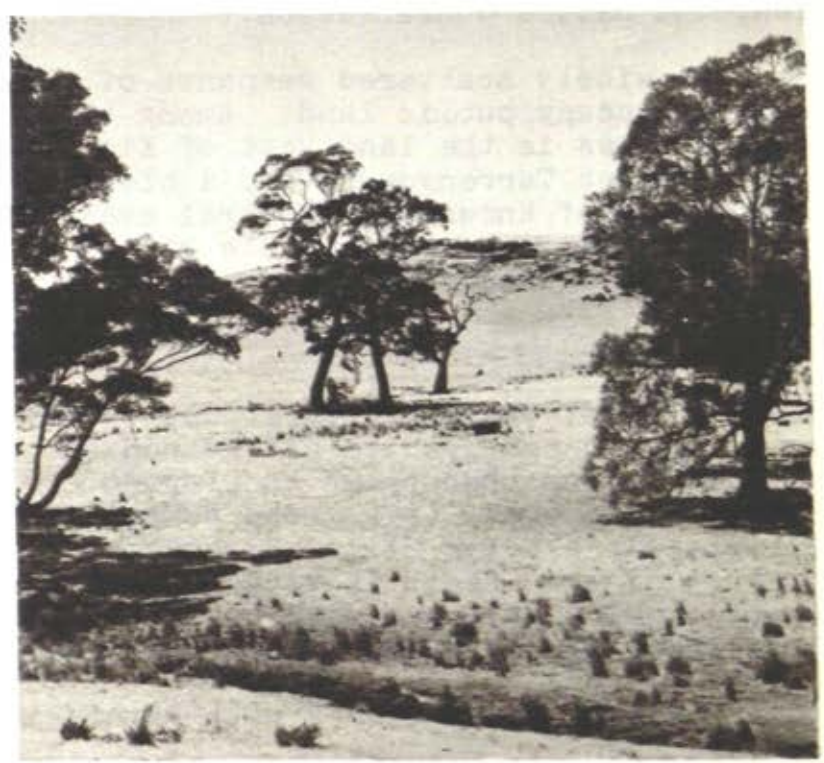
Small scattered blocks of this group remain on public land, including the Green Valley and Bealiba Ranges, Mount Lofty, and ridges east of Mount Tarrengower.

Granite 1 (G1)

These systems, covering 4% of the study area, comprise the undulating granitic hills that are scattered throughout the highlands. These areas correspond to the numerous intruded plutons, the largest of which is the Harcourt Batholith between Bendigo and Castlemaine.

On these low hills the remaining stands of native vegetation are predominantly grey box--yellow gum open forests. There is also a small area of hill gum woodland (or Blakelys red gum) at Sutton Grange west of Kingower.

Soils are generally duplex with an impermeable hardpan between 0.5 and 1.5 m depth. This can have severe limitations on moisture storage for crops. Topsoils are generally deep coarse sandy loams with a very weak structure. Pasture growth can occur in quick response to



Dryland grazing land of the granite 1 group

light rain; but the soils soon dry off unless follow-up rains fall. Conversely, heavy rains saturate the soil profile, impeding the movement of vehicles and machinery. The slopes are very prone to sheet erosion, and gully erosion can occur in drainage lines unless there is adequate vegetative cover.

Most of these land systems have been cleared for grazing and dryland cropping. The few wooded areas are used for timber production, apiculture, recreation, and nature conservation.

Several widely scattered remnants of the systems occupy public land. Among the larger areas is the land west of Kingower, Mount Tarrengower, and a block north-east of Knowsley. Several small plutons also form recognizable hills - for example, Mounts Black and Moliagul.

Granite 2 (G2)

Like those of the previous group, these are found on the granite and granodiorite intrusions throughout the region. In contrast, however, this group comprises the steeply sloping hills and covers only 1% of the area. (A very large tract of similar country occurs just outsive the study area, around Pyalong.)

On these very steep slopes with rainfall of more than 500 mm, coarse sandy soils of uniform texture support messmate and manna gum woodlands. The slightest disturbance of these slopes upsets the stability that exists under native vegetation. When trees are removed, less water is transpired, the soil becomes saturated and unstable, and massive landslides can occur. Some areas of grey box woodland remain on mottled duplex soils on steep slopes. Clearing of these also leads to increased run-off, channelling, and severe gully erosion.

Grazing occurs in the cleared areas, and slopes remaining under timber support forestry, quarrying (the renowned "Harcourt granite"), recreation, and nature conservation.

Representation in public land includes the Mount Alexander "block", Mount Beckworth, Mount Korong, and Melville Caves, near Kingower.

Greenstones (CG)

The prominent north--south strike ridge known as the Mount Camel Range forms a small but distinct group of land systems in the east (less than 1% of the study area). On the lopes the Cambrian greenstones form red stony gradational soils, while colluvium from greenstone is red, calcareous, sodic, and clayey.

These systems have no timber reserves, although a few scattered stands of box woodland occur. Land uses for the whole area are cropping and grazing. Hazards include severe sheet erosion, and the occurrence of saline springs on the lower slopes and in drainage lines.

PART III

LAND USE

13. LAND USE HAZARDS

A land use hazard may be defined as anything that reduces the land's capability to fulfil its chosen purpose. Common examples include soil erosion, flooding, fire, noxious weeds, vermin, and other pests.

As well as obvious local effects, hazards can create problems in adjacent areas; for example, clearing vegetation in one area may cause excessive local run-off and erosion, and consequent flooding downstream. Altering one environmental factor usually produces variations in other factors, and such changes often continue until a new stable relation is attained.

Soil Erosion

Many soils within the study area are sensitive to disturbance by Man's activities such as grazing, cultivation, burning, removal of timber, construction of roads and tracks, or just trampling by people.

Water is the main agent of soil erosion, and can cause damage that affects the productivity and aesthetic appeal of the land. Gully erosion is the most conspicuous and ubiquitous form of deteration, although sheet, rill, and tunnel erosion occur extensively.

The erosion hazard is related to density of vegetative cover and the ease with which it can be restored after disturbance. These in turn depend on the climate, with greater stresses in drier areas. The climate here is dry enough for severe erosion to occur, and hazards increase from south to north with increasing aridity.

Poor structure of soil surfaces, low permeabilities, high sodicities, and other soil features in the area also increase the hazard. Steepness is another factor, with more damage on the hilly areas than on the plains.

The incidence of erosion is also related to past forms of land use and management standards. Most deterioration was brought about by clearing of the native forests and their replacement by poor native pastures, and by overgrazing. Cultivation for cereals imposes particular pressure on the land.

The interplay of all these factors has resulted in widespread erosion in the study area.

A study initiated in 1973 by the Soil Conservation Authority has shown that the area contains more than 9,000 kilometres of eroded gully channels and 12,000 separate, mostly active, gully heads. The most severe deterioration is, however, largely confined to the cleared areas.

In recent years the use of superphosphate, lime, molybdenum, legumes, and deep-rooted species such as phalaris, together with stricter grazing controls, has reduced the incidence of erosion on many farms. Gully heads are treated to prevent extension, and the channels infilled and sown down. Water movement is also controlled by diversion banks and grassed waterways. Suitable salt-tolerant pastures have become available.

Severe gully erosion in the north of the study area

No satisfactory techniques for stabilizing the undulating cropping lands are yet available, however.

Salting

The accumulation of toxic levels of salt in the soil is a significant hazard because it reduces plant productivity. Germination rates and growth rates decrease until eventually the high salt concentration prevents all plant growth. When such an area becomes devoid of vegetation it is susceptible to sheet erosion, and in times of heavy rain overland flow will concentrate in these areas. The situation deteriorates and a small scour soon becomes a gully that quickly erodes into the dispersible sodic clays.

Areas of badly salted land in the study area are common (approximately 5,000 ha), widespread, and obvious and are increasing in size. An even greater problem, however, may well be the incipiently salted land where, although the signs are not obvious, production of crops or pasture is adversely affected. This aspect should cause real concern, for not only are incipiently salted areas likely to be larger than the badly salted areas, but they will soon become unproductive if the problem is not checked.

The accumulation of toxic levels of salts in the surface layer of soils can occur in two different situations: in dryland farming, and under irrigation.

Dryland farming

Mismanagement of a catchment basin can upset the hydrological equilibrium. Increased percolation of water causes the water table to rise, and so the capillary fringe - the moist zone above the water table - eventually intersects the surface on the lower slopes and in the valley floor. Evaporation concentrates the salts on the soil surface, creating an unfavourable environment for plant growth.

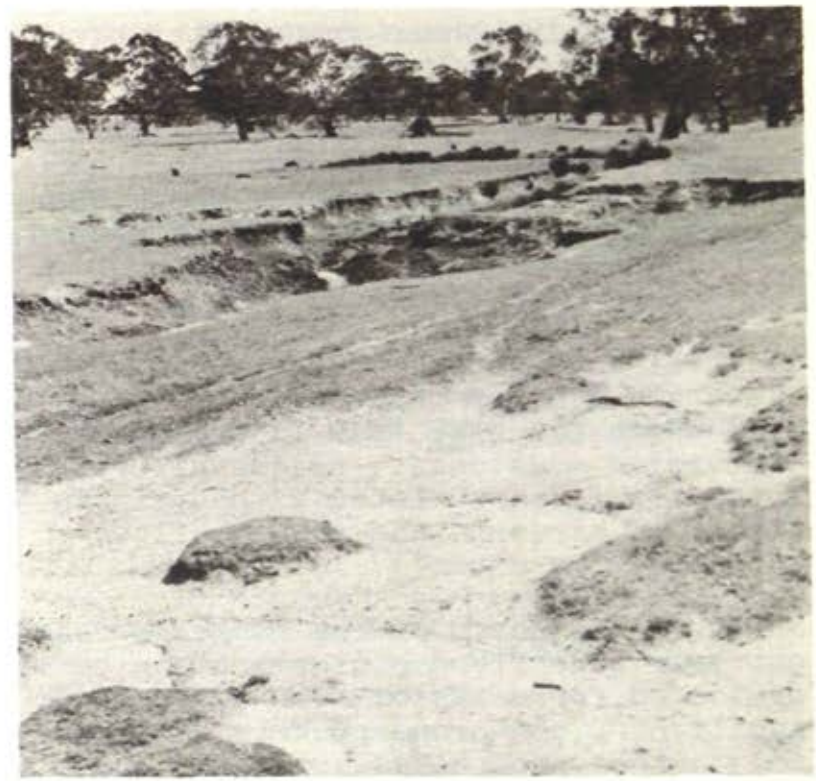
To treat symptoms, salt-tolerant plant species with deep root systems are grown in affected areas to dry out the soil by transpiration rather than evaporation. Subsequent rains then tend to leach the salts down beyond the root zone.

To treat the cause, the level of the groundwater table must be reduced. This can be achieved by planting deep-rooted perennial pasture species and trees on the cleared hills.

Irrigation

When the district water table level has risen to within 2 m of the surface, capillary movement allows water to evaporate from the surface, leaving behind the dissolved salts.

The standard practise of reclamation is to irrigate the area when the surface has dried out sufficiently to leach the salts down below the root zone. To



Salting and gully erosion (on a mottled duplex soil with ironstone)

treat the cause of this problem is far more difficult, involving measures such as more efficient use of water, reduction of channel seepage, and reduction of groundwater pressures.

Increasing groundwater pressures in the Calivil Formation beneath the riverine plain have caused the development of discharge areas (Macumber, 1976) and special problems in irrigation manage-

ment. Reducing these groundwater pressures will be a long-term and very costly programme. The whole catchment area requires improved management techniques to restore a balance to the hydrological equilibrium, and a large-scale pumping program at selected sites may be needed.

Flooding

The drainage pattern and nature of flood flows are similar throughout the study area where the base rock is generally Ordovician mudstones. Recent alluvial materials are associated with drainage lines and streams, and are all flood-prone to some extent.

Major floods north of the ranges spread out over wide flood plains and can be prolonged for weeks or even months. In addition, flood-prone pockets at Dingee and in the Corop Lakes area are caused by the stream geomorphology. These are natural retarding areas and, under certain conditions, water spreads across a wide area linking the various swamps and lakes, reducing flood peaks downstream.

Dams constructed on the rivers in the study area have not significantly reduced major floods, although they may have reduced the frequency of smaller ones.

Clearing of forest and woodland on the hills and flood plains has reduced the retardation of flood flows and has tended to create higher peak flows. Associated with this, increased sheet and gully erosion, damage to structures such as road culverts, and the siltation of reservoirs and creeks downstream all aggravate flooding.

Fire

Wildfires do occur in the study area, but the hazard in box--ironbark forests is low compared with that in other forest types due to the open nature of the stands, the sparseness of flammable undergrowth, and the slow rate of fine-fuel accumulation. Most species in these forests are relatively fire-resistant and possess good capacity for regeneration. In addition, practically all the adjoining agricultural land is cleared and most timbered areas are readily accessible by a network of tracks. In this low-rainfall area there is a need to provide artificial water storages at numerous locations to feed mobile pumping units. Fuel-reduction burning within the box--ironbark forests is confined to burning of wood utilization residues and strategic burning on roadsides.

The stringybark forests present a different problem- as both the trees and the understorey are dense and the vegetation is generally more flammable. Most of these forests are well roaded, however, and protective measures such as water storages and controlled burning are taken. A planned program of broad-area fuel reduction is carried out in messmate--gum forests in the Pyrenees and Mount Alexander.

The woodlands and forests of red gum occurring along the streams in the study area are also less fire-resistant than the box--ironbakrs, and hot fires will kill this species.

Fires in the area

In the study area, fires originate on public land and on adjacent private property with about equal frequency. The number of fires and the area burnt vary substantially, depending on the severity of seasonal weather conditions. January is the month of greatest fire risk, followed by December and February. Wildfires generally occur during the period September to April, and in dry years may be expected at any time.

Fire statistics for the public land during the period 1965--77 are given in Table 16.

In the 10-year period to 1975, 87% of the fires burnt less than 4 ha of public

Table 16

AREA OF PUBLIC LAND BURNT BY WILDFIRE (1965--66 to 1976--77)

Year	Area burnt (hectares)*		
	Reserved forest	Other public land	Total
1965--66	694	356	1,050
1966--67	88	13	101
1967--68	38	6	44
1968--69	1,270	72	1,342
1969--70	31	2	33
1970--71	14	76	90
1971--72	4	10	14
1972--73	6	3	9
1973--74	2	1	3
1974--75	517	21	538
1975--76	162	-	162
1976--77	96	-	96
12-year total	2,922	560	3,482

* These figures refer only to public land - the total area of land burnt in the study area has, in some years, been much greater.

Table 17

CAUSAL AGENTS OF FIRE ON PUBLIC LAND IN THE NORTH CENTRAL AREA (1965--66 to 1974--75)

Agent	Total number of fires over 10-year period	% of total
Landowners, householders	44	16
Deliberate lightings	67	24
Sportsmen, campers, tourists	41	15
Licensees, forest workers	15	5
Smokers	7	2.5
Lightning	13	5
Tractors, trucks, locomotives	13	5
Children	21	7
Sawmills	0	0
Army weapons, vehicles, personnel	7	2.5
Miscellaneous known	8	3
Unknown	43	15
Total	279	100

land, which reflects the relatively accessible nature of the forests, the low levels of fuel accumulation, and the efficiency of fire control.

Most of the fires were caused by human agencies, as Table 17 shows, and lightning caused only 5%. Although 24% of the fires on public land were deliberately lit, no culprits were apprehended.

Fire protection and suppression

Co-operation between the Forests Commission and the Country Fire Authority in fire-protection and suppression operations is necessary because of the fragmentation of public land. Commission representatives serve on C.F.A. regional and local advisory committees for the co-ordination of fire-protection procedures.

Fuel reduction in the study area is carried out by borad-area control burning, and by ploughing, slashing, and mowing of firebreaks and along roadsides. The frequency, location, and extent of the control burns is determined by the fuel accumulations and the strategic importance of the area for wildfire prevention. During 1976--77, 800 ha of

public land in the study area were control-burnt. This is less than in previous years, because of the danger of escape due to the dry year.

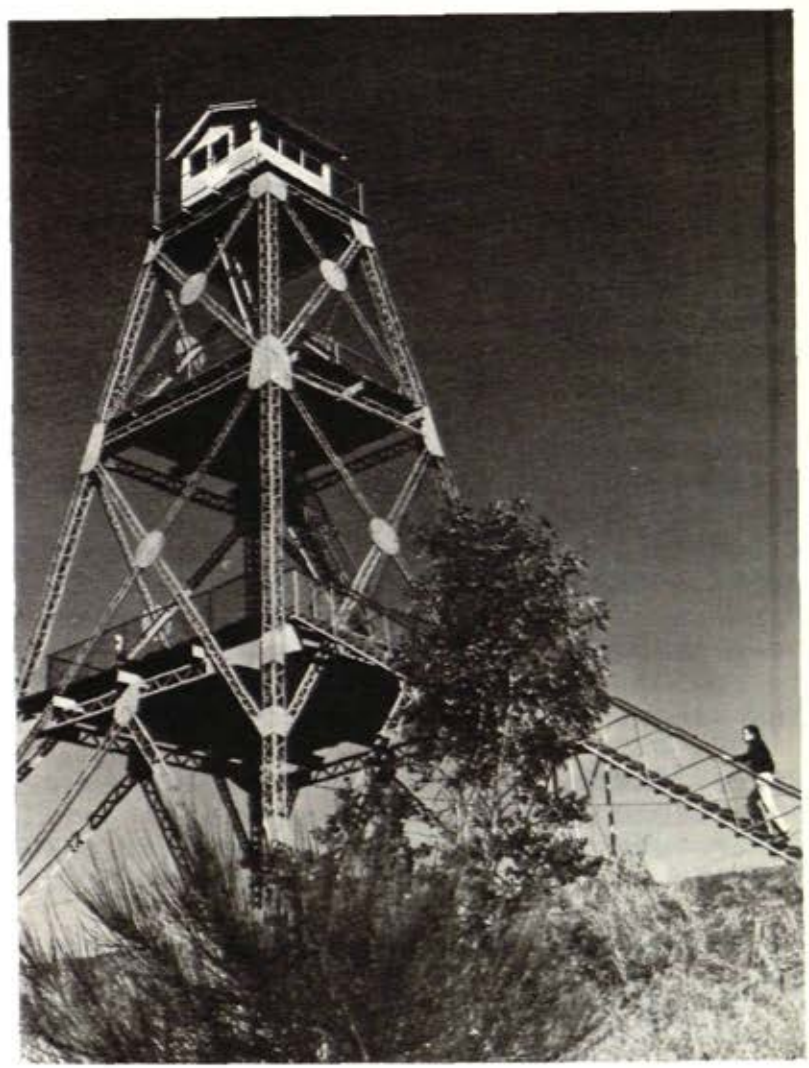
Fire towers are manned during the fire danger period, with additional look-out locations manned on days of extreme fire danger. Also, 300 fire-protection dams form a strategic network of permanent water supply over the forest area. This is approximately one dam for every 700 ha of State forest.

The main provision for fire protection in the softwood plantations is the subdivision of the planted areas into small units separated by cleared firebreaks.

Weeds

Many factors govern the extent and density of weed infestation, whether it be a declared noxious weed or regarded only as a pest plant. Rainfall, soil type, and land utilization have the greatest influence.

Under the *Vermin and Noxious Weeds Act*, 93 plant species have been proclaimed as noxious weeds in Victoria (except the Melbourne metropolitan area), and about one-quarter of these occur in the study area. Many of the plants are presently established on both Crown land and freehold, particularly in areas that have suffered soil disturbance. Legal provisions of the *Act* require control measures to be carried out on these plants irrespective of location. Details of the present noxious weed legislation in various control methods are set out in



The fire tower on Mount Tarrengower, which also serves as a public look-out

the book "Noxious Weeds in Victoria" (Parsons, 1973).

Some of the more important weeds in the area are discussed in Appendix 3. Most of these noxious weeds can be controlled by spraying with herbicides, by mechanical methods such as mowing, slashing, or cultivation, or by biological means. Advice as to the most effective method is available from the local district Inspector of Lands (20 districts lie wholly or partly within the study area). It is the Inspector's duty to enforce weed control in his district and to destroy noxious weeds on all Crown land.

Most control methods have direct relevance to future land use and management. They may upset a stable and balanced situation, resulting in problems more serious than the original weed problem. For example, soil erosion may follow weed removal, or herbicides may persist in soil and in run-off to streams, causing damage to other desirable species.

Three factors should therefore be taken into account when considering the future use of land that is badly infested with weeds:

* whether the weeds can be controlled
* whether the method of control is compatible with the use proposed for the area
* whether the proposed use will lead to the further spread of weeds.

Vermin

The declared vermin animals found in the study area are rabbits, foxes, and wild dogs. In addition, feral cats, kangaroos, possums, mice, and a number of bird species have, in certain circumstances, been considered as pests.

Rabbits

Rabbits are widespread and present a serious hazard to all forms of land use. On farms they compete with stock for pasture, and on public land they severely damage vegetation and accelerate soil erosion.

The worst-affected areas are the Shires of Stawell and Avoca, especially around Navarre and Landsborough, but there are also problems in the Shires of Newstead, McIvor, and East Loddon. Myxomatosis has been an important control factor. This may be further improved with the release of the European rabbit flea.

Effective farm management, especially in more rugged areas, requires extra controls such as 1080 poisoning, ripping, or fumigation. 1080 is widely used for economic reasons, but baits are a hazard to native animals, which often suffer heavily during rabbit control programs.

Foxes

Foxes, too, are widespread in the study area in all types of habitats. Surveys

of their dietary habits indicate that rabbit and sheep carrion form the main diet; being opportunist feeders, they also eat native mammals, birds, and herbage and berries. The claim that foxes account for the high percentage of lambing losses each season is debatable, although numerous scalp-bonus payments are handled by the Shires and Lands Department personnel each year.

Some land-owners carryout poisoning, but most control is by shooting or by secondary poisoning when 1080 baiting is undertaken for rabbits.

Wild dogs

Wild dogs and domestic dogs cause serious sheep and lamb losses in parts of the area, particularly when rural holdings adjoin cities and towns. The Shire of Newstead has in recent years suffered considerable losses from feral dogs.

The hydatid tapeworm is a common parasite in these dogs, but their significance as a source of infection for humans and livestock is unknown.

Feral cats

Feral cats are relatively common in many bushland areas throughout the study area and pose a major threat to the smaller native mammals, lizards, and birds. They also feed on rabbits, but their predation probably exerts little influence on that pest's populations.

Kangaroos

Kangaroos have become an increasing problem to landholders, by encroaching from their habitat in timbered areas and causing considerable damage to pastures and fencing. They also constitute a hazard to motorists in several areas.

Permits to destroy kangaroos have been issued in most shires - in particular in McIvor Shire, where mobs of up to 200 have been sighted. Such populations on public land may have to be controlled, particularly during adverse seasonal conditions.

Other animals for which pest destruction permits have been issued include possums (nuisance and causing damage to trees); rosellas and lorikeets (damage to orchards), and coots and swans (damage to sown crops).

Insects and Other Biotic Hazards

A degree of crown dieback affects some trees in most of Australia's eucalypt forests. This is generally accepted as being within the normal range of a typical healthy stand.

One natural pest causing defoliation in the box--ironbark forests is the mottled cupmoth *(Doratifera vulnerans)*. This insect appears to attack red stringybark and red box more readily than other species, although it also attacks red ironbark, grey box, red gum, and yellow

gum. Its attack retards the growth of the stands and weakens the trees, making them more susceptible to other pests.

Several other insect species, such as chrysomelid beetles, can cuase dieback in the box--ironbark forests. No specific fungal causes of dieback have been detected in the study area, although it is possible that the root pathogen *Armillaria* may occur.

Aquatic Hazards

The discovery of water hyacinth *(Eichhornia crassipes)* at Castlemaine and Bendigo in 1962 caused some concern. These infestations have now been eliminated, although they indicate a hazard that could recur.

The full extent of European carp in rivers and dams in the study area is unknown. It is often caught, but as yet there is no evidence of the serious and destructive effects this fish can have on the environment.

Man

Many of the land use hazards mentioned above are caused or aggravated by the activities of Man. In addition, Man may also cause environmental harm by the deposition of rubbish and wastes, vandalism, and the misuse of chemicals such as pesticides.

Waste is an inevitable by-product of human activity. The disposal of domestic and industrial wastes must be carefully planned and controlled to minimize pollution and environmental degradation.

Irresponsible disposal of rubbish results in despoliation of the scenic values that are such an important attribute of land. This hazard is greatest around towns, along roads, and at viewing points, picnic areas, and camping sites.

Chemicals are widely used in agriculture and are now becoming increasingly important in forestry. Pesticides may spread beyond the area being treated, particularly if applied from the air. Insecticides also affect birds and animals that feed on poisoned insects. Fertilizers are less obviously an environmental hazard; but, by changing the nutrient status of the soil or water, they cause changes in the species and numbers of individuals present.

14. CONSERVATION

Conservation is concerned with Man's relation to his environment. The need for conservation of economic resources is obvious because Man depends on these for many of the necessities of modern life. These aspects of conservation are considered in subsequent chapters under such headings as timber production, water use, and minerals and extractive industries.

This chapter deals with nature conservation (such aspects as native species, natural features, and landscapes of an area), and the conservation of archaeological and historic features. Conservation of these attributes is important for a number of land uses, including reference, conservation of species, recreation, and education. Often these conservation needs are compatible with each other or with commercially productive uses.

Uses of Conservation Areas

Reference

The solution to problems arising from our use of a particular land type is often helped by reference to an undisturbed example of the land type. Here the soils, vegetation, and fauna, and the processes linking them, can be studied under natural conditions. Knowledge of the basic relations operating within a land type is important when studying problems such as soil instability or falling productivity.

Reference areas, therefore, act as standards against which the progress and effect of human alteration and utilization of the land can be measured. They also provide a valuable gene pool of plant and animal species. Such genetic material is already being used, and will be increasingly used, to endow species with advantageous characteristics.

Reference areas must be carefully chosen and managed to permit natural processes to continue without disturbance. In common with standards used in other fields, they should not be tampered with; that is, access should be restricted, experimental manipulation should not be permitted, and they should be protected by a buffer zone.

Although all land types need to be represented in reference areas, the need is most urgent in those that have been extensively developed for uses such as

The mallee fowl reaches the south-eastern limit of its range in this study area

agriculture. Few, if any, areas suitable for reference remain for some land types in the study area, such as those on tillites or greenstones (discussed in chapter 10). Conscious effort must be made to retain reference areas in suitable remnants to represent all land types.

Conservation of species

Each species of plant and animal makes a unique contribution to the richness and diversity of the environment. Each is an essential part of Man's natural heritage and, to many people, there is a moral responsibility to ensure that none of them should knowingly be lost or endangered.

Chemists, geneticists, physiologists, and scientists in many other fields place a special value on each individual species for its potential to provide the means of solving a research problem, or to be used in future as the stock for breeding essential plants or animals.

Conservation of the existing plant and animal species and associations in their natural habitats is therefore an important land use. The survival of some species may require certain precautions in an area because few individuals remain in existence. In other instances, particular species may be living in unusual habitats, or near the limits of their distributions, and it may be justifiable to devote the land expressly to their conservation.

Chapter 9 contains a list of rare and endangered plant species, and the significance of several important fauna species is discussed in chapter 10.

It is essential for the conservation of plants and animals to recognize the ecosystems they form (the interdependent complexes of soils, water, air, plants, and animals), and to conserve examples of each major one.

The range of different exosystems in a region is reliably indicated by the veg-

etation. Plants express the various conditions of soil and climate, and they determine the types of food and shelter available for birds and animals. Conservation of a representative area of each distinct plant association or formation therefore ensures the protection of most of the different ecosystems of a region, and also most of the individual species.

Special natural values

Particular areas of land are often needed to preserve significant natural values such as distinctive geological features. A report on the conservation of geological features in the Loddon--Campaspe region (1977) lists some of the more important and spectacular sites. Many of these have important scientific values, while others are valuable in education. Most of the more accessible and spectacular features also attract tourists.

Unlike historic or archaeological features, geological features have no legislation in Victoria designed specifically to protect them. It is therefore important that these features be satisfactorily preserved in suitable reserves or as geological monuments.

Archaeological and historic features

As stated in chapter 2, the study area contains a number of Aboriginal relics, mostly on private land. Although many of these sites are culturally and scientifically important, only one, the Carisbrook stone arrangement, is a proclaimed archaeological area. Some of the more significant sites on public land may require special protection.

Buildings of structures on Crown land or on land vested in any Minister are not listed in the Register under the *Histor-*

The Aboriginal ceremonial stone arrangement near Carisbrook

ic Buildings Act 1974. The National Trust of Australia (Victoria), however, records or classifies all historic buildings, landscapes, areas, objects, and sites that members consider worthy of preservation.

A report on the Loddon--Campaspe region (1977) lists proclaimed archaeological areas, other relics, Designated Buildings, and National Trust classified and recorded features, many of which are in the study area. Additional sites within the study area, but not in that report, have been supplied in lists provided by the Victorian Archaeological Survey and the National Trust.

Recreation

Most Australians live in the artificial environment of large cities and towns, and many find that their lives are enriched by renewed contact with the natural world. Chapter 13 discusses the requirements of natural surroundings for many forms of outdoor recreation. Bird-watching, nature study, hunting, and bushwalking all require conservation of the native plants and animals; picnicking and driving simply require a background of trees or shrubs in the recreation areas. These requirements can all be filled in the study area.

Due to the fragmented nature of the vegetated land, and the accessibility of most parts of this region, there are few areas, if any, that most people would regard as having any characteristics of wilderness. Smaller areas, however, can still have value by providing some degree of solitude and contact with nature, and by reducing the pressures on places more suited for conservation of particular natural features or species.

Education

Education is another important use of land in a natural or near-natural condition. Forests, rivers, and other natural landscapes have many applications in education - from primary to post-graduate levels - giving students opportunities to see, interpret, collect, and monitor natural land forms and processes. In some circumstances laboratory facilities and associated accommodation are needed so that successive groups can undertake long-term studies. This may require land to be specifically set aside for education.

Productive uses

Some productive and commercial uses of land are achieved by conserving the natural ecosystems in varying degrees. The commercial product is obtained by harvesting a proportion of the population of a species or group of species at a controlled rate, which the ecosystem can sustain. Examples include the sustained yield of hardwood timber and the conservation of wetlands to produce game birds. The continued success of such uses depends on maintaining many of the

natural features of the ecosystem. Land under such management can also be used for education, recreation, and scientific purposes, and it may form a protective buffer around small areas specifically devoted to nature conservation.

Viability of Areas

The viability and effectiveness of conservation areas depend on a number of factors, including the size of the area, the type of community, ecosystem, or feature to be conserved, and the degree to which the area can be managed to control influences that tend to upset the natural balance.

Large consolidated reserves have less perimeter relative to their area than small or irregular ones, and so tend to be better-buffered against the effect of intrusive factors.

Small areas can nevertheless contribute to nature conservation or the preservation of particular features. They include narrow reserves along streams, roadsides, and railways, and those originally set aside as gravel, water, cemetery, school, and camping reserves. Where these small areas retain native vegetation, and are surrounded by cleared and developed land, they can make a major contribution to the regional character of the landscape.

Narrow strips of native vegetation are important for migratory and nomadic

Box--ironbark forest, a major ecosystem that is widespread and common within the study area, but unknown elsewhere

birds and as wildlife "corridors" for small animals. These are particularly so in the study area because the areas of natural landscape are so fragmented.

Careful management may enable small areas to remain viable. Management may take the form of using controlled fires to change vegetation, culling animal populations, practising silviculture, strictly controlling the number of visitors, fencing to exclude introduced animals, or eradicating introduced species.

Table 18

AREAS RESERVED UNDER SECTION 50, *FORESTS ACT* 1958

Name	Type*	Approx. area (ha)	Date established	Resource	Activities							Facilities			
					Picnicking	Pleasure driving	Walking	Historic interest	Nature study	Sightseeing	Other	Picnic area	Toilets	Walking track	Other
Bendigo Whipstick	F.P.	8,134	1972	Scenic, recreation, flora and fauna, historical	x	x		x	x		Hiking	x			
Wychitella	F.P.	1,239	1973	Mallee fowl habitat	x				x			x			
Pink Cliffs Reserve	S.P.R.	17	1972	Geological, historical						x					
St. Arnaud Wax Garden	S.P.R.	4	1972	Flora					x						
Gobarup Wildflower Reserve	S.P.R.	259	1974	Wildflower preservation					x						
Moliagul Historical Reserve	S.P.R.	198	1974	Historical	x					x		x			
Mount Alexander Koala Park	S.P.R.	31	1939	Koala colony	x		x				Koala viewing	x	x		Shelter
Dargile Reserve	S.P.R.	119	1973	Experimental plantings of pines and eucalypt form abundant fauna											
Big Reef Reserve	S.P.R.	8	1976	Geological, flora						x					
Snake Hill Wildflower Reserve	S.P.R.	34		Wildflower preservation					x						
Moonlight Flat Geological Reserve	S.P.R.	0.4	1971	Geological features							Geological study				
McIvor Range Reserve	S.P.R.	18	1971	Recreation and historical	x		x					x	x	x	Display pavilion, powder magazine
Native Water Wells Reserve	S.P.R.	0.2	1959	Aboriginal water holes				x			Interest point				
Native Wells Reserve	S.P.R.	0.2	1959	Aboriginal water holes				x			Interest point				
Heathcote Wildflower Reserve	S.P.R.	2	1959	Wildflower preservation											
Mandurang Wildflower Reserve	S.P.R.	0.01	1960	Wildflower preservation				x							
Paddy's Ranges Wildflower Reserve (1)	S.P.R.	38	1957	Wildflower preservation					x						
Paddy's Ranges Wildflower Reserve (2)	S.P.R.	6	1960	Wildflower preservation					x						
Mount Beckworth Summit Reserve	S.R.	75	1967	Scenic, flora, fauna											
Governors Rocks	S.R.	3	1972	Scenic							Look-out point				
Mount Alexander Dog Rocks	S.R.	2	1959	Views, granitic outcrops	x					x		x			
Melvilles Caves	S.R.	47	1949	Caves, scenery, history	x		x			x		x	x	x	Picnic shelters

*FP Forest Park SPR Special Purpose Reserve SR Scenic Reserve

Types of Reserves

Many of the uses discussed above are complementary, and this is reflected in the types of reserves into which natural land is placed. In reference areas, where the emphasis is on the retention of natural conditions, conservation of species and water production are the only other compatible uses.

Parks, however, encompass a wider range of uses - conservation of plants, animals, and land forms, differing forms of recreation, education, and other uses such as the preservation of historical sites, and landscape preservation. There are different types of parks, and individual parks are zoned to prevent conflict between uses.

In wildlife reserves, the conservation of species of animals and their habitats is the main aim, and this may sometimes be compatible with recreation.

Education areas may need to be set aside where extensive alterations to the environment for experimental purposes, not permitted in parks, can be carried out. Other types of reserves that may be proclaimed include flora reserves, bushland reserves, streamside reserves, recreation reserves, and scenic reserves.

Current status in the study area

Although proposals have been made in the past, there are no national parks or reserves controlled by the National Parks Service in the study area.

Table 18, however, lists 22 forest parks and reserves in the study area set aside for various purposes under section 50 of the *Forests Act*. These vary in size from more than 8,000 ha (Bendigo Whipstick Forest Park) to about 0.01 ha (Mandurang Wildflower Reserve). All have some value for nature conservation, although only some of the larger reserves are viable for the conservation of vegetation associations or large animal species.

These reserves, and other local government reserves, are often utilized for other types of compatible land uses.

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15. RECREATION

Recreation is a term loosely applied to any activity freely undertaken for personal pleasure during an individual's leisure time. It takes a multitude of forms, and individual preferences vary widely.

Outdoor recreation is an important use of public land and, as discussed in the preceding chapter, it is one reason for the retention of natural areas. It includes a wide range of pursuits, some of which are regarded as active (for example, bushwalking, canoeing, car rallying), while others are passive (for example, picnicking, sightseeing, pleasure driving).

North-central study area contains many fragmented and scattered blocks of public land containing a variety of recreational features, each with a different appeal to visitors. Many of the active recreational pursuits here are water-based, and consequently most of the rivers, lakes, and reservoirs are popular recreational sites. Lake Eppalock probably attracts the greatest number of visitors, as it is suitable for a variety of activities and is readily accessible from a number of population centres.

Few rugged areas suitable for adventure-type land-based pursuits occur, but the extensive areas of open forest and even the rural environment provide opportunities for many forms of recreation. There is also great scope for passive activities, particularly those of a cultural nature. Many of the towns reflect the atmosphere of the gold-mining era, and some of the many historic buildings have been classified by the National Trust (see the recreation map for locations). In addition, several memorials and museums throughout the area provide plenty of local history for the interested tourist.

Many of the recreational activities are closely linked with tourism, and most visitors to the area probably engage in some form of recreation. The booming tourist industry in turn depends considerably on local industries such as the Bendigo Pottery, the vineyards at Great Western, or the eucalyptus distilleries throughout the mallee areas.

Recreation and tourism must therefore be collectively recognized as significant factors in the local economy, and as important components of land use in the study area.

Recreational resources on public land

Only a small proportion of the public land is at present specifically reserved for recreation. Recreational use is obviously not confined solely to areas set aside for that purpose, however, and many activities are accommodated on land managed for additional purposes. Exceptions include formal recreation sites such as golf courses, rifle ranges, racecourses, etc. Opportunities for open-space recreation are available to varying degrees on the remaining public land, sometimes supplemented by private land as well.

In order to understand the recreational potential and types of recreational use, it is convenient to define several zones, as well as the various recreational activities and their requirements.

Zones

Urban zone

Most towns in the study area offer facilities for formal recreation activities such as tennis, golf, bowls, football, and rifle-shooting as well as passive recreation sites (parks, picnic tables, etc.). In addition, nearly all the major towns support some form of racing (horse-racing, trotting, greyhounds, motor sport, etc.).

Most towns also provide facilities for campers, caravaners, and tourists. The Bendigo area is probably the most popular for tourists, with many attractions nearby and within the urban zone.

Agricultural zone

A large proportion of the study area is agricultural land, characterized by extensive clearing or alteration of the natural vegetation. The open landscape of the broad plains does not have a high

Attractive agricultural land near Sutton Grange

Turpins Falls, on the Campaspe River - little-known but interesting and attractive

potential for recreation because of the general lack of features and problems of access through private land.

Undulating to hilly agricultural land is more aesthetically attractive than flat, and country roads through these areas provide good opportunities for pleasure driving.

Zones of natural vegetation

These zones are described in detail in the vegetation chapter.

Most of the public land (excluding the lakes and reservoirs) remains under natural vegetation, although there is a distinction between disturbed areas and those that remain relatively undisturbed.

Disturbed areas occur commonly throughout the study area and result from the alluvial, reef, and deep-lead mining activity of the past. Most areas have revegetated considerably and provide a distinct but interesting environment, with considerable recreation potential.

The relatively undisturbed vegetation occurs mostly on the more-inaccessible rugged topography. These areas often provide wildflower displays in spring, and many include rock outcrops such as granitic tors, which often provide panoramic views.

All these zones of natural vegetation are popular for pleasure driving, picnicking, hiking, fossicking, and nature study.

Inland waters

Much of the active recreation in the study area is water-based. The rivers and natural lakes have always been popular attractions for fishing, swimming,

and picnicking, but the construction of water storages has added considerably to the appeal of the area for recreation.

The activities allowed depend on the use for which the water is intended, and to some degree on physical parameters such as the size of the water body. Access to urban supply reservoirs is normally restricted, to protect water quality. Irrigation supplies have fewer restrictions, and many of these storages are very populuar.

A number of mineral springs occur in the study area (see chapter 11, Water Resources), and these are increasing in popularity.

Softwood zone

Although covering only a small porportion of the area, the mature softwood plantations are popular for picnicking. The Harcourt plantations contain a number of exotic species, and present a visually diverse landscape for walking and pleasure driving.

Other recreational opportunities

Road reserves frequently provide a valuable landscape element for the motorist in areas predo-inantly cleared for agriculture. These narrow strips of public land often contain remnants of the original vegetation and provide opportunities for nature study and local refuges for wildlife.

Also, several features on public land that are presently unused, like the dismantled railway between Heathcote and Bendigo, have considerable recreation potential.

Recreational Activities

The main recreational activities on public land in the study area are listed and discussed below.

- bushwalking and hiking
- camping and caravanning
- canoeing
- car rallying
- fishing
- fossicking
- hunting
- swimming
- nature study
- off-road vehicle driving
- orienteering
- picnicking
- pleasure driving
- power-boating
- salling
- water-skiing
- formal recreational activities (golf, tennis, horse-riding etc.)

Bushwalking and hiking

Walking for pleasure here is mainly restricted to short hikes and walks to sites of interest or for nature study. Few are particularly strenuous, as the vegetation is generally open, and there are often tracks and disturbed areas.

At Melville Caves, approximately 13 km of walking tracks serve various parts of the reserve, and these provide pleasant views in a photogenic area. Although the study area has no true rock climbs, many of the granitic areas provide interesting scrambling for the adventurer.

A number of other day and half-day walks have been described in bushwalking magazines over the years. Those to features such as river cascades or historic sites frequently necessitate permission to cross private land.

Camping and caravanning

Some 30 developed caravan and camping grounds occur within the study area, especially at the more popular tourist centres. Most of these are equipped with modern facilities and are particularly busy during holiday periods.

Also, 44 public land leases for campsites at Lake Eppalock are held by a number of schools, church groups, and social clubs (see also chapter 18).

Camping at undeveloped sites in conjunction with fishing, hunting, and motoring trips has increased in popularity over recent years.

Canoeing

Although several suitable stretches of river may be found in the study area, they are not particularly popular with keen canoeists because of the lack of rapids. The Goulburn, upstream from Nagambie, is the only one mentioned in the "Canoeing Guide to Victorian Rivers", which says of it: "the water flow can be quite fast, and this conbined with the trees and logs in the river can make it dangerous...although it is technically an easy river...".

Opportunities for flat-water canoeing exist on most of the reservoirs and lakes in the area.

Car rallies and hill climbs

Forest tracks and other secondary roads here are often used for competitive car trials and rallies. These trials are normally held overnight, are strictly supervised by a co-ordinating body, and present little danger to the public as they avoid roads with regular traffic use. Social club car rallies occur on weekends in parts of the study area, and often terminate at picnic sites.

Mount Tarrengower near Maldon is a popular venue for motoring hill climb events.

Fishing

Fishing is widespread throughout the study area in lakes, reservoirs, and streams. The main species caught are redfin (or European perch) and trout, although Murray cod and European carp are also fished. Table 19 lists the

Table 19

FISHING SITES

Location	Main fish species				Intensity of use	Site grading
Cairn Curran Reservoir	RF	T			Moderate	Good
Goulburn Weir	RF	T	MC		Moderate	Good
Greens Lake	RF			EC	Low	Poor
Barkers Creek Reservoir	RF	T		EC	High +	Good
Laanecoorie Reservoir	RF	T		EC	Low	Poor
Lake Batyo Catyo	RF			EC	Low	Fair
Lake Cooper	RF				Low	Poor
Lake Eppalock	RF	T			High	Good
Nagambie Lake	RF	T	MC		Moderate	Good
Teddington Reservoir	RF	T			High	Good
Tullaroop Reservoir	RF	T			Low +	Good
Waranga Reservoir	RF	T	MC		Moderate	Good
Avoca River	RF	T		EC	Moderate	Good
Campaspe River	RF	T		EC	Moderate	Fair
Coliban River	RF	T			Moderate	Fair
Goulburn River	RF	T	MC		Moderate	Good
Loddon River	RF	T		EC	Moderate	Fair
Wimmera River	RF	T			Moderate	Good

Note: Only major streams listed - numerous tributaries are also fished.

RF = Redfin
T = Trout
MC = Murray Cod
EC = European Carp

\+ = Boating and wading prohibited

main fishing spots and their intensity of use.

Fossicking

Week-end prospectors fossick for alluvial gold at many of the old gold-field areas.

Gemstone fossicking is popular in the area north of Heathcote to Mount Camel. Gem minerals in this area include variously coloured jaspers, black cherts, Selwynite, coloured quartz, sapphires, and common corundum. A gem hunt is held annually at Heathcote each November.

Other gem minerals reported in the area include topaz (Castlemaine, Dunolly, and Maldon), agates (Moolort, Avoca, and west of Heathcote), tourmaline, and zircon.

Hunting

Hunting for duck and quail in the study area is very popular with local and Melbourne-based hunters. Table 20 lists the areas used for hunting duck, mainly black duck, grey teal, wood duck, and mountain duck. Less common species hunted include chestnut teal, hard-head, pink-eared duck, and blue-winged shoveler.

The whole of the study area is important for quail-hunting, although the only species that it is permissible to hunt is the stubble quail.

Nature study

The vegetation here is quite diverse and many naturalists' clubs and conservation societies use the area for nature study and field excursions. Probably the best-known area is the Bendigo Whipstick, which is frequently visited for its multitude of ground flora and variety of birds.

The Environmental Studies Association of Victoria also conducts field excursions in various parts of the study area. Bird and plant lists for such studies are available from field naturalists' clubs and the Forests Commission for a number of areas (see Table 18).

Off-road vehicles

The use four-wheel-drive vehicles and that of trail- and mini-bikes are established recreational pursuits here. Most users revel in challenging their driving skills over difficult terrain. Indiscriminate use of such vehicles can cause serious damage to the environment, and they are now coming into increasing conflict with other land uses, and other forms of recreation. Demand is growing, however, for areas suitable for their use, catering especially for trail-bikes near urban centres.

Orienteering

This sport is rapidly increasing in popularity and already several local

Table 20

DUCK-HUNTING AREAS

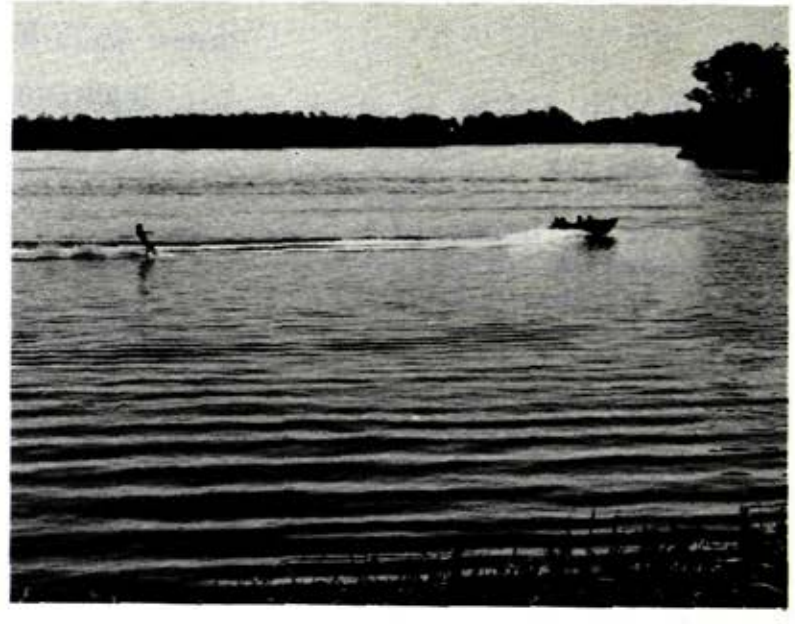
Area/locality	Habitat quality	Intensity of use*
Cairn Curran Reservoir	Fair	Moderate
Clunes Swamps	Fair	Moderate
Doctor Swamp	Excellent	High
Gaynors Swamp	Excellent +	High
Goulburn Weir	Good	Moderate
Horseshoe Lake	Excellent	High
Lake Batyo Catyo	Excellent	Moderate
Lake Cooper	Excellent	High
Lake Eppalock	Fair	Moderate#
Lake Grassy	Fair	Moderate
Lake Kimbolton	Fair	Moderate
Little Wallenjoe Swamp	Excellent	High
Laanecoorie Reservoir	Fair	Moderate
Mansfield Swamp	Excellent +	High
Nagambie Lake	Good	Moderate
One Tree Swamp	Excellent	High
Reedy Lake	Excellent	High
Salt Lake	Excellent	High
The Fresh Lake	Excellent	High
Thunder Swamp	Excellent	High
Tang Tang Swamp	Excellent	High
Tullaroop Reservoir	Fair	Moderate
Two Tree Swamp	Excellent +	High
Wallenjoe Swamp	Excellent	High
Waranga Reservoir	Fair	Moderate

* Intensity of use depends very much on the quality and supply of water during the hunting season

\# Shooting is prohibited in parts of Lake Eppalock

\+ State Game Reserves (Fisheries & Wildlife Division)

A picnic area in an attractive forest setting



Water-skiing on Goulburn Weir, a popular activity on many of the water storages

areas are extensively used by local and Melbourne orienteers. The area around Lake Eppalock is the most popular site, although One Tree Hill, Bendigo Whipstick, and the area east of Mount Ida are also used. The association that controls orienteering is continually looking for new courses in a variety of areas. The most suitable land is flat to undulating terrain, with forest cover and minimal undergrowth.

Picnicking

Picnic facilities are provided throughout the study area, as shown on the recreation map. The sites usually coincide with areas of recreational interest such as Melville Caves or Mount Alexander. Facilities in forest reserves are listed in Table 18. Many spots not serviced with any facilities are also popular.

A picnic or barbecue is often the main aim of a day-trip and therefore these are frequently associated with pleasure driving.

Pleasure driving

Driving for pleasure is becoming increasingly popular throughout the study

Table 21

WATER-BASED ACTIVITIES AND RECREATIONAL FACILITIES ON LAKES AND RESERVOIRS

Lake or reservoir	Recreation management	Facilities			Boating						Other Activities			Other
		Picnic area	Toilets	Camping/ caravan sites	Power boats	Non-power boats	Boat club	Launching ramp	Marine or mooring	Boat fuel	Fishing	Swimming	Hunting	
Barkers Creek Reservoir	SR & WSC		x								Bank only			
Cairn Curran	SR & WSC, *Shires of* Newstead, Maldon, and Tullaroop	3	x	2	x	x	x	x			x	x	x	Water-skiing
Goulburn Weir	SR & WSC, Shire of Goulburn	3	x	3	x	x		x	Floating jetties		x	x	x	Water-skiing
Greens Lake	SR & WSC Management Committee	1	x		x	x	x	x			x	x	x	
Laanecoorie Reservoir	SR & WSC	2	x	1	x	x		x			x	x	x	
Lake Batyo Catyo	Shire of Kara Kara	1	x	1	x	x		x	Jetty		x	x	x	Speed-boat carnivals
Lake Eppalock	SR & WSC Management Committee	6	x	4	x	x	x	x		x	x	x	Part only	Regattas and boating events, water-skiing
Tullaroop Reservoir	SR & WSC	1	x								Bank only			
Waranga Reservoir	Shire of Waranga	2	x	1	x	x	x	x			x	x	x	Water-skiing

area. "Day trippers" are attracted to good roads with such features as scenic views, historic interest, wildflowers, mineral springs, etc., and many travel from Melbourne or further afield.

Traffic surveys in recent years have shown a marked rise in the number of recreational drivers, and this will probably continue as car ownership increases in the community and as tourist roads and facilities are improved.

Water-based activities

Power-boating, sailing, swimming, and water-skiing are among the most popular forms of outdoor recreation in the study area, attracting large crowds to many of the lakes and reservoirs. The following

car-count figures for Lake Eppalock show the rapid increase in the use of reservoirs that has occurred in recent years:

1972 - 7,956 cars	1974 - 22,261 cars
1973 - 23,078 cars	1975 - 31,307 cars

Table 21 indicates which activities are permitted on each of the lakes, along with the facilities (such as launching ramps) that are available. There are boating clubs at Lake Eppalock, Cairn Curran, Green Lake, and Waranga Basin.

These water-based activities vary considerably in their requirements but they all need access to the shoreline, maintenance of water-quality standards, and usually the provision of parking areas and amenities.

Pattern of Recreation Demand

Present use and demand

The present pattern of recreational demand is related to the local population distribution. The accessibility of the area from Melbourne, however, which is only 150 km from Bendigo, and from other urban centres means that many of the users come from outside the study area.

A network of major highways, railway links, secondary roads, and tracks means that most of the study area, and practically all the public land, is available for tourists and recreationists.

A survey by the Australian Travel Research Conference in 1973--74 examined the number of visits to each of the Ministy of Tourism's 13 regions in Victoria. Although the boundaries of their "North Central Region" differ slightly from those used in this report, it was the third-most popular region after Melbourne and Gippsland during 1973--74, attracting some 600,000 visitors - more than 8% of all the travellers in the State. The places of origin of these visitors were:

Victoria (metropolitan area)	60%
Victoria (non-metropolitan)	35%
Interstate	5%

Estimates by the Forests Commission of the number of visitors during 1975--76 at several forest reserves are:

Bendigo Whipstick Forest Park	80,000
Wychitella Forest Park	3,000
Melville Caves Scenic Reserve	5,000
Dargile Special-purpose Reserve	2,000
Mt. Alexander Koala Park	5,000
Pink Cliffs Special-purpose Reserve	2,000

A case study of the current level

Lake Eppalock is one of the most popular water storages in Victoria, but its intensive use has already taxed its recreation capability, and posed a potential health risk for its primary use as a water supply. This is currently being examined by an inter-departmental comm-

ittee; its conclusions are not yet publicly available.

Existing developments at Eppalock include four caravan parks, 45 club sites, day-visitor areas, a hotel/motel with a convention centre, boat storage, and servicing facilities, and a co-operative housing estate. This effectively means that a population of 6,200 persons can reside around the lake at one time.

It is also estimated that there are 150,000 day visitors per annum, reaching a peak on the Australia Day week-end, when approximately 25,000 people attend the annual speedboat races.

Expected future demand

A number of factors are expected to markedly increase recreation pressures on public land in the study area. The latest projections from the Bureau of Census and Statistics indicate substantial increases in Melbourne's population, and also increases in regional centres such as Bendigo and Ballarat. Populations in some rural areas such as the south-eastern shires in north-central Victoria are also expected to grow as land is developed for hobby farms and rural retreats.

Other factors affecting the demand for recreation include increases in leisure time, mobility, environmental "awareness, and "disposable" incomes, combined with improved access and facilities. Planning for outdoor recreation must cater for these factors, but must also be flexible in order to cope with possible changes in the nature of the demand.

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16. AGRICULTURE

About 87% of the land in the study area is privately owned and, except for that in the cities and towns, supports agriculture. In addition, grazing licences or leases cover about 20% of the public land and almost all the public land is used intermittently for honey production.

Land use is strongly influenced by topography, climate, soils, availability of irrigation water, and land tenure.

Very broadly, the undulating to steep country is used for mixed grazing of sheep and cattle, while the plains and gently undulating areas carry mixed farming - crop production associated with grazing. A small proportion of the pasture land is irrigated and used for dairying, and for lamb and beef production. Irrigation also supports fruit- and tomato-growing, and a little crop production. Map A shows the distribution of the different agricultural activities, and Table 22 lists the areas involved and stock numbers.

Farm size is extremely variable; an indication of the most common (modal) sizes for various types of farm is given on this page.

Farm type	Modal farm size (ha)
Mixed cropping--grazing	700
Dryland grazing	500
Irrigation grazing	250
Irrigation dairying	40
Horticulture	8

Livestock Production

Sheep

Sheep predominate the grazing in the study area, which carries about 13% of the State's sheep population.

The three types of sheep enterprise are concentrated in fairly distinct parts of the area. Prime-lamb production - using crossbred ewes mated to British-breed (usually Dorset Horn) rams - is prominent in the north-east (in the Shires of Waranga, Huntly, East Loddon, and Marong). This involves both dryland and irrigation farms here. Farmers in the north (Shire of Korong) run sheep for both wool and prime-lamb production, while in the remainder of the study area wool production predominates. Some wool-producing properties run flocks consisting wholly of Merino wethers.

Table 22

AGRICULTURAL LAND USE AS AT MARCH 31, 1975

Item*	Northern shires**	Southern shires+	Study area total	% State
No. of holdings	2,994	2,258	5,252	8.4
Total area occupied	1,037,019	476,490	1,513,509	10.5
Area under crop	166,089 (16%)	21,322 (4%)	187,411 (12%)	10.5
Area under fallow (approx.)	60,519 (6%)	3,200 (1%)	63,719 (4%)	-
Area of sown pasture including lucerne	506,960 (49%)	246,011 (52%)	752,971 (50%)	11.7
Area of native pastures	184,881 (18%)	128,129 (27%)	313,010 (21%)	11.9
Balance	118,570 (11%)	77,828 (16%)	196,398 (13%)	-
Under irrigation				
Irrigated horticulture	296	471	767	1.5
Irrigated pastures	35,230	5,455	40,685	7.9
Livestock numbers				
Sheep	2,087,735	1,308,000	3,395,735	12.9
Beef cattle	139,221	106,388	245,609	5.9
Dairy cattle	40,094	8,694	48,788	2.5
Pigs	69,015	7,551	76,566	20.0

* Areas are given in hectares

** Northern shires - include Stawell, Kara Kara, Korong, Bet Bet, East Loddon, Marong, Huntly, and Waranga

\+ Southern shires - include Avoca, Tullaroop, Talbot/Clunes, Maldon, Newstead, Metcalfe, Strathfieldsaye, McIvor, and Goulburn

(%) Indicates percentage of total area occupied in the various zones

Sheep grazing near Moonambel

Sheep numbers reached a peak in 1970--71, subsequently declining due to the comparative profitability of beef cattle. As a result of the recent slump in cattle markets, however, this downward trend is likely to halt and sheep numbers stabilize or increase slightly.

Beef cattle

Beef cattle are run throughout the study area, but are less important in the north-west than elsewhere. Herefords are the most common breed - although others are represented - and vealer production is the most important activity. Fattening (the finishing of "carry-over weaner animals or purchased store cattle) is also common. Few properties, however, are run exclusively for fattening and most herds contain some breeding stock.

Virtually no properties produce only beef; in this area beef cattle are generally run in conjunction with sheep.

The buoyant state of the beef market in relation to the sheep and wool markets led to a dramatic increase in beef cattle numbers from about 142,000 in 1970--71 to about 245,000 in 1974--75. A trend towards the heavier breeds developed during this period, but the uncertainty of the overseas markets ended both this trend and the increase in numbers. Recent poor markets and a run of dry years have caused a marked drop in cattle numbers in the study area.

Dairying

North-central Victoria is a relatively unimportant area for dairying. The 370 licensed dairy-farms here carry only 2.2% of the State's dairy cow population, and 20% of the total milk production is used for town milk supply.

Most dairy farms within the study area are concentrated on the permanent irrigation areas of the Waranga and East Loddon Shires, and have relatively large herd sizes (90--100 cows). Farms in the former supply milk for manufac-

turing purposes, while those in the East Loddon Shire mainly supply town milk.

Other dairy farms are scattered throughout, both under irrigation and, in the south, in dryland areas. These farms, smaller than those in the main irrigation areas, supply mainly town milk or cream. With the decision to phase out milk contracts, a large number of them will cease dairying.

Pigs

The study area contains about 20% of the State's pig population, and its importance as a pig-raising region is likely to increase.

Pig farms occur throughout, although the greatest concentration is within Waranga Shire. The number of separate pig farms is tending to decrease, while numbers per farm are increasing. Housing and confinement of pigs is also increasing.

Pig production is a continual, year-round process, with only minor seasonal variations. About half the pigs in the area are fed on commercially prepared feed, while for the remainder food is mixed on the farm.

Poultry

This is one of the main parts of Victoria producing eggs for domestic consumption. Although the proportion of birds in the area has decreased from 34 to 25% of the State total during the past 8 years, this reflects an increase in numbers elsewhere rather than a decrease here. Weekly production is approximately 200,000 dozen eggs. The prominence of egg production in this area is likely to continue, although table meat (broiler) production may increase proportionately following the establishment of processing plants at Lockwood and Raywood.

Beef cattle

Barley crop near Corop

As with the dairying and pig production, the number of small part-time producers is decreasing, but fowl numbers on the larger farms are increasing. There is also a trend away from deep-litter sheds towards the technique of housing of birds in cages. Some of these latter sheds have controlled environments.

Crop Production

Cropping is an important form of land use here, particularly in the drier areas in the north. Except for the basalt plains of Moolort, the southern districts are generally not well suited to cash cropping because the land is too rocky or too steep, or the climate is too wet or unreliable.

Wheat is the main crop, but barley and oats grown for grain, fodder, and hay are also important. During the past 10 years the area has produced about 12% of the State's wheat, 10% of the barley, and 15% of the oats.

Crop rotations vary. The flatter and/or better soils - particularly in the north - can frequently support two wheat crops in successive years.

The first crop is grown on land that was fallowed (cultivated) the previous spring and periodically worked until sown, and the second "on stubble" - that is, on land that carried wheat the previous year and has been worked only 2--3 times in autumn just before sowing.

Soils that are more subject to erosion or are generally poorer usually carry only one crop of wheat. In these situations - for example on the Ordovician or granite soils in the western part of the study area - "minimum" cultivation techniques may also be required.

Occasionally, anywhere in the cropping zone, wheat may be sown as a "ley" crop - that is, into pasture land that has been cultivated and prepared quickly following the autumn rains.

In the more-intensive cropping districts, oats and barley are generally grown as "stubble" crops, whereas in the grazing districts of the south the farmer sows oats, for fodder or hay, as a "ley" crop.

As the "last" one in the rotation, the oat crop is normally undersown with subterranean clover and in some cases perennial grasses. The length of the pasture phase in the grain cropping districts varies from 2 to 8 years; the better the ground, the shorter is the pasture phase. A typical rotation comprises fallow, wheat (or barley), oats, followed by 2--3 years of pasture for the better soils. In the less-favourable situations, the rotation may be fallow, wheat, oats, followed by 5--7 years of pasture.

In some areas, particularly in the Loddon valley, wheat is now being grown under irrigation.

Harvesting wheat on the basalt plain near Moolort

Oil-seeds

Oil-seed crops gained some popularity during the operation of wheat quotas, and again in the 3 wet years of 1973--75. Under dryland conditions, however, soils are generally unsuitable for these late-maturing crops, which consequently occupy an insignificant area compared with that under cereals.

Horticulture

Fruit

The main fruit-growing district is at Harcourt, near Castlemaine. Although

Orchard at Harcourt

A vineyard near Avoca

small by comparison with other Victorian orchard districts, covering only some 570 ha, it produces some 2--3% of the State's crop of apples and pears, its main products.

Historically the apply industry developed at Harcourt because the unique combination of climate, soils, and irrigation produced an apple of exceptional flavour - keenly sought by the overseas and inter-State trade. Jonathan was the most popular variety.

In more recent years, following a shift from the export trade, the main outlets for orchard produce have become the local and Melbourne markets. As a result, there has been a change from export varieties to those more suited to the home market.

The area under orchards has decreased during the past 10 years, but this trend appears to have slowed and it now seems unlikely to alter greatly in the short-term future.

Vegetables

There is very little vegetable production in the study area except for some market gardens around Bendigo and Harcourt and some tomato-growing in the Waranga. Marong, and Strathfieldsaye Shires. Production is insignificant compared with other parts of the State.

Grapes

Vineyards here are used solely for wine production. The industry is also small by comparison with other regions, with the largest plantings in the Avoca and Goulburn Shires. Recently, the area being planted to vines has increased, involving both established vineyards and newcomers to the industry.

Potential of Private Land

Agricultural potential in the study area will depend as much on the marketing prospects as much on the marketing prospects for the various crops and livestock products as on the physical potential of the land to produce them.

Uncleared land

Agriculture potential from uncleared land on existing holdings is limited. In 1974--75, only 13% of the occupied area was not under crop, fallow, or pasture. Much of this land is retained for shelter, or is unsuited or uneconomic to develop.

Grazing

The greatest agricultural potential exists in the cleared freehold land. In 1974--75 only half the pasture area was sown to improved species, but, in the short term at least, it may be uneconomic to develop and maintain a greater area of improved pastures.

Nevertheless, recent experimental work has shown that productivity of pastures can be increased. The use of inoculated seed, superphosphate, lime, and molybdenum has increased the chance of success in establishing improved pastures - particularly in the southern grazing districts.

Furthermore, two new varieties of subterranean clover - Larisa and Trikkala - are now available. These varieties, which can withstand water-logging and also have a better resistance to fungal disease, can be combined with existing clovers for general use or used alone in special circumstances.

More information on types and rates of fertilizer to maintain pasture may increase productivity further in future.

Dairying

Block grazing, faster milking systems, and automatic irrigation devices are all innovations that will enable dairyfarmers to increase their output and reduce costs.

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Cereals

In general, cereal-farmers are using sound practices. Most of the study area is in a low-protein region and "hard" wheats should not be grown. Consequently, for many years, Olympic has been the only wheat variety recommended. Recently a number of other varieties - Egret, Kalkee, Kewell, and Zenith - have been released.

These, together with Olympic, offer growers a more diverse range. Cereal yields could be improved by the application of higher rates of phosphate - but the marginal return to additional inputs often does not warrant the growers using optimum rates determined under research conditions.

Conflict

During the past few years, people with little or no farming experience have bought considerable areas of land here. In many cases, this has happened in response to the city-dwellers' need for a recreation outlet, while in others it has been purely for investment.

Generally the demand is for small holdings, and consequently large areas of rural land have been subdivided into a number of small allotments. In some cases, however, the demand is for relatively large areas or complete farms so that large-scale farming ventures can be continued.

The high demand for land in many districts has generally resulted in the inflation of prices beyond the ability of the land to give a fair return on invested capital - in other words, its price exceeds its productive value. As a result, many genuine farmers or prospective farmers are unable to purchase extra land or sufficient land to make economically viable farms. On the other hand, the high demand for land for subdivision has provided an opportunity for some farmers to sell some land for capital gain.

Owners of small or medium-size holdings are commonly referred to as "hobby farmers". This is a poor term - particularly as different people have different motives, needs, attitudes, and hence behaviour. Absentee-ownership, poor attitude, and ignorance can create problems - with important implications relating to stock management, diseases of stock, control of verming and noxious weeds, erosion, and fire hazard. Most of the newcomers are, however, genuinely interested in developing the land. Those with sufficient finance have been able to highly develop their properties.

Agricultural Use of Public Land

Forest grazing

Approxijately 27% of the public land supports grazing, mainly by sheep, under licence or agistment. Although the forested blocks have a low carrying capac-

ity, they have always been sought by local graziers. They supply an important supplementary growing reserve as well as shelter after shearing and at lambing, and provide a source of roughage for a balanced stock diet. Grazing is an aid to fire protection by reducing the build up of fine fuels on the forest floor.

Annual licences allow grazing control, although agistment has been favoured in certain areas as it allows flexibility in areas grazed and stocking rates. Licensed areas must be fenced by the grazier, and stock rates can be restricted or stock completely excluded if environmental values are threatened.

Development potential of public land

Public land is generally of poor agricultural quality. The early settlers occupied the better tracts of land, with the result that the public land remaining is confined mainly to areas of steep relief or to hills of low relief derived from sedimentary material.

The quality of the soils in these areas varies, with those in the gullies being better than those on the ridges. By comparison with soils on private land, however, they have poor potential for development. Like most Australian soils, these are deficient in major elements such as phosphorus, sulphur, and nitrogen and, in many cases, in the trace element molybdenum.

While such deficiencies can be rectified with fertilizer, these soils are also low in organic matter and generally have only shallow topsoils - a situation that has often been aggravated by past mining activity and subsequent erosion.

Agricultural development of forested land, either private or public, is a costly and lengthy operation. Increased costs - particularly those of fertilizer, fuel, and labour - make clearing and pasture improvement expensive. Most of the area has a low and unreliable rainfall and, in some mallee scrub areas, scrub regrowth is a major problem. Consequently development is a slow process and - because of the long delay before cash return, and its low rate - is not an attractive investment.

Considering the current state of agricultural markets, in particular sheep and beef markets and factors listed above, it is unlikely that the investment in the development of forest land will be as profitable as other forms of investment.

Reference

"Rural Industries 1970--71 to 1974--75." (Commonwealth Bureau of Statistics: Melbourne 1976.)

17. APICULTURE

The forested public land of the study area is one of the main sources of honey in the State. The forest types - especially the eucalypt species of red ironbark, grey box, and yellow gum - are renowned for producing quality honey, often in large quantities during good flowering years. It is an important use of public land and provides few conflicts with other land uses.

Although forested public land is of greatest importance, beekeepers also use agricultural land from time to time when suitable species, including weeds such as cape weed, are in flower.

Products

Beekeepers harvest honey, beeswax, and pollen. Honey, apart from table use, is important in confectionery manufacture, as a stock food, in the preparation of meat products, vinegar, and some types of tobacco, and in some pharmaceutical and cosmetic products. Beeswax has many uses, including cosmetic and polish manufacture. Pollen has a market as high-protein health food. Some beekeepers derive a significant proportion of their income from the sale of young queen bees. Beekeeping is also of economic importance to other primary industries: domestic bees are important in the pollination of many fruit, vegetable, and seed crops.

About half the honey crop is exported, making Australia the third-largest exporter of honey. The main markets are the United Kingdom and West Germany, while Africa, Asia, and the Middle East are also important.

One of Australia's largest honey-processing and packing plants, located at Maryborough, packed about one-third of the honey exported from Australia in the year to June 1975.

Beekeeping in the study area

Victoria has approximately 1,850 registered beekeepers, the majority of whom operate part-time. Only 240 live in the study area, but most are fully employed in the industry.

Beekeepers usually move their hives from district to district in search of good nectar flows, so it is difficult to estimate the actual number dependent on the forests of the study area for a living. Local beekeepers could be expected

to have their hives outside the area for part of the year, while apiarists from East Gippsland, New South Wales, or South Australia may locate their hives within it for one or two months each year. Local part-time beekeepers with only a few hives keep them in the study area throughout the year.

Winter is a dangerous period for hives unless proper husbandry techniques are practised. Hive activity slows down with the cooler weather, and harvesting of the few eucalypt species that do flower is hazardous. High water contents of the nectar can cause hive fermentation and a consequent loss of bees with alimentary upsets. Carrying of hives through winter, called overwintering, can be achieved either by ensuring that adequate food reserves of honey and pollen are retained within the hives beforehand or by moving the hives to warmer areas with winter-flowering species, for example the banksias of the Little Desert.

Hives can be returned to the forests of the study area in early spring to work such species as the reliable yellow gum and the pollen-rich understorey species. Pollen is essential at this time for maintaining balanced hive populations, rearing queen bees, and building up the hives for the coming harvest season.

To use public land, beekeepers need ready access and a permanent supply of water. Public land here is well provided with tracks, and the system of fire-protection dams ensures the availability of water.

Beekeepers are issued with licences to work their bees on public land. Licence conditions stipulate area of operations and the occupancy period, rental being calculated for the apiary site (farm) and for the forage area (range). Licences are short-term and renewable, to facilitate management control.

Beehives on public land in the Pyrenees

Table 23

HONEY AND BEESWAX PRODUCTION FROM SEVEN BEE-FARM SITES ON PUBLIC LAND

Area covered by site (ha)	Location	Period under consideration (years)	Actual no. of seasons site worked	Species*	Min & max no. of hives when worked	Total honey production (kg)	Total beeswax production (kg)	Average annual honey production (kg)	Average annual beeswax production (kg)
500	Wellsford	20	4	RIB	200--400	191,000	2,384	9,534	119
700	Wellsford	18	9	RIB	200--1,200	283,000	3,178	15,713	177
500	Whipstick	18	5	YG, RIB	100--300	116,000	1,700	6,457	94
470	Neilborough	20	9	RIB	400--1,200	389,000	4,857	19,431	243
470	Neilborough	20	9	YG, RIB	Not avail.	438,000	613	21,883	31
730	Nerring	12	6	RIB	100--1,740	278,000	3,178	23,177	265
160	Eaglehawk	13	3	RIB	100--500	54,000	817	4,191	63
							Mean	14,341	142

* RIB = red ironbark YG = yellow gum

Public land within this area contains about 550 bee-farm sites, but is also worked from unlicensed sites on adjacent private property. Records of apiarists indicate that, in most years in the Bendigo area, the amount of honey produced from State forest by unlicensed beekeepers far exceeds that produced by the legal licensees.

Table 23 lists yields of honey and beeswax over a period of years for bee-farm sites in the Bendigo area for which statistics were recorded. Most sites would carry more than 200 hives during seasons of good nectar flow.

During 1974--75, beekeepers received around 77 cents per kg for honey, although price depended on type, quality, and market conditions. Beeswax brought around 176 cents per kg, and young queen bees about $4.50 each during this same period. Based on these figures, honey and beeswax produced annually in the study area had a gross value to beekeepers of approximately $4.3 million.

Important plant species

More than 90% of the honey harvested in Australia is produced from eucalypts. All of those growing in the study area

Table 24

EUCALYPT FLOWERING PERIOD AND HONEY AND POLLEN YIELD

Eucalyptus species	Common name	Usual flowering period	Honey yield	Pollen
E. albens	White box	Mid summer--mid winter	Light colour, medium density, mild flavour; candies readily	Yielded, but unreliably
E. aromaphloia	Scent-bark	February--April	Amber colour, not very dense; granulates to a certain degree	Yielded quite freely
E. baxteri	Brown stringybark	October--May	Dark but fairly clear, good density, pleasant flavour; inclined to candy	Useful yield
E. behriana	Bull mallee	September--January	Unreliable yield of poor-quality, dark, and strongly flavoured honey	Yielded in abundance
E. blakelyi	Hill gum	Summer	A good producer of fairly dark and strong-flavoured honey	No information
E. camaldulensis	River red gum	Late spring--mid summer	Straw colour, not as dense as yellow box, less aromatic, milder but very good flavour; candies quickly and sets hard	Produced in great quantities, very valuable in pollen-deficient areas
E. cladocalyx	Sugar gum	January--February	Pale straw colour, medium density, excellent flavour and aroma; very unreliable yield	Only sometimes collected
E. cypellocarpa	Mountain grey gum	Autumn	Medium colour, flavour, and density	Yielded abundantly
E. dives	Broad-leaf peppermint	September--October	Low yield of pale honey that candies quickly	Adequate yield
E. froggattii	Kamarooka mallee	January--April	Light amber-coloured honey	Adequate yield
E. goniocalyx	Long-leaf box	March--July	Medium to dark in colour, of flair flavour; candies with a coarse grain	Prolific yielder
E. leucoxylon	Yellow gum	April--December	Fine quality, clear pale straw colour, medium density, mild flavour; candies quickly but with fine grain	A pollen-deficient tree
E. macrorhyncha	Red stringybark	February	Clear but highly coloured, fair density, good flavour; remains liquid for some time	Yielded in medium quantities
E. melliodora	Yellow box	November--February (every second year)	Pale straw colour, very dense, aromatic, pronounced flavour; remains liquid	Not collected from yellow box
E. microcarpa	Grey box	February--April	Amber colour, medium density, excellent flavour; candies quickly	Gathered in large amounts (often only source at end of season)
E. obliqua	Messmate stringybark	December--March	One of the darkest-coloured honies, medium flavour and density	Yielded copiously
E. polyanthemos	Red box	September--November (every second year)	Very pale, dull in appearance, very dense (difficult to extract), tallowy flavour; does not candy	Not yielded in any worth-while amounts
E. polybractea	Blue mallee	March--June	A good-quality honey that candies white and hard	Yielded in good amounts
E. radiata	Narrow-leaf peppermint	September--March	Medium amber, candies quickly and becomes very hard; poor yield	Yielded only at higher altitudes
E. rubida	Candlebark	January--February	Clear amber, medium density; candies quickly	Good yield
E. sideroxylon	Red ironbark	May--August for normal (winter) type, but a less common summer-flowering type occurs	High quality, pale colour, good density, mild flavour; candies with a fine grain	Pollen unavailable
E. st. johnii	Blue gum	September--January	Medium amber colour, fair density, good flavour	Good yields
E. viminalis	Manna gum	December--April	Amber, medium density, distinct sweetness; candies quickly	Yielded in medium to abundant quantities
E. viridis	Green mallee	November--January	Good colour and flavour	Poor yield

yield nectar, most giving moderate amounts of good-quality honey. All eucalypts yield pollen except red ironbark, yellow gum, and yellow box. Table 24 lists information on honey and pollen yield and seasons of flowering.

The ironbark and box forests of the bulk of this area are most important. The messmate--peppermint gum foothill forests of central Victoria, as typified by the Pyrenees are of lesser importance, but do increase the variety of plant species available and extend the period when suitable species are flowering.

Most eucalypt species in the study area flower during the summer of every second year. Grey box in the Heathcote area flowers heavily about once every 8 or 9 years. Some mallees flower about every fourth year, but heavy flowerings may occur less frequently. The mallee eucalypts are valuable, as they flower in the early spring when few other plants are in flower.

One unusual feature of the red ironbark around Bendigo is the occurrence of a summer-flowering form, as well as the usual winter-flowering one. The summer-flowering form is quite limited in extent, occurring in the Whipstick Forest, Wellsford, Tarnagulla, and Whroo areas. It is highly prized by local beekeeprs for its excellent-quality honey. Honey from the winter-flowering red ironbark is not so valued, as its high moisture content causes the bees to develop alimentary upsets. The bees cannot be allowed to work areas of pure ironbark for long periods, as lack of pollen causes their health to deteriorate.

Felling of mature trees for timber and silvicultural operations, including thinning and regeneration treatment, which temporarily reduce flowering, are necessary for the long-term survival of the red ironbark stands. Within 2 years of thinning, crown development is enhanced and flowering is more profuse. Maximizing present flowering of the summer form of red ironbark by restricting forest utilization can be done only at the expense of flowering in years to come.

A variety of honeys is produced from the study area, due to the nature of the forest, its species mixtures, and the tendency for many species to be in flower at once, especially during the summer. Much of the table honey is blended by the distributors, so the mixing of honey types by the bees causes no problems in marketing. Honey produced from yellow box has the best reputation for quality and flavour, with summer-flowering red ironbark, yellow gum, and red gum also being highly regarded. The area contains relatively few patches of yellow box, mainly in the Pyrenees and the St. Arnaud Range.

18. EUCALYPTUS-OIL PRODUCTION

The leaves and green branchlets of eucalypts contain a number of volatile aromatic oils. The proportions of the different constituents, and also the amount of oil contained in the leaves, vary greatly between eucalypt species, and even between different plants of the same species.

The principal constituents of eucalyptus oil are cineole, piperitone, phellandrene, and citronellal. Cineole, the main constituent sought from Victorian eucalyptus oil, is used mainly for medicinal or pharmaceutical purposes. Piperitone, which has a peppermint odour, is used for producing synthetic menthol and thymol. It makes up 40--50% of the oil in some varieties of broad-leaf peppermint. Phellandrene, used as a general solvent for perfumery and (in the past) for mineral flotation in mixture with piperitone, makes up 60--80% of the oil of one variety of broad-leaf peppermint. Citronellal, used in perfumery, forms 65--80% of the oil from lemon-scented gum.

Oil content ranges from about 0.5% of leaf weight (for example, bull mallee has 0.6%) to about 4% (for example, one variety of broad-leaf peppermint has 3.0--4.0%).

Demand for eucalyptus oil

The estimated world market for all types of eucalyptus oil is 2,000 tonnes per annum.

Use of eucalyptus oil within Australia amounts to about 300 tonnes per annum , of which 25 tonnes is for pharmaceutical use, 105 tonnes for household disinfectants, and 170 tonnes for industrial purposes.

Supply of eucalyptus oil

Until about 1950 Australia was virtually the only source of eucalyptus oil, but now the bulk is produced overseas. Of world production today, Australia contributes only about 15% (approximately 300 tonnes per annum, of which 90--100 tonnes is pharmaceutical-grade oil), although world price fluctuations result in variation in local production.

Australia exports mainly pharmaceutical-grade oils, but competition from other exporting countries has constricted our

export market to south-east Asia. In recent years we have imported (mainly from Swaziland, but also from South Africa, Peoples Republic of China, Spain, and India) more eucalyptus oil than we exported, and about half the imports are cineole-rich.

Total Victorian production amounts to about 50 tonnes annually and 98% of it comes from the study area, which produces about 40% of Australia's pharmaceutical-grade oil.

The Eucalyptus Oil Industry in the North Central Area

Species used

Blue mallee is the preferred species because of its high cineole content and high yield, because it is suited to mechanical harvesting, and because it has an established traditional market. It grows in large pure stands near Inglewood, Wedderburn, and St. Arnaud. Green mallee, bull mallee, and red ironbark are also harvested where they are minor components of blue mallee. Annual production from blue mallee on public land (including the other species within blue mallee areas) is about 35 tonnes from 16 distillers.

Green mallee is less important, partly because of poorer yields and partly because it tends to grow on the stony rises, which are unsuitable for the current system of mechanical harvesting.

An area of blue mallee used for eucalyptus-oil production

Green mallee in the vicinity of Bendigo, however, produces about 5 tonnes of oil - about half the total oil production from this part of the study area.

Three operators use red ironbark, yellow gum, and long-leaf box for eucalyptus-oil production, although their use is declining. Current annual production is approximately 3.5 tonnes.

Table 25

PRODUCTION OF EUCALYPTUS OIL - CURRENT (1974--77)

Locality	Species used (predom.)+	No. of distillers (commercial)	Total employment (men/year)	Public land*			Private land	
				Gross area (ha)	Area harvested** (ha)	Production (tonnes p.a.)	Area harvested** (ha)	Production (tonnes p.a.)
St. Arnaud	BM	2	0.5	915	408	2.8	-	0.2
Wedderburn	BM	3	1	2,383	446	1.5	75+	3.5
Inglewood	BM	4	7	6,466	1,678	23.0	64	2.3
Bendigo	BM/GM	6	6	3,745	694	4.7	676	5.3
Rushworth	BM	1	0.5	9,000	240	1.9	30	0.1
Sub-total		16	15	22,509	3,466	33.9	845+	11.4
Maryborough	RIB, YG, LLB	3	3	1,200+	?	1.1	?	2.4
Total		19	18	23,700+		35	900+	13.8

\+ BM - blue mallee GM - green mallee
RIB - red ironbark YG - yellow gum
LLB - long-leaf box

* 70% under occupation licences issued by Lands Department
30% under licences issued by Forests Commission

** Area currently managed for oil production

Production areas

Eucalyptus oil is produced mainly from public land, which is occupied under licence.

Because only the most suitable mallee sites are harvested, each district contains a mosaic of harvested and unused mallee. Thus the area licensed for eucalyptus-oil production greatly exceeds the area actually harvested.

The Inglewood vicinity is the most important part of the study area for oil, producing 23 tonnes annually from blue mallee from 1,700 ha (net) of public land (6,500 ha under licence). A further 2.3 tonnes per annum is produced from private land in this district.

Areas of public land used for eucalyptus oil production are listed in Table 25 and are shown on the Primary Production map.

Harvesting methods

Different harvesting methods have greatly differing effects on the environment, with modern mechanical harvesting having more severe impact than earlier harvesting by hand.

Most of the mallee used for oil production is now harvested by forage harvester. A medium-weight agricultural tractor tows a tritter (a hammer-mill looking like a rotary hoe), which bashes the shoots off the stump, or strips the leaves from the more woody stems. The draught created throws the cut material up into a towed tipping trailer with high sides. Some operators using this method cut at ground level, leaving the site bare after harvesting. Others cut about 5 cm above the ground. Cutting at ground level usually bruises the top of the mallee root stock, but it has been claimed that blue mallee regrowth is better following such treatment.

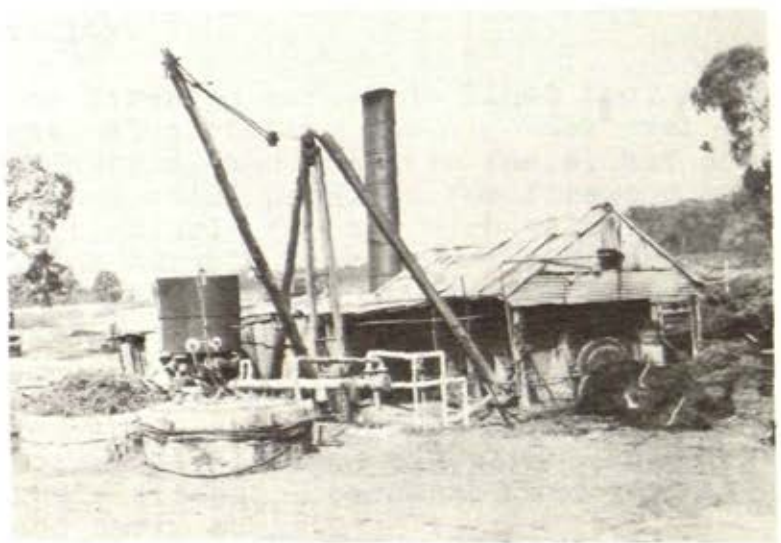
Mallee harvested by forage harvester quickly sends up new shoots from the "mallee roots" (or lignotubers). In this area harvesting is carried out every 2 years, when the plants have reached a height of half to three-quarters of a metre.

Some mallee areas are still harvested by hand with a sickle. Foliage is also cut in this way from the heads of trees of the non-mallee species felled for other timber produce. Hand-cut foliage is stacked by hand, then loaded by hand onto a tray-truck for transport to the still.

A horse-drawn horizontal circular saw is infrequently used, generally to bring older-growth mallee into production. Material cut in this way is raked with a horse-drawn rake and hand-forked onto a truck.

Distilling

Most stills are on private land, although seven occupy public land. They are close to or within the area being harvested, usually in a small clearing adjacent to a dam. Each still has a boiler, often dating from the gold era,



A eucalyptus oil factory on public land near Inglewood

housed in a shed. The boiler is generally fired with material from which oil has been extracted, sometimes supplemented with firewood.

Adjacent to the boiler house are usually two cylindrical vats, about 2 m diameter and 3 m deep. One vat is steamed while the other is cleared and recharged. When the vat is filled with foliage, a concrete lid is fitted and sealed with mud. Boiler steam is piped into the bottom of the vat and rises through the foliage. Then, carrying the vaporized oil from the leaves, it is piped through a condenser. The crude oil is skimmed off the top of the water in a collector bucket at the end of the condenser.

Employment

Of the 19 distilleries operating within the study area, most work on a part-time basis. Eucalyptus-oil production provides employment for the equivalent of 18 men per year. Most of this employment is generated near Inglewood and Bendigo (see Table 25).

19. TIMBER PRODUCTION

Hardwood Timber

Prior to the 1850s, virgin stands of the red ironbark--grey box--yellow gum associations comprised open grassy forests with a small number of large trees per hectare, the diameters of such trees reaching 120--150 cm.

The gold rushes in the 1850s - and later the spread of settlers over Victoria - generated great demand for timber products from these forests. Accessible stands were virtually clear-felled and the resultant regeneration cut as soon as it reached merchantable size.

Government intervention to halt this abuse commenced in 1869, with reservations of public land for forestry purposes permitting control over timber utilization. Silvicultural treatments to rehabilitate the forests began around the turn of the century.

Unemployed workers during the 1930s depression (and later aliens and prisoners of war) were employed in stand-improvement treatments in virtually all of the productive forest area. This intensive treatment highlighted the importance placed on these forests for the production of durable and fuel timbers.

Pressure-preservative treatment of fast-growing non-durable timbers such as radiata pine and certain mixed-species eucalypts for telephone poles began in 1957. It proved successful and the market for durable species as poles declined rapidly. Demand for fencing materials also fell, but these are required because of their strength and durability.

The firewood market declined too, as gas, electricity, and oil took over as industrial and domestic fuels, but some demand still persists for firewood - particularly for the high-calorific-value durable species - for domestic use in rural Victoria and in suburban Melbourne.

Durable species such as red ironbark, grey box, and yellow gum are eagerly sought for railway sleepers because of their strength, hardness, and toughness, and their resistance to termites, insects, and decay. The area is important in supplying sleepers and in meeting the demand for other durable products.

Trees cut in thinning operations are an important source of firewood

Present production

The hardwood forests of the study area produce various classes of timber at the following annual rates:

Firewood	78,000 m^3
Fencing timbers	15,000 m^3
Sawlogs	4,000 m^3
Sleepers	2,000 m^3
Other products	2,000 m^3

Hardwood output for the financial year 1974--75 amounted to 100,057 m^3, compared with 149,021 m^3 in 1970-71.

The box--ironbark forests provide high-quality firewood. Firewood is obtained as residue from utilization operations and stand-improvement treatments such as thinnings and regeneration fellings. Contractors obtain the produce by tender, and local residents can obtain licences to cut firewood for their domestic needs. In the past, old defective cull trees were ringbarked for firewood, but this operation is now rarely used and some veteran trees are retained as wildlife habitat and as nesting and resting sites for birds.

Posts, strainers, and other fencing timbers are cut in the study area from red ironbark, grey box, yellow gum, red stringybark, and red box. The forested public land has served as a source of strong durable fencing material for the surrounding plains country for the last century.

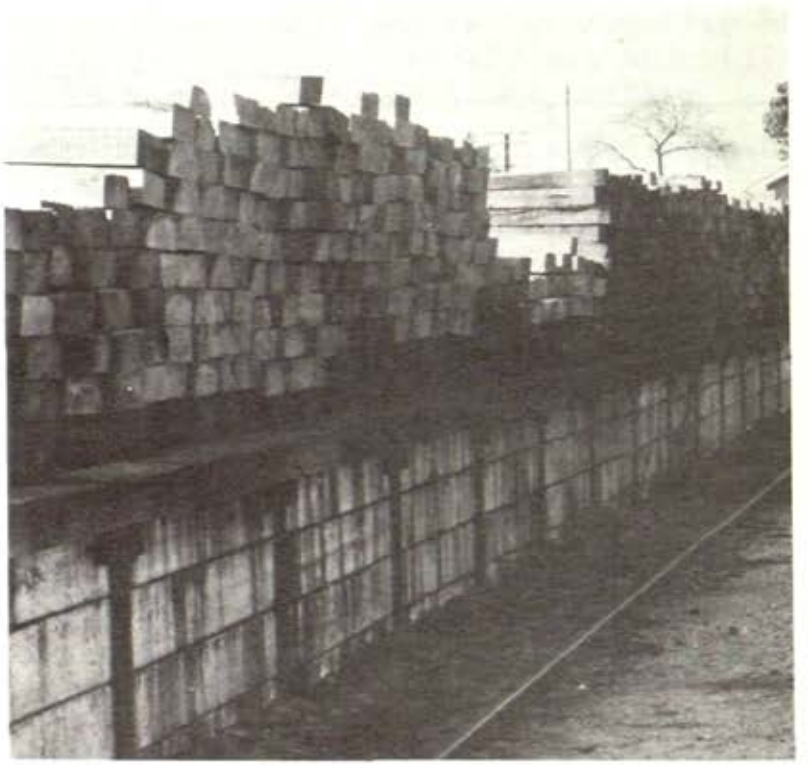
Trees suitable for sawn posts have been depleted, however, and preservation plants for treating small round native timbers have been set up at Stawell and Heathcote. Round timbers suitable for preservation can be obtained from thinning operations in non-durable species such as red stringybark. Such material can be expected to meet future demands for fencing materials.

Of the eight sawmills in the area, three at Stawell are supplied mainly from outside the study area. The stands of messmate and gum in the Pyrenees supply logs to two mills at Avoca and also to those at Stawell. The only mill cutting red ironbark, located in Rushworth, draws half its supplies from public land.

A sawmill near Castlemaine specializes in supply of bed logs for S.E.C. constructions, but some logs cut near Castlemaine are taken to sawmills to the south of the study area.

Railway sleepers of red ironbark, grey box, and yellow gum are cut from the public land, although output has declined because of the lack of suitable large trees. Privately owned forest areas have also been important in supplying sleepers in recent years, but few suitable patches remain.

Poles cut in the forest are mostly used locally. Durable timber is no longer used for telephone and power poles.



Railway sleepers on Bealiba station

Employment

The 1971 census indicated that hardwood industries in the study area provide employment for about 240 people. The towns of Tarnagulla, Heathcote, and Rushworth depend heavily on forest industries, which are also important to Bendigo, Maryborough, Castlemaine, and St. Arnaud.

One of the sawmills at Stawell belongs to a large firm assembling prefabricated

Table 26

HARDWOOD TIMBER PRODUCTIVITY

Structural form	Main timber species and distribution	Major soils	Approximate potential productivity (M.A.I. m^3/ha/annum)
Open forest III	Messmate, blue gum; higher elevations of Pyrenees	Friable brown gradational soils	3.0
Open forest II	Grey box, yellow gum, river red gum; Kamarooka, Ascot, Costerfield; along Goulburn River	Brown gradational soils on alluvium; red and yellow duplex soils	1.75
Open forest II	Red stringybark, red box; One Tree Hill, Fryers Ridge, Southern Pyrenees	Red duplex soils	1.50
Open forest II	Red ironbark, grey box, yellow gum; Mandurang, Whroo, Wellsford, Dunolly	Shallow and stony duplex soils	1.2

housing, an industry providing considerable local employment.

Another large firm specializing in joinery and prefabricated housing, at Maryborough, uses milled timber from outside the area.

Forest productivity

The forests of the study area have been under intensive management for many years. Because of past clear-felling, the stands are mostly even-aged, as new coppice resulting from thinnings has been either knocked down or suppressed. The increase in mean annual diameter measured over bark of the grey box--yellow gum--red ironbark type averages 0.6 cm, being 1--1.3 cm in the sapling stage and diminishing to 0.25 cm after 50 years.

The diameter increment is much the same in all three species.

The volume increment of both grey box and yellow gum on good sites is of the order of 1.75 m^3 per hectare per annum, total volume under bark, but that of red ironbark is less because of the greater volume of bark and the shorter height at maturity. It may reach 1.19 m^3 hectare per annum. Trees of pole size can be

grown on good sites on a rotation of 60 years by undertaking progressive thinning of the stand.

Growth information is unavailable for the poorer sites of the box--ironbark stands where red stringybark, red box, or long-leaf box are found. Their growth rate is certainly considerably less than that of the red ironbark--grey box--yellow gum of the good sites.

No growth data are available for the messmate--gum or red stringybark--red box of the Pyrenees, but as the soils are more fertile and rainfall greater there, growth rates would be expected to exceed those of the red ironbark--grey box--yellow gum stands.

Table 26 gives the general level of productivity of the main timber species. The potential mean annual increment (M.A.I.) is that expected to be achieved from natural forests with improved utilization, better stocking, and intensive management.

Both seedlings and coppice provide regeneration in the box--ironbark forests. Controlled burning is not practised in these forests because of the low build up of forest fuel and the strong risk of resulting erosion. Firebreaks and utilization slash are sometimes burnt.

The messmate--gum forests of the Pyrenees are different in nature, and small areas may be clear-felled, with seedling regeneration being encouraged by burning. Controlled burning is undertaken in the Pyrenees and Mount Alexander for fire-protection purposes.

Softwood Timber

Mature radiata pine plantations in the Harcourt area supply two small sawmills locally, and logs are also sent to mills outside the area. Veneer logs go to a plant at Melbourne, and pulpwood goes to a particle-board plant at Ballarat. In the 5 years July 1970--June 1975, the annual cut for these areas of softwood averaged 3,744 m^3.

A 50-ha plantation at Mount Beckworth supplies timber to Ballarat.

Reference

Newman, L.A. The box ironbark forests of Victoria, Australia. *Forests Commission of Victoria Bulletin* No. 14, 1961.

20. MINERALS AND EXTRACTIVE MATERIALS

North-central Victoria contains a range of metallic and non-metallic minerals, as well as deposits of other materials sought by extractive industries (slate, granite, gravel, sand, clay, etc.). By comparison with the mining boom of last century, little extraction of minerals occurs today. This means that present mining activities cover only a small percentage of public land.

Known occurrences of minerals and other extractive materials are shown on the Minerals map and discussed below.

Metallic Minerals

Gold

Some of the most productive gold-fields in Victoria were worked in the study area during the gold rush period of last century. Production reached a peak during the 1850s and has subsequently declined, with only a few minor revivals. In 1975 gold production in the area was 104 kg, and today it is negligible. Considering the current importance of gold, the following details may seem disproportionate in comparison with those for other minerals and stone extraction. Nevertheless, the enormous effect that gold-mining had on the history, settlement, subsequent mining, and land use in the study area warrants such discussion.

The first major gold discoveries were in exceptionally rich shallow alluvial deposits (secondary deposits). These were followed downstream beneath a cover of younger alluvium and basalt to be worked as deep leads. Gold-bearing quartz veins (primary deposits) were discovered beneath the alluvial deposits and in bedrock outcrops.

Primary deposits

All significant production of primary gold in the study area has come from quartz veins or "reefs" confined to sediments, or intrusions into sediments, of Cambrian to Middle Devonian age. The most important are the anticlinal or "saddle" reefs, such as those around Bendigo, although reefs also occur along reverse faults approximately parallel to the strike of the sediments.

In each gold-field, relatively long narrow mineralized zones a few hundred

metres wide have provided the bulk of the yield - some fields consisted of two or three such zones.

Other primary deposits of gold have also been found finely disseminated in sediments, as reported from Amherst, Kamarooka, and Wedderburn. Gold is also reported as an accessory in granitic rocks at Harcourt.

The following brief notes indicate the main areas of reef mining in the study area, and the extent of their gold production.

The Bendigo gold-field produced 539,900 kg of reef gold - more than half of the Victorian production. Here the gold characteristically occurred in saddle reefs at the crest of anticlines in a tightly folded sequence of beds. These saddle reefs recur one below another and presumably may be found below the deepest levels worked (1,407 m in the Victoria Quartz Mine).

Fault reefs and spurs were also important sources of reef gold in the Bendigo area.

The Castlemaine--Chewton--Fryerstown quartz reefs yielded approximately 23,000 kg of gold, most of which came from some 50 mines in a narrow belt between Fryerstown and Chewton. The only substantial gold-producer at Castlemaine was the Bolivia Mine, which was worked between 1857 and 1886. Mining revived

Poppet Head of the Golden Age Mine near Muckleford

at Chewton in 1935 with the discovery of the Wattle Gully reef.

Quartz reefs on the Clunes gold-fields were worked from 1857 to 1894, after which they flooded due to poor mining practices. The Port Phillip Mine produced more than a million tons of ore - more than any other gold-mine in Victoria.

During the 1860s high gold values were obtained from the quartz--stibnite--gold reefs at Costerfield, but gold recovery later became a by-product of antimony production.

More than 27 reefs in the Maldon district were worked between 1858 and 1926,

yielding 5,727 kg of gold. Some of the outcrops were extraordinarily rich, with yields of 14.4 kg per tonne from surface exposures such as the Nuggety Reef. Particular geological processes at Maldon caused the remobilization of gold with other ore constituents, producing rare minerals such as maldonite (gold--bismuth alloy).

At Maryborough more than 34 mines were established on four main lines of reefs. Although these were worked from the 1850s to 1914, reef mining was depressed by the prosperity of deep-lead mining.

Between 1855 and 1905 some 19 mines were established in the St. Arnaud gold-field. Ore here was characterized by the presence of galena, sphalerite, and a high silver content. Gold production amounted to 10,780 kg, 85% of which came from the Lord Nelson Mine.

The Stawell gold-field comprised four different lod systems of varying ore grades, with sulphide contents up to 50%. Between 1857 and 1920, Stawell produced 39,930 kg of gold.

Tarnagulla was a thriving reefing centre around 1859, and up until 1892 its output of gold exceeded 12,450 kg.

In the Rushworth--Whroo area more than 90 reefs were mined, most only to water level. At the Balaclava Mine near Whroo, three separate vein systems were worked below the floor or a large open cut, producing an estimated 1,240 kg of gold.

Secondary deposits

There are three categories of secondary deposits:

* shallow alluvial and eluvial deposits
* high-level gravel deposits of Pliocene age
* deep leads, formed during the Cainozoic period, in ancient drainage systems

Shallow alluvial and elluvial deposits

These deposits, particularly in the central part of the study area, were largely responsible for the gold rushes of the 1850s. They were extremely rich, and more gold was taken from them during the short period they were worked than from the whole of the subsequent deep-lead and quartz-mining operations.

The most important fields were Castlemaine, Bendigo, Dunolly, Moliagul, Wedderburn, Tarnagulla, and Inglewood. Each of these towns and many others developed on the site of a gold rush last century. Small towns today, such as Heathcote and Dunolly - and others such as Moonambel and Graytown, which are now deserted - once supported populations of 40,000--50,000 people. The early mining procedures of stripping large areas - plus the use of large quantities of wood for shafts, crushers, pumps, etc. - soon

resulted in the removal of much of the surrounding forests.

At Bendigo, the incredibly rich alluvial deposits yielded 5,669 kg of gold in the first 3 months after discovery. These alluvial deposits, which varied from a few centimetres thick to 30 m at Sebastian, yielded 13,466 kg in 1852.

At Castlemaine, most of the 99,000 kg of gold produced between 1857 and 1861 was alluvial gold from shallow deposits. Such deposits, up to 12 m deep, were initially worked by primitive methods. Large-scale sluicing was later introduced - often causing the entire removal of the alluvial and elluvial cover, exposing the bedrock over large areas.

North-central gold-fields were notable for the large numbers of nuggets. The largest one, the "Welcome Stranger" found near Moliagul, contained 71.07 kg of gold, while Kingower was nicknamed "The Potato Field" due to their prevalence.

High-level gravel deposits

Many areas, from Stawell to Bendigo, contain auriferous gravel at various elevations above present streams. Production from these sources has been intermittent and small.

Deep leads

Deep leads are auriferous river channel deposits buried beneath Quaternary alluvium or basalt or both. In the heads of valleys and gullies the leads were often shallow, but "downstream" they were more deeply buried, and extensive drilling was often required to locate their sinuous courses. The gold-bearing gravel or wash was commonly up to 1 m thick, about one-third the width of the lead, and contained about 10--20 g of gold per cubic metre of wash.

The largest and best-known deep leads were those in the valleys of the Avoca and Loddon Rivers and their tributaries (especially those running north from Maryborough and junctioning with the Avoca lead in the Bet Bet Valley).

The leads were mined underground from 1870 until the end of World War I. Specialized techniques were required to cope with the weak ground and the enormous quantities of groundwater. In 1909, the Charlotte Plains Consolidated Company was pumping 38,500,000 litres of water per day from a lead 150 m wide.

One of the longest continually operated deep-lead mines in Victoria was the Grand Duke at Bowervale--Timor. Between 1867 and 1896 the mine produced 13,730 kg of gold and employed an average of 150 men, before water forced its closure.

Dredging

Following the 19th Century workings,

many of the alluvial areas still contained fine gold spread throughout the gravels. Early this century large-scale dredging treated thousands of cubic metres of the same gravels, restoring old mining areas to productive land. Much of the Loddon valley and Campbells Creek was dredged prior to World War I. Later, dredges worked at Guildford (1918--23), Newstead (1938--48), Redbank (1939--40), Fryerstown (1940--43), Jim Crow Creek (1949--54), and Amphitheatre (1953--56). Returns were often lucrative; the Victorian Gold Dredging Co. at Newstead treated 14,944,438 m^3 of gravel for 3,646 kg of gold in 10 years. A small dredge still operates on public land at Maldon.

A gold dredge operating on public land at Maldon

Other Metallic Minerals

Antimony

The quartz--gold--antimony veins at Costerfield were discovered in 1860, and have subsequently been exploited during several periods. The most productive was from 1905 to 1925, when 25,190 tonnes of concentrate averaged 50.7% antimony and 74 g gold per tonne. The mine again operated from 1930 to 1940. Mining again proceeded in 1968--71 and 1974--75, following new discoveries in the Brunswick reef. Proved reserves on this reef are 1,320 tonnes of antimony and 280 kg of gold.

Costerfield has accounted for 92% of Victoria's recorded antimony production. Current lease areas at Costerfield occupy both private and public land.

Antimony in quartz reefs has been recorded at Munster Gully 2 km north-east of Dunolly, further north at Sydenham reef (both areas are public land), and at Macfarlanes reef near Havelock (west of allotment 4, section VI, Bet Bet Parish). Occurrences are also known at Whroo and Redcastle (both on public land), and at Bailieston.

Arsenic

Arsenic in the form of arsenopyrite is recorded in quartz reefs at Bendigo and Maldon, and on public land at the Wattle Gully Mine at Chewton.

Bismuth

Gold--bismuth alloys occur in reefs at Maldon and Redbank. Sulphides of bismuth occur at Mount Kooyoora, Kingower, Moliagul, St. Arnaud, Tarrengower, Clunes, and Mount Douglas. All the ore is very low-grade and uneconomic.

Copper

Native copper occurs in deep leads at Majorca and Castlemaine, and as films in reefs at Castlemaine. Copper carbonate occurs at Mount Camel also, on private land.

Iron

A small deposit of iron ore outcrops 0.8 km south of Heathcote on public land. Scattered stratified deposits of haematite and limonite make up a low-grade deposit 6 km north-west of Heathcote.

Lead--silver

Native silver occurs as small specks and hair-like filaments in quartz veins at St. Arnaud, Crowlands, Landsborough, Moonambel, and Stawell. Silver sulphide occurs at Landsborough, Stawell, and Mount Douglas, and with galena at St. Arnaud.

Native lead is recorded in deep leads at Avoca and as rolled grains at Mount Greenock.

Manganese

Manganese ore segregations occur along shear zones associated with Cambrian rocks in the Heathcote district. The Mount Ida Manganese Mining Co. worked such segregations by open cut between Bald Hill and the railway line about 1 km north-west of the Heathcote railway station. Heathcote was the major area of manganese production in Victoria.

Manganese oxide also forms cementing material in deep leads at Timor, but is not present in commercial quantities.

Molybdenum

Molybdenite is associated with quartz veins or granite at Mount Douglas and Maldon. At Mount Moliagul, molybdenite lenses and flakes occur in quartz veins in granodiorite and the surrounding contact metamorphic rocks on private and public land. All the deposits are small and low-grade.

Osmiridium

Osmiridium is reported in residues from the Glendhu reef on private land at Crowlands.

Tungsten (wolframite)

Quartz veins in the parishes of Barrakee and Cornella contain wolframite, and on private land at Henry's Hills, north of Avoca, lumps of wolframite up to 1.3 kg are present in the quartz. During 1943, the Wolfhound lease, 9 km east of Toolleen, yielded 152 kg of wolframite.

Uranium

At Mount Kooyoora, very low concentrations of torbernite (<0.01%) have been found in a surficial iron-stone. Extensive drilling failed to reveal any further signs of radioacticity, apart from slight increases associated with joint plains in the granite.

Non-metallic Minerals

Brown coal

Brown coal has been encountered in bores beneath the plains in the study area. Some of the more significant intersections are:

Calivil 2	10.4 m of brown coal at 99.4--109.8 m
Tandarra 1	8.2 m of brown coal at 77.7--85.9 m
Marma 2	(0.8 km outside study area) more than 28 m of brown coal, from 36 m downwards

Future exploitation of these coals is unlikely as they are relatively thin and deep, and would require underground mining.

Diatomite

Diatomite is a sedimentary rock composed of millions of siliceous skeletons of diatoms (algae that are microscopic single-celled plants). When pure it is chemically inert, and has low specific gravity, high porosity, and low thermal conductivity. It is used extensively as an insulating medium or filtering agent, and in mild abrasives, metal-polishes, bricks, and water glass.

Deposits of diatomite up to 4 m thick occur on private land in the Parish of Lillicur, where they have been worked intermittently since 1866. The deposits constitute the largest known high-grade deposits in the state, and reserves not covered by basalt flows are estimated at 40,000 tonnes. (Deposits covered by basalt should amount to several times this figure).

Other deposits are known at Talbot and Tullaroop Creek north of Clunes.

Feldspar

Large feldspar crystals, up to 10 cm long, have been recorded in a small granite outcrop 8 km west of Dunolly and in a pegmatite dyke 3 km west of Llanelly.

Gemstones

Gemstones were often reported in alluvial wash in early Mines Department publications. The deep-lead mines also produced a variety of precious stones of little interest to the gold-miners then. The Cambrian rocks running from Tooborac to Lake Cooper contain bands of coloured jasper and black chert. Other gem minerals reported in the area include topaz (Castlemaine, Dunolly, and Maldon), agates (Moolort, Avoca, and west of Heathcote), tourmaline, and zircon.

Magnesite

Magnesite is recorded from the Whipstick and Costerfield areas, and as scattered deposits running south from Axedale.

At Heathcote, small granitic intrusions are associated with Cambrian igneous rocks. Metamorphism has developed a talc rock containing magnesite veins in both rocks close to the contact zone. Between 1911 and 1945, deposits 1.6 km south-east of Heathcote yielded 3,349 tonnes.

Mineral Leases and Licences

Since the introduction of the exploration licence system in the mid 1960s, more than 60 mineral exploration licences have been granted in the study area. Nine areas between 66 km^2 and 660 km^2 are presently under exploration licence here, with another six areas under licence application (October 1977). All these licences contain some areas of public land.

Most exploration has been concentrated on the Lower Palaeozoic sediments known to contain gold mineralization. Several licences have also been granted over deep-lead systems. The basic Cambrian rocks running from Tooborac along the Mount Camel Range are known to contain small surface deposits of metallic and non-metallic minerals, some of which have been mined in the past. Exploration has revealed further weak base anomalies in these rocks.

In addition, 36 gold licences, 16 mining licences, and 2 mineral leases are current in the study area, most being between 10 ha and 300 ha in size. One-third of these licences ane leases occur entirely or partly within public land. Numerous tailings licences are also current on public land.

Stone

In this chapter "stone" means rock of any kind (granite, slate, etc.), quartz, gravel, clay, sand, soil, or other similar material as defined under the *Extractive Industries Act*. Stone can be removed from a site under at least seven

different *Acts of Parliament*, and some operations technically require no permit at all.

Table 27 shows the amount of stone extracted under the *Acts* and outside the *Acts* in the study area between July 1974 and June 1976. Currently, of the 16 operations under the *Extractive Industries Act*, four are on (or partly on) public land. Operations outside the *Extractive Industries Act* account for at least 68% of the stone extracted for the year ending June 1976.

Table 27 also shows the various types of stone extracted between 1974 and 1976. By far the greatest use of stone in the study area is in road construction and maintenance. This material is sought by private operators, shires, and government departments, such as the Country Roads Board, although collectively the 17 shires use the greatest amount. This type of stone is obtained either as aggregate from major quarries or by shallow stripping operations.

Aggregate from major quarries

Five major hardrock quarries operating within the study area supply aggregate primarily for road-making purposes, but also for several concrete industries. Crushed and broken basalt are quarried on private land at Axedale, Mount Burramboot, and Carisbrook. Another basalt quarry south of Talbot is partly on public land, and hornfels is quarried on public land at Maldon. The aggregate from these quarries supplies most of the study area, although the northern and western parts are supplied from outside (from Pomonal, Charlton, and Pyramid Hill).

Some of the quarries also supply places outside the study area: for example, the bulk of the Carisbrook aggregate has in recent years supplied ballast for railway lines throughout central and western Victoria.

Shallow stripping operations

Shallow stripping operations are carried out on all rock types in the study area. On private land, stripping operations are generally orderly; topsoil is stockpiled, and progressive reclamation follows. Public land, however, frequently carries unused stock piles, bare areas, and other signs of extraction years after working.

The 17 shires in the area shallow-strip sand and gravel from both private and public land. About 35% of their total road-making requirements come from the latter, although this varies between shires. Metcalfe, Strathfieldsaye, and Talbot and Clunes Shires obtain only 5% of their requirements from public land, while others like Maldon and McIvor obtain more than 50%.

Most shires look to public land for future reserves, even though similar

rock types and topography may exist in adjoining private land. Few have considered a program of searching for such deposits, or utilized the gravel-search facilities provided by the State government.

Table 27

STONE EXTRACTED FROM PRIVATE AND PUBLIC LAND (TONNES)

	Under *Extractive Industries and Mines Acts*		Other	
	1974/75	1975/76	1974/75	1975/76
Crushed and broken - basalt	461,786	228,423	-	-
- hornfels	-	-	21,406	16,259
- granite	2,420	-	-	-
- shale	2,420	1,720	-	-
Dimension stone - granite	-	-	7,671	14,456
- slate, quartz	2,717	1,435	-	-
Clay - brick-making	8,683	4,934	49,948	44,755
- stoneware	1,272	1,040	16,728	15,738
Sand, gravel, tailings, soil	98,297	138,720	735,052*	706,956*
Total	577,070	372,272	830,805*	798,164*

* These figures may actually be underestimates - they refer only to government departments and local government bodies.

The main groups of suitable sands and gravels are:

* weathered residues and colluvial slopes developed on Lower Palaeozoic rocks
* Tertiary gravels
* mine tailings
* Quaternary alluvial sediments

Weathered residues and colluvial slopes

North and east of Bendigo, Lower Palaeozoic sediments are a major source for roading purposes. Ordovician sandstone and slate are quarried under Forests Commission licence from a large pit in the Kamarooka Forest. This material is shared by the Shires of Marong, Huntly, and East Loddon.

Numerous pits exist in granitic areas, some supplying large quantities of granitic sand. The Shire of Talbot and Clunes extracts granitic sand from private land on the northern slope of Mount Beckworth. Current working is systematic; topsoil is stock-piled ready for respreading and sowing down following completion of extraction.

On the eastern slope of Mount Beckworth, granitic sand is extracted from public land. Extraction extends to a depth of 3 m and is concentrated along a drainage line, presenting an immediate erosion problem. There are numerous signs of older workings, with overgrown stock-piles and negligible attempts at reclamation.

Similar comparisons exist throughout the study area. Public land on the steep eastern slopes of Mount Korong has been devasted by gravel extraction. Large trees have been left perched on columns of gravel up to 5 m high, and have now died because their root systems have been damaged. These, together with large boulders, uneven surfaces, and bare areas, make a very unsightly picture. The adjoining private land presents much easier working conditions with large reserves, yet this, except for one small neat operation, remains untouched.

North of Mount Korong at Fiery Flat, gravel extraction has been confined to the only piece of public land in the area, and no attempts at restoration have been made.

In the south-west of the study area, many small reserves (often gravel reserves) have been completely stripped bare to bedrock. Without soil, the natural revegetation is minimal.

It is unlikely that such abuse of public land will continue in future. Recently commenced operations, such as those on the western slopes of Mount Egbert, are proceeding satisfactorily under conditions imposed by the Soil Conservation Authority, including systematic working and progressive reclamation.

Mine tailings

The southern central part of the study area contains many large tailings dumps of quartz gravel derived from deep-lead mining. These are extensively used by shires and the Country Roads Board, either raw for pavement material or washed for aggregate. Some operators have purchased dumps, and are selling the material to the shires or supplying Melbourne gardens with river pebbles.

In March 1974 it was estimated that the City of Bendigo and the Borough of Eaglehawk contained 3 million m^3 of mine tailings. The sand and mullock, made up principally of Ordovician sediments, are piled in 121 heaps and used both by the city and borough as well as the surrounding shires. Some heaps have now been fully exploited and others have been reclaimed.

Tertiary gravels

Deposits of medium to coarse quartz gravels and conglomerates with minor sand and clay lenticles are located throughout the study area (shown as Tp on the geological map). The majority of these gravels were worked for gold last century.

Many deposits have subsequently been surface-scraped to a depth of 1002 m for gravel, and then abandoned on striking a "floor" of hard siliceous conglomerate. Drilling of the Strathfieldsaye Gravel

Part of an extensive area of public land near St. Arnaud stripped for gravel

Reserve revealed that the floor was only 1--2 m thick, and overlay up to 14 m of uncemented or lightly cemented clayey gravel. Estimated reserves were tripled - sufficient to support a washed sand and aggregate operation. Gold could be recovered as a by-product to any such operation.

The Shire of Strathfieldsaye contains 33 such occurrences, although only three are on public land. Exploitation of the deposits may provide an alternative source of sand and gravel for Bendigo once the mine tailings are exhausted.

Two operations under Extractive Industry Licences are working Tertiary gravels on private property at Mount Egbert and

Guildford, the latter supplying a washing plant at Castlemaine. Deposits some 4 km north-east of Mount Bolangum are carted to Donald and Birchip Shires outside the study area. Large portions of two large deposits on public land - 6 km north-east of St. Arnaud, and 4 km east of Mount Bolangum - are being stripped down to the conglomerate layer.

Further investigations should be made to locate suitable deposits that would be economically viable for quarrying in preference to widespread stripping.

Quaternary alluvial sands

Many small streams within the study area contain deposits of sand. Most shires requiring sand for construction purposes obtain small amounts from these streams. Unfortunately, the large-scale removal of sand from stream-beds and banks along Bullock and Myrtle Creeks, combined with above-average stream flows in the past 2 years, has resulted in considerable disruption and damage to the stream-beds. Consequently the removal of sand is now more closely controlled.

The alluvial plains in the north contain defunct stream-beds, both at the surface and buried, composed of medium to very coarse quartz sands. Commonly called prior streams, these deposits are 1--2 m thick and 1.5 km wide, and may meander for up to 80 km. Such deposits, if located and proved economic, will provide a valuable sand resource.

Dimension Stone

Granite

Granite quarries in the Ravenswood--Harcourt area opened in 1859 to provide culvert material for the construction of the Melbourne--Ecucha railway.

The adaptability of Harcourt granite to quarrying has since led to a widespread demand for this grey granite for use in monuments and for other building purposes.

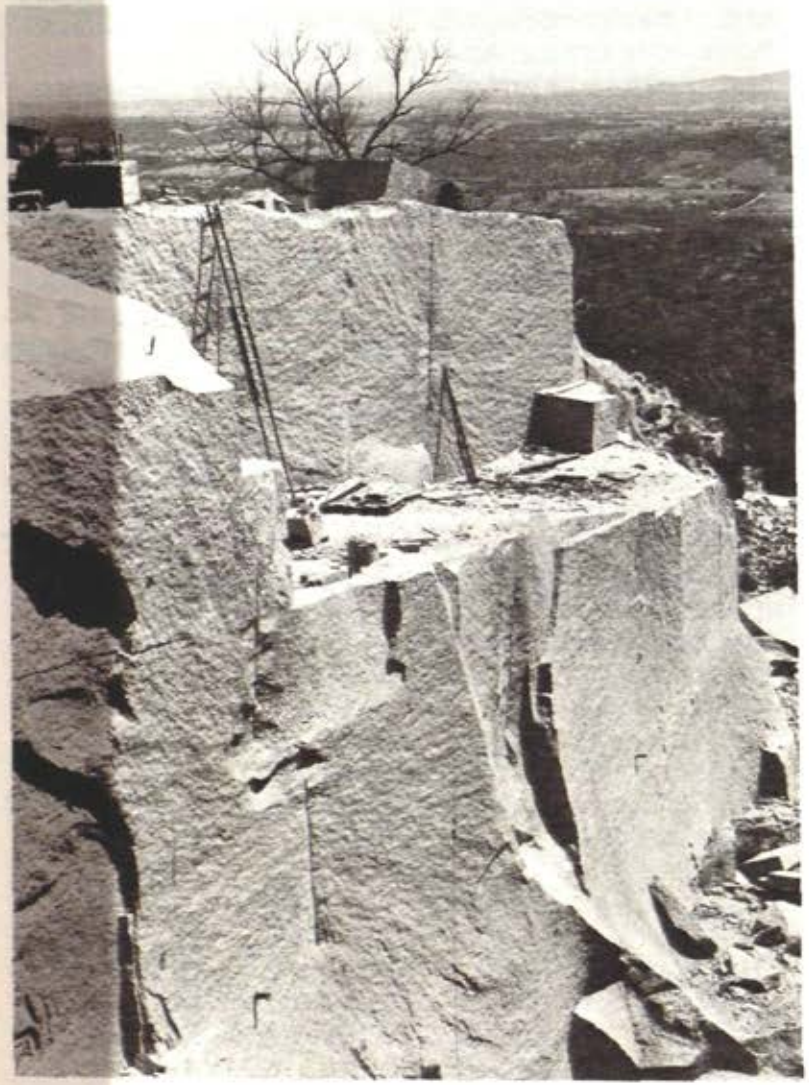
Five granite quarries are currently operating, all on public land. Four operate under Forests Commission licence, producing dimension stone. Two of these operators cut and polish the quarried material on site, while the other two transport it to Melbourne for cutting etc. The remaining quarry produces aggregate for external wall paving slabs under Extractive Industries Licence and Lease.

Other rock types from interstate and overseas are imported to Mount Alexander for cutting.

Sandstones and slate

The Ordovician sandstones at Castlemaine were worked last century by prison labour, and later privately for buildings, street channels, paving, etc. Some quarries were 60 m deep by the turn of the century.

Deeply weathered slates are widespread. Today a number of small quarries east of Castlemaine near Faraday produce



A granite quarry on Mount Alexander

"Castlemaine Slate" for fireplaces, facing walls, etc. Those on public land operate under Lands Department licences.

Clay

Brick-making is the largest industrial use of clay in Victoria. Clays suitable for bricks and other clay products (pipes, tiles, etc.) are widespread in the study area. Smaller quantities of higher-grade clays are also present and used for stoneware, whiteware, and medicinal and other uses.

The clays are associated with four main rock types:

* residual clays from Lower Palaeozoic sediments
* alluvial clays of the Cainozoic period
* residual clays from decomposed dykes
* residual clays from decomposed granite

Residual clays from Lower Palaeozoic sediments

Intense leaching and oxidation of these sediments during the Caniozoic period, to a depth of 30 m, have rendered them suitable for a variety of clay products. While these clays may be "short" - that is, lacking the plasticity that enables them to be cast or moulded into various shapes - they can be blended with other clays of high plasticity to produce tiles, earthenware, bricks, etc.

Bendigo has supported industries based on clay products from the early mining days. The Bendigo Pottery was established in 1857 using local clays, and the stoneware produced today is sold throughout Australia and overseas. Raw materials are drawn from several sites on public land at Huntly, and are used raw or blended with the more "plastic" Axedale clays.

East of the Whitelaw Fault, the Middle Ordovician shales have weathered deeply to form white clay. This formed the basis for a flourishing brick industry during the 1950s and '60s, thanks to the popularity of cream-coloured bricks.

Phillips Bricks and Pottery - the only current brick-works at Bendigo today - produces a line of clinker bricks not made by the larger Melbourne companies. The St. Arnaud brick-works closed in 1976 because it was unable to compete with the larger companies.

The only other brick-works in the study area, at Stawell West, extracts white clay from pits on public land in the town. It requires a steady supply of red clay, from surrounding tailings dumps, for blending purposes to produce darker-coloured bricks.

Alluvial clays of the Cainozoic period

Huge volumes of weathered products were eroded and re-deposited during the Cainozoic period as alluvial or lacustrine clay. At Axedale, white clays up to 20 m thick interfinger with sands and gravels partly overlain by Newer Volcanics. Current workings are by open cut, and overburden varies from 0.3 to 15 m. Most workings are on private land, but the full extent of the clay is unknown and the deposit may extend into areas of adjoining public land. Estimated production from Axedale since 1905 is more than 750,000 tonnes. Today the bulk of it is trucked to Craigieburn or Brunswick to plasticize or lighten other clays for brick manufacture. Some of the better material is used for pottery, whiteware, insulators, porcelain, etc. in Bendigo, Melbourne, and interstate.

North-west of Huntly in the Whipstick Forest, and south of Huntly in the Wellsford Forest, restricted deposits of thin Tertiary clays occur. These clays, up to 6 m thick, have proved suitable for pottery, stoneware, and brick manufacture.

At Stawell, white clays exposed to a depth of 35 m beneath plastic yellow clay of varying depth have been used for fire bricks.

Residual clays from decomposed dykes

High-grade china-clays in the study area result from the kaolinization to depths of 100 m of intrusive dykes. Siliceous china-clays and stoneware clays derived from quartz porphyry dykes occur at Stawell, Maryborough, Clunes, and

Castlemaine. Pure china-clay from aplite dykes with little or no quartz has been recorded at Stawell.

Residual clays from decomposed granite

Clays for paper and rubber filters, paint, etc. are produced when residual china-clays developed in granite are washed to remove quartz. Residual clays on the Cobaw granite have been worked at Pyalong, just south of the study area, and this pluton extends into the area.

Residual clays are developed on the Koroong pluton and, if separated from the remaining quartz and feldspar, would yield china-clay.

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21. WATER UTILIZATION

The demand for water in the study area is met largely from surface water resources, although groundwater usage is increasing. The main supply systems incorporate a number of major storages constructed to safeguard irrigation, urban, stock, and domestic supplies. Table 28 lists the characteristics of the major water storages.

The major systems are managed by the State Rivers and Water Supply Commission, and municipal authorities and Waterworks Trusts operate the remaining works. There are also numerous privately constructed storages and private diversions from watercourses or bores.

Estimated total annual water use in the area at present is approximately 250,000 Ml, of which some 20,000 Ml per annum is for town supplies.

Major Water Supply Systems

Goulburn--Murray and Campaspe system

The Goulburn--Murray and Campaspe Irrigation Districts include about 43,000 ha of land in the northern part of the study area. These are managed as an integrated system, using the resources of the Goulburn, Campaspe, and Loddon Rivers.

The Goulburn--Murray Irrigation District includes parts of the Calivil, Dingee, Tongala--Stanhope, and Deakin irrigation areas. Water is diverted by the Goulburn Weir to the Waranga Reservoir in the north-east, and the Waranga Western Main Channel then conveys it to those areas. Green Lake, adjoining the main channel near Corop, is used as an off-channel reservoir for storage of surplus flow at periods of low demand. When demand increases, water can be pumped from the lake back into the channel,

Waranga Western Main Channel

Table 28

MAIN WATER STORAGES

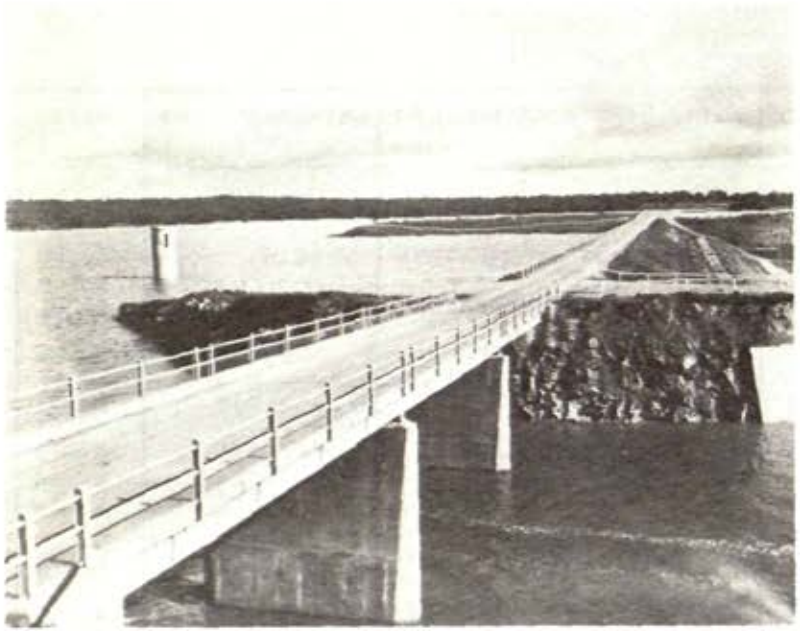
River system	Storage	Year of construction	Capacity (Ml)	Major source of supply	Catchment area (km^2)	Use#
Goulburn	Goulburn Weir	1890	25,500	Goulburn River	10,772	I, D
Goulburn	Waranga Reservoir	1905 (1917)	411,200	Waranga western channel	N.A.	I, D
Goulburn	Greens Lake	-	32,750	Waranga western channel	N.A.	I, D
Campaspe	Lake Eppalock	1964	311,900	Campaspe River	2,028	I, D
Loddon	Cairn Curran	1956	148,800	Loddon River	1,593	I, H
Loddon	Tullaroop	1959	73,690	Tullaroop Creek	730	I
Loddon	Laanecoorie	1891 (1909)	7,770	Loddon River	4,178	I
Coliban	Upper Coliban*	1902 (1935)	31,700	Coliban River	192	I, D
Coliban	Lauriston*	1941	19,620	Coliban River	223	D
Coliban	Malmsbury*	1874	17,760	Coliban River	290	I, D
Coliban	Spring Gully	1935	2,470	Coliban River	N.A.	

* Reservoirs outside study area, but area of supply is within it.

\# D = Domestic
I = Irrigation
H = Hydroelectricity generation

enabling operational flexibility and improved supplies to areas further west.

The Campaspe Irrigation District is supplied by water released from Lake Eppalock and diverted by Campaspe Weir, 10 km south of Rochester. Eppalock water also supplements the Goulburn--Murray system, as well as augmenting the Bendigo urban supply and providing for private diversions under licence. The Loddon River system is also used to supplement the Goulburn--Murray. Water in the Cairn Curran and Laanecoorie Reservoirs is diverted to the Boort irrigation area by diversion weirs near Serpentine and Fernihurst. Tullaroop Reservoir stores water before release into Laanecoorie and also provides water for urban use in Maryborough.



Tullaroop Reservoir

About 85% of the area irrigated consists of sown pasture, with perennial or summer pastures exceeding annual or winter varieties. The remaining irrigated land mainly carries fodder crops, lucerne, and very small areas of vegetables and orchards.

In addition to irrigation supplies, about 55,000 ha of dryland farms are supplied for stock and domestic purposes, and seven towns receive urban supplies. Most of the farms are in the East Loddon Waterworks District, where water is supplied by earthen channels to fill farm dams once, or twice, each year.

Where land in the district has been allocated water rights, the owner is obliged to pay a compulsory annual irrigation charge. This is based on the volume of water right "attached" to the land, irrespective of whether it is actually used. Any additional water supplied as "sales" is paid for at the same unit charge as water rights. In addition, most properties receive a "domestic and stock allowance" up to a maximum of 12.5 megalitres per holding, for which the same unit charge is paid.

Coliban system

This is one of the oldest water supply systems in Victoria, having been built for the Bendigo area during the gold-mining era. Today it serves about 63,500 people, of whom some 57,000 live in urban areas. It also provides for irrigation of 4,140 ha, and water for stock, domestic, and industrial use within the study area. The major headworks are on the Coliban River and comprise the Malmsbury, Lauriston, and Upper Coliban Reservoirs. The remainder of the system includes 96 km of main channel, 540 km of other channels, 45 km of main pipeline, and 644 km of reticulation mains.

The Coliban system supplies water for urban use to the greater Bendigo area (with the exception of Strathfieldsaye), Castlemaine, and a number of other towns and townships. Strathfieldsaye is supplied from Lake Eppalock via the Eppalock

pipeline. Supplementary supplies for the Coliban system are obtained by pumping from Lake Eppalock, and can be used to supply Bendigo and the channel system north of the pipeline.

Urban use in the Coliban system is increasing by about 3% per annum, as is the number of services installed. Most of the increase occurs in the Bendigo area, where water consumption is expected to double in the next 20--25 years.

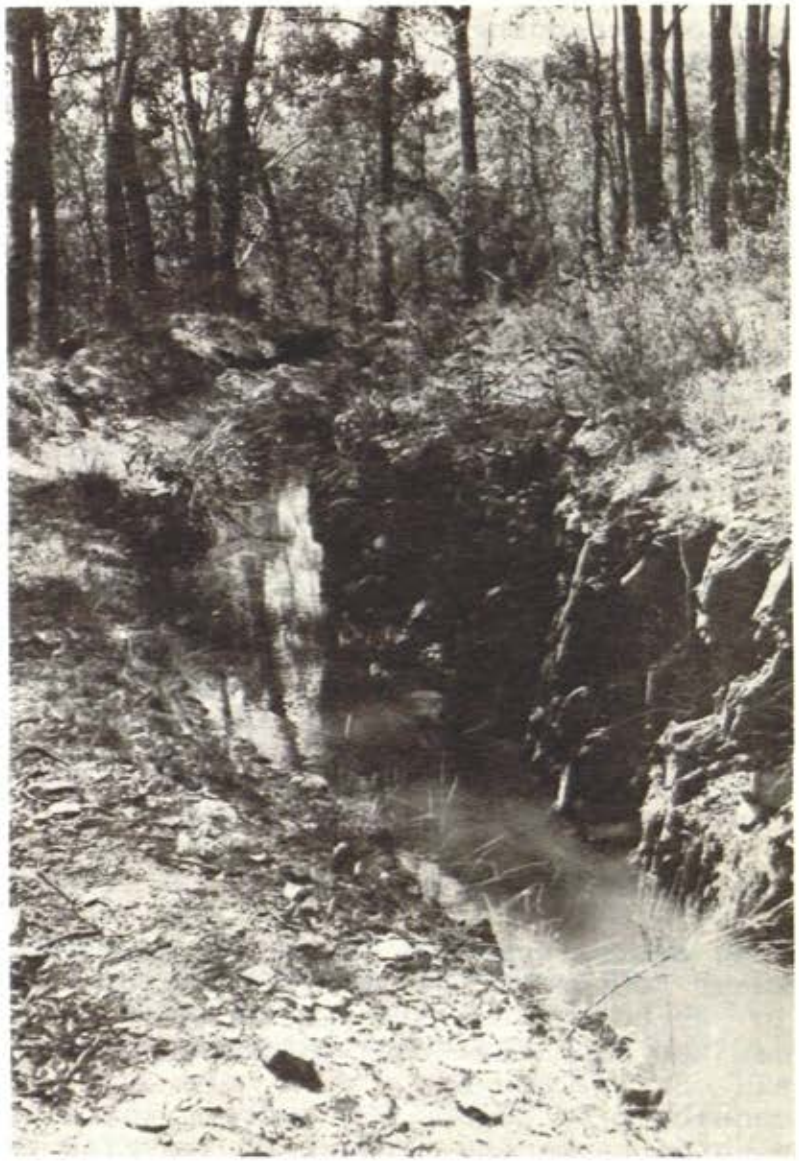
Irrigation and stock supplies are available as a volume allocation under annual permit. The present system was introduced in 1961, and since then the irrigation allocation has remained at a relatively static level (see Table 29).

Table 29

IRRIGATION WATER, COLIBAN SYSTEM, 1976/77

	Volume allocation (Ml)	Usage (Ml)
Irrigation	14,974	10,826
Stock	1,876	786

The volume allocated under a stock permit may be reduced if necessary to conserve supply for urban use, and excess sales are permitted if surplus water is available. A decision to permit excess sales may be made at any time during the



A channel of the Coliban system - constructed during the gold-mining era and still in use

season depending on the demand, if the storages contain sufficient to ensure that this will not restrict urban supplies in the following year.

The issue of further stock permits is now limited to properties not already supplied, which abut or are traversed by a Water Commission channel.

There are no prospects for increasing either the volume of water or the areas for irrigation, and the reliability of supplies is already less than for the northern irrigation areas. The present supply system is not suitable for irrigation because of its sprawling layout, and its many inefficient channels and steep slopes. (During the 1967/68 drought, only 50% of the irrigation allocation was met in the Coliban system.) Increased urban and industrial demands from Bendigo will also lead to a reduction in the water available for irrigation in the Coliban system.

Wimmera--Mallee system

This system supplies stock and domestic water to approximately 47,000 ha of land in the north-west via a network of open earthen channels. Ten major storages, all outside the study area, are interconnected to supply the system, which is reputed to be the largest of its kind in the world. Water for the section within the study area is distributed by the main Charlton channel, which runs from Lake Lonsdale and collects water from the Wimmera River as it crosses Glenorchy Weir. The northern part of the system can also be supplemented from the Warange Western Main Channel when the Grampians storages are at low levels.

Farm and town earthen storages are replenished once a year. The filling period commences about late autumn and continues through the winter and early spring, when distribution losses are lowest.

Seven towns receive urban supply from this system and most have an elevated reservoir into which water can be pumped (enabling gravity-reticulation throughout the town).

Private Diversions

Throughout the study area, some 650 landholders adjacent to rivers have permits or licences to divert water from streams for irrigation. These have an annual volume entitlement of about 64,000 Ml, authorizing irrigation of about 10,700 ha. Some 300 additional landholders have diversion permits for domestic and stock water, and there are a few industrial permits. Table 30 summarizes these diversion permits and licences.

In addition to water diverted from streams, considerable use is made of small farm dams to conserve local runoff. This is one of the most common methods of providing stock water, but

Table 30

PRIVATE WATER DIVERSIONS
(approximate only)

Catchment	Irrigated area	Volume entitlement (Ml)	No. of permits and licences		
			Irrigation	Domestic & stock	Industrial
Goulburn	5,200	31,200	48	109	2
Campaspe	1,250	7,500	166	86	2
Loddon	3,850	23,100	314	75	2
Avoca	360	2,160	104	8	-
Wimmera	80	480	12	12	-
Total	10,740	64,440	644	290	6

may also provide water for irrigation or domestic purposes.

Groundwater

No detailed records of groundwater use are available, but significant pockets of established irrigation bores are in use near Murchison, Elmore, Bridgewater to Serpentine, Natte Yallock, and Maryborough. It is estimated that about 100 such irrigation bores in the study area serve an area of approximately 600 ha. Also some 3,000--4,000 bores in the area provide stock and domestic water.

Mineral Springs

Mineral water from the springs at Vaughan and Glenluce is popular among local residents and others familiar with the spas of Europe; however, the extent of utilization of mineral water for its reputed medicinal benefits is not known.

Urban Supply

Apart from the urban areas supplied from the Coliban system, 42 other towns in the study area have a reticulated water supply operated by the Water Commission,

by a Waterworks Trust, or by the local municipality. Where no Waterworks Trust has been gazetted, the Shire Council may proclaim a Water Supply District.

Urban supplies are taken from rivers and streams, local catchment bores, or Water Commission channel storages. Most of the supplies are untreated, and in some towns the reticulated supply is only intended for garden-watering and washing, supplemented by rain-water tanks for cooking and drinking. Table 31 lists the towns supplied, population served, approximate annual usage, treatment, and source of supply.

Future Requirements and Supplies

Over the years the construction of new storages has enabled continuous increase in water usage, but future increases are likely to be small, as surface resources are now highly regulated and almost fully committed. Throughout the study area, diversions have been authorized up to the capacity of most streams.

A small percentage of private diverters, mainly on the Goulburn, have not yet developed their properties to fully utilize their authorized volumes.

Several important pipeline projects are currently in progress to improve supply of water to parts of the study area.

The Parliamentary Public Works Committee is currently holding an inquiry into future water allocations for all purposes in northern Victoria, including the study area. Following completion of Dartmouth Reservoir, some additional water resources will become available, although the volume and method of allocation cannot be determined until the inquiry is completed.

Further development is possible by the construction of private storages, either on-stream or off-stream, to impound high winter and spring flows for use in the following summer. This type of development will probably increase as it becomes economically attractive.

Table 31

URBAN SUPPLY

Supply authority (and year gazetted)	Towns served	Treatment	Est. annual usage (Ml)	Population served (approx.)	Major source of supply
SRWSC (Coliban System)	(a) Bendigo area				Upper Coliban, Lauriston, Malmsbury Reservoirs (all storages on Coliban River); Lake Eppalock (Campaspe River)
	Ascot	Chlorination			
	Bendigo	"			
	Eaglehawk	"			
	Epsom	"			
	Huntly	"			
	Kangaroo Flat	"			
	Kennington	"			
	Myers Flat	"			
	Spring Gully	"			
	White Hills	"			
	Golden Square	"			
	(b) Castlemaine area				
	Campbells Creek	Nil	14,000	59,100	
	Castlemaine	"			
	Chewton	"			
	Fryerstown	"			
	Guildford	"			
	Yapeen	"			
	(c) Other				
	Axe Creek	Nil			
	Barkers Creek	Nil			
	Elphinstone	Chlorination			
	Harcourt	Nil			
	Maldon	Nil			
	Marong	Chlorination			
	Raywood	Chlorination			
	Sebastian	Nil			
	Strathfieldsaye	Chlorination			
	Taradale	Nil			
Avoca Township W.W.T. (1909)	Avoca	Nil	114	1,700	Sugar Loaf Creek and Glen Gully Creek
Axedale W.W.T. (1963)	Axedale	Nil	14	100	Pumped from Campaspe River
Bealiba W.W.T. (1935)	Bealiba	Nil	20	310	Local catchment drains
Bowenvale--Timor W.W.T. (1965)	Bowenvale	Nil	17	260	Maryborough W.W.T.
Bridgewater W.W.T. (1927)	Bridgewater	Nil	82	530	Loddon River
Carisbrook W.W.T. (1892)	Carisbrook	Nil	91	400	Maryborough W.W.T. and pumped from Deep Creek
Colbinabbin W.W.T. (1918)	Colbinabbin	Nil	36	180	Pumped from Waranga western main channel (SR&WSC)
Bet Bet Shire Council (1884) (1956) (1884)	Dunolly*	Nil	180	1,350	Pumped from Loddon River at Laanecoorie
	Laanecoorie*				
	Tarnagulla*				
Elmore W.W.T. (1891)	Elmore	Nil	99	750	Bores
Goornong W.W.T. (1961)	Goornong	Nil	20	150	Pumped from Campaspe River
Heathcote W.W.T. (1893)	Heathcote	Nil	109	1,690	Reservoir on McIvor Creek
	Tooborac				
Korong Shire Council ((1875) (1882) ((1882)	Inglewood*	Nil	273	1,450	Pumped from Loddon River
	Korong Vale*	Nil	318	1,660	Rocklands and Lonsdale Reservoirs via SR&WSC channel
	Wedderburn*	Nil			
	Borung +	Nil			
	Mysia +	Nil			
	Wychitella +	Nil	15	100	SR&WSC channels
Landsborough W.W.T. (1964)	Landsborough	Nil	36	350	Malakoff Creek
	Navarre	Nil	19	200	Landsborough W.W.T.
Longwood W.W.T. (1891)	Longwood	Nil	32	240	Nine Mile Creek
Maryborough W.W.T. (1882)	Maryborough	Nil	1,590	8,000	McCallums Creek and Tullaroop Reservoir
Murchison W.W.T. (1890)	Murchison	Nil	273	900	Pumped from Goulburn River
	Murchison East				
Nagambie W.W.T. (1886)	Nagambie	Chlorination	106	1,560	Pumped from Goulburn River
Redbank W.W.T. (1968)	Redbank	Nil	5	115	Reservoir Creek
Talbot and Clunes Shire Council (1873) (1876)	Talbot*	Nil	65	650	Stony Creek
	Clunes*	Nil	170	1,260	Birches Creek
St. Arnaud W.W.T. (1898)	St. Arnaud	Nil	468	3,700	Reservoirs on Strathfillan Creek, Mount Teddington
Stawell W.W.T. (1882)	Stawell	Nil	650	6,070	Fyans Creek (outside study area)
	Glenorchy	Nil	10	100	Pumped from Wimmera River
	Great Western	Nil	21	200	Panrock Creek (outside study area)
Rushworth W.W.T. (1898)	Rushworth	Nil	318	1,600	Pumped from Waranga western main channel
East Loddon Shire Council	Serpentine +	Nil			Pumped from irrigation supply channel
SR&WSC	Marnoo	Nil	100	450	SR&WSC channel
	Newstead	Nil	50	450	Jim Crow Creek
	Corop	Nil	4	30	Pumped from Waranga western main channel
	Dingee	Nil	7	80	Pumped from irrigation supply channel
	Stanhope	Chlorination	60	600	Pumped from irrigation supply channel
	Mitiamo	Nil	17	156	Pumped from domestic and stock supply channel

W.W.T. = Waterworks Trust
SR&WSC = State Rivers and Water Supply Commission
* = Proclaimed Water Supply District
+ = Supplied by municipality under the *Local Government Act.*

22. PUBLIC UTILITIES AND INSTITUTIONAL USES

In addition to the supply of water, several other types of public services or utilities have important implications for the use of public land. A continuing need for these services is created by the expected growth of the main population centres.

Utilities

Waste disposal

In the study area, waste disposal is becoming an issue of growing magnitude for both the urban and rural sectors - in social, economic, and environmental terms.

The bulk of solid waste disposal has traditionally occurred by land fill in disused quarries, on land reserved for municipal dumps, or on land with low economic productivity. Many disposal sites have been established in scattered locations on public land throughout the area, but availability of suitable sites is rapidly diminishing. More stringent regulations regarding the siting, operation, and rehabilitation of disposal areas has also effectively reduced the number of potential sites. Most towns currently operating land-fill schemes will probably require additional sites in the forseeable future.

The disposal of liquid waste to land or streams is licensed by the Environment Protection Authority. In the study area the delegated agencies acting for the Authority are the Commission of Public Health (for discharge to land) and State Rivers and Water Supply Commission (for discharge to streams).

Bendigo, Castlemaine, Maryborough, and Stawell Sewerage Authorities are licensed to dispose of purified effluent to streams, while the St. Arnaud Sewerage Authority is licensed to dispose of treated effluent by irrigation. Nagambie and Heathcote Sewerage Authorities should have fully operational works by 1980, and will use irrigation to dispose of their effluent.

Under the *Sewerage Districts Acts*, municipal councils or local Waterworks Trusts can initiate proposals for the provision of sewerage facilities for country towns. It normally takes several years to approve and construct such a scheme. Currently the one for Rushworth has been approved by the Water Commission, and Waranga Shire Council is expec-

ted to proceed with the constitution of a sewerage authority in the near future. Proposed schemes for Colbinabbin, Murchison, and Stanhope are being considered by the Health Commission and Water Commission. These involve the disposal of effluent by irrigation, but it is not expected that they will be completed and the towns sewered before 1982.

Electricity

Most of the power within the study area comes from the State's electricity network, although some is generated by a small (2-MW) hydroelectric station at the Cairn Curran Reservoir. There are a number of main transmission lines, and a substantial network of sub-transmission and distribution facilities. Most of the low- and medium-voltage lines run in road reserves, but some sections are in easements, often in private land.

The State Electricity Commission has numerous proposals for additional facilities to be successively built over the next decade to complement existing works. In some cases the routes for transmission lines have not yet been selected, although many proposals include the duplication of existing lines.

Transport

Several recent regional studies have examined the existing extent and possible development of the transportation network. Currently the main form of transport is by road, although rail also plays an important role. Land reserved for roads and railways covers a considerable amount of the study area. The width of these public land reserves varies between 20 m and 200 m and they often contain valuable relics of natural vegetation. (Chapter 12 discusses their significance for nature conservation, while chapter 13 considers their recreation potential.)

The construction of roads into forested land for timber extraction and fire control has increased accessibility for the public. Today, few localities are more than 3 km distant from conventional two-wheel-drive vehicular access. While some forestry roads have been upgraded to form important thoroughfares, many have reverted to overgrown tracks since logging operations have ceased.

While it has no "government aerodromes", the study area contains three licensed ("public") ones - at Bendigo, Maryborough, and St. Arnaud - and a number of Authorized Landing Areas ("private" airfields). Licensed aerodromes are usually owned by the municipality concerned, which shares the maintenance costs with the federal government. All these areas are used regularly by crop dusters, flying enthusiasts, freight operators, passengers, and the air ambulance service. A regular air service is available between Bendigo and Melbourne, and charter flights have also increased in recent years.

Other services

In addition to telephone facilities, telecommunication transmission and repeater sites occupy a number of elevated areas of public land. As the communication needs of the area grow, additional facilities on existing sites and new sites with access roads will be required.

Table 32

SCHOOL CAMPS

School	Camp	Vicinity	Capacity			Development*	Date allocated	Ownership
			Boys	Girls	Staff			
Black Rock	Wychitella	Wedderburn 38 km	8	8	3	B	October 1974	Freehold
Castlemaine	Faraday	Harcourt 6 km				B	March 1977	Public land and freehold
Ferntree Gully Inspectorate	Yumbunga	Lake Eppalock	25	25	8	A	1970	Lease (SR&WSC)
Gardenvale Central	Fryerstown	Chewton 8 km	20	18	7	A	December 1973	Public land
Kangaroo Flat	Myrtle Creek	Lake Eppalock 13 km				C		Public land
Keilor South	Strangways	Newstead 3 km	17	18	4	A	August 1972	Public land
Brunswick	Lake Eppalock	Lake Eppalock	20 or 20		6	A	September 1969	Lease (SR&WSC)
Macleod	Lake Eppalock	Lake Eppalock	20	20	4	B	December 1974	Lease (SR&WSC)
Maryborough	Betley	Maryborough 16 km	20 or 20		2	B	October 1972	Public land
Richmond	Lake Eppalock	Lake Eppalock	20 or 20		4	A		Lease (SR&WSC)
	Neilborough East	Raywood 10 km	Environmental studies centre			B		Public land
Bendigo Inspectorate	Shelbourne East	Marong 10 km				C		Public land

* Level of development:
A Permanent facilities for sleeping, ablutions, cooking, and eating
B Partly developed facilities, site in use
C Partly developed, site not yet in use

Other public uses requiring small areas of public land include hospitals, schools, cemeteries, navigation aids, and trigonometric stations.

Institutional Uses

Military

The Australian Army and Army Reserve uses the Puckapunyal Military Area of 20,750 ha (11 km north-west of Seymour) as a permanent base for military training throughout the year. Approximately half of this lies within the study area, but it belongs to the Commonwealth and is therefore not public land as defined by the *Land Conservation Act* 1970.

As far back as 1961 there were proposals to acquire additional land for training to the west of the existing military area. In 1976 an Environmental Impact Statement prepared by the Department of Defence proposed that 20,048 ha of land, including three large blocks of public land, be acquired for defence purposes. Two of these forested areas would be used for armoured-vehicle training, while the third would be used for infantry training only. The Army proposed that public access to the area be permitted subject to similar conditions to those existing for the present Puckapunyal Military Area.

The Victorian government has since agreed in principle with the proposal, but has requested the clarification of a number of issues, predominantly environmental considerations.

In addition, a number of other areas of public land are currently used on an *ad hoc* basis for specific army exercises. This requires prior approval from the responsible managing authority and is unlikely to pose a threat to public safety or cause major inconvenience.

School camps

School camps for environmental education and recreation are popular in the study area. Table 32 lists 12 camp sites, many of which have permanent accommodation facilities. Five are situated in the vicinity of Lake Eppalock, while the remaining seven are scattered in the central part of the study area. All but one of the camps are located on, or partly on, public land.

23. LAND USE RELATIONS

The preceding chapters of this report have described the natural resources of the study area, along with the existing and potential types of land use. Each type requires certain resources, but in many cases those required for different uses overlap, providing a source of potential conflict. There is a growing demand for resources on public land from groups with a wide range of interests.

Land uses are considered to be competitive when an increase in one leads to a decrease in another based on the same set of resources, supplementary when a change in one does not change another, and complementary when an increase in one benefits another.

The more obvious physical or economic aspects of such interactions are only part of land use relations. There are also other direct and indirect effects, such as social or environmental consequences. All these factors collectively determine the degree of compatibility of various land uses.

These interactions (land use relations) must therefore be considered before decisions can be made regarding the uses of public land. What are the long-term effects of the present or short-term use of the land, realizing that future needs may differ markedly? Does any activity or use preclude, by its operation, another's utilization of a given resource?

This chapter considers some of the interactions between the following land uses in the study area - agriculture, apiculture, eucalyptus-oil production, mining, nature conservation, recreation, timber production, utilities, and water production.

Agriculture

Grazing and crop production are currently the main uses of private land in the study area. In addition, about 27% of the public land is grazed under licence or agistment. Agriculture, therefore, interacts considerably with a number of other forms of land use.

Some native animals have benefitted from the increased area of grassland and forest margins resulting from agricultural development. Farm dams have extended the range of some amphibians, reptiles, and bird species. Nevertheless, agriculture is normally incompatible with most aspects of nature conservation

because, although some benefit, most species are severely reduced in number or eliminated by the removal of their habitat and the introduction of alien plants and animals.

Agricultural activities have in many cases added visual variety to the landscape, increasing enjoyment for those sightseeing, picnicking, or driving for pleasure. The undulating hills around Sutton Grange provide an example of a scenic agricultural landscape. In most cases agriculture has little effect on water production; conversion from forest to grassland can change run-off characteristics, however, sometimes causing erosion and so affecting water quality.

The use of additional public land for agriculture would compete, in particular, with timber production, apiculture, eucalyptus-oil production, and most aspects of nature conservation, and to varying degrees with most other forms of land use. Forest grazing may aid fire protection, however, by reducing the accumulation of fine fuels in forested areas.

The greatest conflict with existing agricultural use in the study area arises from the increasing pressures of urbanization, tourism, and recreation. This relatively recent trend means a new demand for non-agricultural forms of land use in agricultural areas. The activities of land speculators are forcing the land prices and rates to rise well in excess of economic rural values. Farmers on viable properties are therefore placed under increasing pressure to subdivide their land for "rural retreats" or hobby farms for people from Melbourne and local towns.

Apiculture

Apiculture may complement agriculture where the bees serve the useful function of cross-pollination. As noted above, however, the replacement of forests by pasture is usually detrimental to honey production.

Being based largely on the maintenance of native flora, apiculture is supplementary to timber production, recreation, water production, and some aspects of nature conservation.

Bees do compete with native fauna for nectar and pollen, but the significance of this competition and its ecological effects remain unknown.

Eucalyptus-oil production

Eucalyptus-oil production - a relatively inflexible activity - competes with all other forms of land use. Regular harvesting, although suiting the industry, appears detrimental to apiculture, recreation, and nature conservation. The actual ecological effects of repeated harvesting of foliage are not known, although studies indicate a reduction in diversity and number of floral species.

Adverse effects are moderated to some extent by the normal practice of leaving uncut patches of mallee scattered through the area being harvested. Current methods of harvesting can also cause erosion hazards and lead to reduction in water quality. Rowan (1963) describes areas of blue mallee, regularly cut for eucalyptus oil, that have suffered severe sheet erosion, and claims that run-off from these produces a gullying hazard on surrounding low lands.

He also considers it important to leave eucalyptus stalks after harvesting, to minimize wind erosion. Such recommendations are now being incorporated into management plans for areas such as the Whipstick Forest Park.

Mining and quarrying

Operating mines and current areas of quarrying are scattered throughout the study area. These have varied effects on other land uses depending on the type and scale of the operations. Most conflicts with landscape values are localized, but they may be serious where the values are high or the operations are obvious. Site rehabilitation can reduce these effects.

Most of the mines only compete with other uses in the immediate vicinity of their operation, whereas some of the larger extractive industries have widespread deleterious effects due to factors such as major site disturbance, indiscriminate roading, polluted run-off, and lack of regeneration.

On the other hand, some quarries are complementary with the study of aspects of natural history, providing sites for fossil collection and geological study. Sites may also facilitate the collection of gemstones. Exhausted quarries and open-cut mines are often useful for rubbish disposal, or as sites for forms of recreation such as trail-bike riding.

Most forms of mining and quarrying are incompatible with timber production, water production, apiculture, agriculture, nature conservation, and eucalyptus-oil production. Many relics of last century's mining boom, however, are now extremely popular with tourists for their historical interest. Some (like the Balaclava Mine at Whroo) remain derelict, while others (like the Wattle Gully Mine) have been developed with tourist facilities.

Nature conservation

Nature conservation is generally compatible with a wide range of uses, such as water production, apiculture, and low-intensity recreation and hardwood production. It tends to compete with any activities that radically change the natural vegetation, such as mining, agriculture, or urban development.

A major problem in many nature conservation areas is the threat of over-use for

recreation, because these areas are often fixed in the public mind primarily as recreational resources. Other aims of parks and reserves, such as biological conservation, landscape preservation, and research opportunities, are therefore threatened.

Areas set aside specifically for reference must be managed to exclude activities other than limited scientific study. This use is complementary with nature conservation and water production only.

Recreation

Outdoor recreation encompasses a wide range of activities, and their interactions with other land uses vary according to the type of recreation and its intensity.

Some recreational activities actually depend on other land uses - for example, many of the water-based pursuits require the storages used for water production. Other activities need their own particular areas with specialized recreational facilities (golf courses, trotting tracks, etc.). Also, some informal types of recreation need natural undisturbed sites, and these compete with all other land uses, except perhaps nature conservation and water production.

A single land use in a particular area may conflict with one type of recreation, and yet simultaneously complement another. For example, an abandoned quarry may mar a panoramic view for sightseeing, yet provide an ideal site for gem fossicking. Similarly, forestry tracks may reduce the value of an area for nature study, but make it more accessible for picnicking and pleasure driving.

Most recreational activities are relatively flexible, however, and can be accommodated in areas managed primarily for other uses. Nevertheless, some (such as fishing or the use of off-road vehicles) can become self-competitive, especially at high usage rates.

Timber production

Although timber production is widespread on public land in the study area, it is of low intensity in most areas and therefore does not conflict with many other types of land use. At these intensities, hardwood production is compatible with forest grazing, apiculture, and some forms of nature conservation. Roading associated with forest protection and harvesting operations also benefits some types of outdoor recreation by providing access tracks for walking and pleasure driving. Timber production competes with recreation activities requiring solitude in natural areas.

Harvesting operations have an immediate effect on vegetation, fauna, and landscape values, but most of these effects are short-term. If the intensity of the operations remains the same, the larger

the harvested area is the greater and more protracted will be the effects. Increasing the intensity of hardwood production further decreases its compatability with other uses, particularly nature conservation and recreation, although increasing the intensity of harvesting may reduce the total area required.

Softwood production competes with most other forms of land use, but occurs in only a small part of the study area. These plantations have limited use for passive recreation.

Public utilities and transport

Generally the provision of these services requires the allocation of small areas of land only, but in most cases this represents an inflexible use.

Due to growing recreational pressures and more interest at a local level in nature conservation, there are increasing problems with waste disposal. Most disposal sites are generally regarded as unsightly, sometimes produce offensive odours, and, if not carefully managed, may have detrimental effects on other uses such as water production.

Cleared easements for transmission lines or gas or water pipes are competitive with vegetation and some wildlife habitats, and may be visually unattractive from surrounding areas. Similarly, telecommunication facilities on peaks or ridges conflict with scenic and other values, especially when sited on attractive or remote landscapes.

Since these services, and most others, are considered essential, however, compatability with other land uses is achieved by careful siting and location to minimize the conflicts.

Water production

The production of water is an important use of public land. To some extent it is competitive with agriculture, hardwood timber production, mining, and recreation, depending on the intensity of these uses, the management techniques employed, and the intended use for the water.

Activities such as logging, road-making, clearing, and grazing can cause soil disturbance and reduce water absorption, leading to increases in surface flows, stream turbidity, peak stream flows, and siltation. Extensive restoration and conservation works were necessary in the Puckapunyal military training area to control excessive siltation, which was affecting the Goulburn River system.

Four catchments in, or partly in, the study area are proclaimed water supply catchments under the *Soil Conservation and Land Utilization Act* 1958. Land use determinations have been made for the Avoca water supply catchments and for parts of the Eppalock catchment. Notic-

es have also been gazetted prohibiting changes in land uses in parts of the Cairn Curran water supply catchment.

In many cases, activities involving only the use of catchments (as distinct from storage areas) are not regarded as posing a substantial threat to either water quality or yield. Such catchment areas are therefore normally complementary with nature conservation and, to varying degrees, with other forms of land use.

Nevertheless, the actual storages can have various effects on nature conservation. Inundation by water destroys the original habitats, and this may be significant if the area contains endemic species or notable features. Storages also alter flow regimes and may also affect water temperature and oxygen content, and consequently wildlife habitats downstream.

On the other hand, storages also create a new aquatic habitat, which has value for some fish and waterfowl, and the resultant recreational activities of hunting and fishing. While water storages complement all water-based recreation and lakeside activities, however, their uncontrolled use may also cause detrimental effects, particularly if they provide urban supplies.

Much controversy exists over the land use relations incurred by River Improvement Trusts. Two such Trusts here (Bendigo Creek and Bullock Creek) carry out streamside conservation and drainage works under the *River Improvement Act* 1948.

The districts controlled by each of the Trusts encompass only sections of each creek, so the "improvements" made in one area may also cause adverse ecological effects downstream. Rogan (1977) advocates a broader "total-catchment" approach, or the co-operative co-ordination of existing groups.

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PART IV

BLOCK DESCRIPTIONS

BLOCK DESCRIPTIONS

Nine arbitrary blocks have been delineated in North Central to provide more detail in particular areas. The block boundaries are shown in a key diagram at the beginning of each description, although greater detail is shown in Map 1.

These block descriptions describe the characteristics and nature of the land, its capabilities for various uses, and the likely hazards and conflicts involved with such uses. The discussion refers specifically to public land, but it also describes outstanding capabilities or other features of special significance.

A consistent format of headings and subheadings is used so that specific information can be readily found for any block, and comparisons can be easily made between blocks.

Capability

This term refers to the suitability of public land for the particular use to which it may be put. Assessment is based on a number of considerations, including the inherent characteristics of the land, the proximity of public land to centres of population, the level of accessibility within it, the relative scarcity of the type of land, and the hazards associated with the various uses. Present levels of use are described to give some indication of capability.

In most cases, capabilities are given in general terms only, because the amount of information available varies from block to block, and because some of the values are difficult to quantify. The ratings for various uses thus cannot be directly compared with each other.

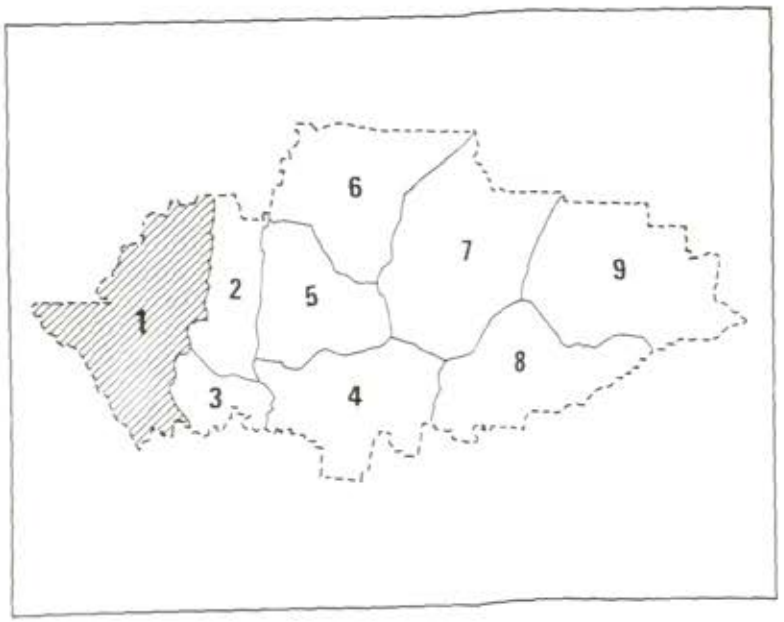
In assessing capability, comparisons have been made with other blocks, and where practicable, with other parts of the State.

1. CALLAWADDA

General

Callawadda block occupies the western end of the study area; the town of Stawell lies on its western boundary. Public land occupies only 11,000 ha, or 4% of the block. It consists mainly of reserved forest, but there are also numerous narrow public land reserves along streams and rivers.

Most of the land is used for agriculture.



Nature of the Land

Climate

Average annual rainfall decreases from more than 550 mm in the south to around 440 mm in the north. Temperature, frost, actual rainfall, and effective rainfall probability data for Stawell are listed in the climate chapter (Tables 2--5).

Geology and physiography

The southern and eastern parts of this block are of moderate topographic relief. The rocks - Cambrian to Lower Ordovician sediments - form a prominent ridge running from Navarre to Mount Bolangum. Around Great Western, granitic rocks of Devonian age outcrop. In the north and west the topography becomes subdued, and undulating Cambrian to Lower Ordovician sediments are covered in part by younger Tertiary marine and non-marine sediments of the Murray Basin.

Quaternary alluvium associated with the stream system forms extensive flat areas near Navarre, along the Wimmera, and north of Glenorchy.

Soils

The steep hills to the south carry shallow stony gradational soils, whereas red sodic duplex soils are more common on the gentler topography formed on Ordovician sedimentary rock.

Extensive areas have mottled duplex soils with ironstone and yellow sodic duplex soils with coarse structure. On the riverine plains and alluvial flats, red calcareous duplex soils predominate. In the majority of land systems the drainage lines contain yellow duplex soils or yellow gradational soils.

Vegetation

Almost all the vegetation on public land is either grey box--yellow gum or red ironbark--grey box--yellow gum open forest, although small pockets of red stringybark--red box--long-leaf box open forest are scattered throughout, and river red gum woodland occurs around some of the lakes in the north and along streams. Appendix 1 lists other species commonly associated with these eucalypts.

Fauna

The following habitats are represented: open forest, woodland, pasture--grassland, and aquatic. Apart from the lakes in the north, the public land is mainly open forest and woodland. The common animals of these habitats are listed in Appendix 2. The occurrence near Stawell of the squirrel glider, a rare species, is of interest.

Mount Bolangum

Land systems groups

Geomorphic groups of land systems (which are described in chapter 12) are distributed in the block as follows: alluvial 40%; Tertiary sediments 43%; Palaeozoic sediments (1) 13%; Palaeozoic sediments (3) 1%; metamorphics 2%; and granite (1) 1%.

Although the alluvial and Tertiary sediment land systems collectively comprise a large proportion of this block (83%), their actual representation in the few

Squirrel glider, a rare species recorded near Stawell

scattered areas of public land is minimal. These areas of public land are composed mainly of Palaeozoic sediments (1 and 3) with some Tertiary sediments.

Capabilities

Nature conservation

The public land contains almost all the bushland in the block and thus has value for the provision of a habitat that is rare here. The squirrel glider (rare in Victoria) occurs near Stawell. The lakes in the north provide valuable wetland habitat for many bird species.

Recreation

The forested public land does not have outstanding value for recreation, although the general lack of forest in the block accentuates its value for picnicking and nature study.

The lakes in the north, particularly Lakes Cope Cope and Batyo Catyo, are valuable for picnicking, fishing, duck-shooting, and boating.

Agriculture

Much of the public land has low capability for agriculture, but some areas, mainly those carrying grey box, have moderate capability. Most of the public land is held under grazing licences.

Apiculture

The public land has high capability for apiculture, but most of the block is cleared freehold land.

Eucalyptus-oil production

Capability of the public land in this block is low.

Timber production

The public land generally has high capability for the production of durable hardwood timber and firewood, despite slow growth rates.

Mining

The southern part of this block contains the Stawell gold-field. Although no mines are currently operating, the area is regarded as having a reasonable potential for further development from ore reserve projections. Exploration licences for parts of the gold-field are regularly requested.

Stawell, Deep Lead, Great Western, and Armstrongs were major alluvial and deep-lead mining areas. Little is known of the Wimmera deep-lead system during its course through this block.

Grey box woodland

Shoestring sands associated with Quaternary alluvial deposits in the west of the block supply sand and gravel on a small scale and offer potential for further use. The Tertiary Parilla Sand is widely used for surfacing unmade roads.

Water

This block includes a large part of the Avon River catchment in the north, and part of the Wimmera catchment (most of which lies outside the study area).

Average annual run-off varies from about 50 mm in the south to a negligible amount in the north.

The public land has only low potential for supplying water because of its small area and the low run-off. Groundwater supplements supplies of surface water, and the possible reserves may be significant.

Water for Stawell, Glenorchy, and Great Western is supplied by the Stawell Waterworks Trust. Marnoo, however, receives supplies from a State Rivers and Water Supply Commission channel. Batyo Catyo Reservoir lies in the north-west of the block, most of which falls within the Wimmera--Mallee Stock and Domestic System.

Hazards and Conflicts

Serious sheet erosion occurs when steep hills of Ordovician sandstones and mudstones are cleared or overgrazed. The hydrological equilibrium is upset, leading to the development of saline springs. Evidence suggests that the rising saline water table on the riverine plains - for example, along the Richardson River - is the result of over-clearing the steep hills in the upper catchment.

The light sandy soils on Tertiary gravel deposits are prone to severe wind erosion if cleared and cultivated.

There are few conflicts between potential uses of public land. Forest grazing may conflict with nature conservation, and cutting older trees for timber may conflict with apiculture and reduce the availability of nest sites for birds and mammals requiring tree hollows. Recent changes in forest management minimize this conflict.

Significance

The lakes in the north are valuable for recreation and nature conservation. The forested blocks have significance as isolated areas of bush in a predominantly cleared landscape.

2. ST. ARNAUD

General

This block extends for 65 km from north to south, incorporating a major range of hills and surrounding country. The range has been known by several names, but in this report is called the St. Arnaud Range to avoid confusion.

St. Arnaud, in the north, is the only major town, although there are several small settlements such as Barkly, Redbank, and Stuart Mill.

Public land is confined mainly to the St. Arnaud Range and to an area of mallee north-east of St. Arnaud. It amounts to 25,000 ha (21% of the block). Most of it is reserved forest.

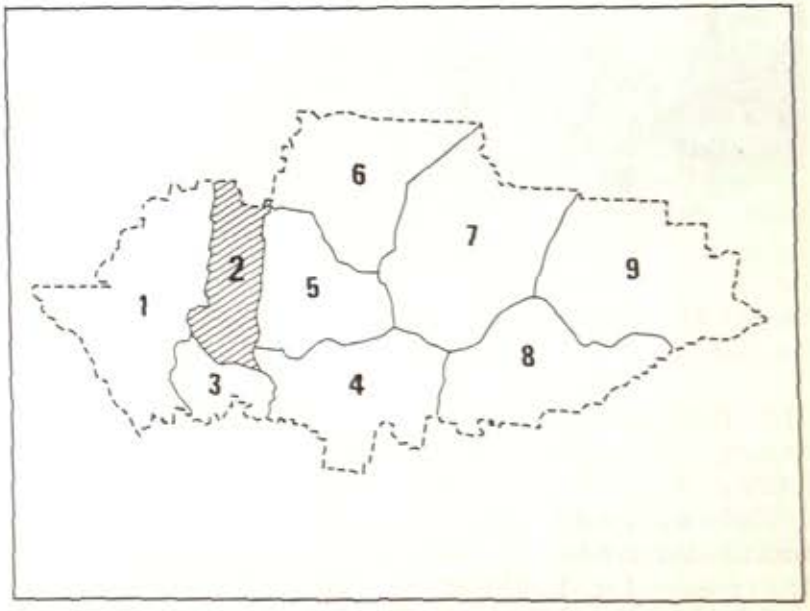
Nature of the Land

Climate

Average annual rainfall varies from about 420 mm in the north to about 600 mm in the southern part of the St. Arnaud Range. Temperature, frost, actual rainfall, and effective rainfall probability data for St. Arnaud are listed in the climate chapter (Tables 2--5).

Geology and physiography

This block is dominated by Cambrian to Lower Ordovician sediments, which form the St. Arnaud Range. Although dissected by numerous creeks, the range runs north--south through most of the block. The public land occupies the higher and steeper parts of this range, with private land in the valleys and around the range. North of St. Arnaud, Lower Palaeozoic sediment, schist, and granite



form gently undulating topography - particularly north of Sutherland, where Tertiary sediments overlie these rocks. In the north-eastern corner of this block and north of Emu, granitic rocks form prominent hills such as Yawong Hill. Flat areas of Quaternary alluvial sediments are extensive around Sutherland.

Soils

The southern part of the St. Arnaud Range has shallow stony red gradational and yellow gradational soils. To the north, the red gradational and red sodic duplex soils occur on the remaining Ordovician sedimentary rock. Uniform coarse sands occur on the steep granite outcrops, but on the lower slopes red duplex soils overlie a dense hardpan layer impregnated with silica. Red calcareious duplex soils predominate on the river flats.

Vegetation

Vegetation in this block varies greatly from north to south. North-east of St. Arnaud, a large parcel of public land is vegetated with mallee - mainly blue mallee.

The northern part of the St. Arnaud Range is forested, mainly with red ironbark, yellow gum, and grey box, although red box, red stringybark, and long-leaf box also occur. These latter species increase in dominance further south until the ironbark, yellow gum, and grey box are few and scattered. Yellow box woodland occupies ridge-top sites in the central part of the St. Arnaud Range.

In the wetter parts of the southern end of this range, blue gum and manna gum grow on sheltered sites. Other species commonly associated with the various eucalypts are listed in Appendix 1.

Cane spear-grass, a rare and localized species, inhabits rocky streamsides in the St. Arnaud area.

Fauna

The following habitats are represented: open forest, woodland, mallee, pasture--grassland, and aquatic. The public land is nearly all open forest. Appendix 2 lists the common animals of these habitats.

Land systems groups

Geomorphic groups of land systems (which are described in chapter 12) are distributed in the block as follows: alluvial 12%; Tertiary sediments 20%; basalts 1%; Palaeozoic sediments (1) 40%; Palaeozoic sediments (3) 18%; metamorphics 1%; granite (1) 3%; granite (2) 6%.

Stretching from St. Arnaud to Moonambel, the public land in this block is composed mainly of Palaeozoic sediments 1 and 3. Small areas of Tertiary sediments also remain as public land.

Capabilities

Nature conservation

The public land supports a wide range of vegetation types with their associated flora and fauna. It includes the habitat of cane spear-grass, a rare plant. The ridge-top occurrence of mature yellow box is unusual.

Recreation

Most of the public land is little used for recreation, although parts of the St. Arnaud Range are attractive and provide good views. Some areas around St. Arnaud are locally valued for wildflower displays. The Teddington Reservoirs near Stuart Mill are popular for picnicking and fishing.

Agriculture

The public land generally has low capability for agriculture. Almost all of it is held under grazing licence.

Apiculture

Most of the public land has high capability, but the forest at the southern end of the St. Arnaud Range has only moderate capability. A notable feature of this block is the occurrence of mature yellow box along the ridge-top in the central parts of the St. Arnaud Range, although heavy nectar flows are infrequent.

Eucalyptus-oil production

North of St. Arnaud an area of about 800 ha of blue mallee has high capability for eucalyptus-oil production. The rest of the public land has low capability.

Timber production

The box--ironbark forests of the northern St. Arnaud Range have high capabil-

View from the "West of England Lookout", looking south along the St. Arnaud Range to Mount Avoca and Mount Cole

Part of an area north-east of St. Arnaud from which gravel has been stripped

ity for production of durable hardwood timber and firewood. The stringybark forests of the southern part of the Range have low capability.

Mining

This block contains two major gold-fields. The St. Arnaud gold-field is of continuing interest, as reef gold was produced essentially from only one mine. The ore is also characterized by the presence of lead and a high silver content and has potential has a base-metal field. Towards the south in the Stuart Mill--Redbank--Moonambel area (Pyrenees gold-field), many reefs were worked for a short period, many only to the water table. This latter area offers potential for small-scale mining operations.

Tertiary deposits east of St. Arnaud and north of Navarre may contain large gravel reserves of value for local use. Granitic sand is present in the north-eastern corner of the block.

Water

The St. Arnaud Range divides the Avon River catchment from the Avoca River catchment to the east. A small part of the Wimmera catchment extends into the southern end of the block. Average annual run-off is negligible in the north, increasing to around 50 mm in the south.

The St. Arnaud and Redbank Waterworks Trusts serve their respective towns for urban supplies.

Hazards and Conflicts

The St. Arnaud Range is prone to severe sheet erosion and landslips where clearing or roading occurs. The range is also a large supplier of salt to surface springs and groundwater.

In the cleared granite country, sheet erosion and landslips occur on the steep outcrops whereas, on the gentler slopes, the drainage lines are prone to gully erosion following clearing or over-grazing.

Extensive mechanical harvesting of eucalypts for eucalyptus oil north-east of St. Arnaud may conflict with nature conservation. Extensive gravel extraction further north-east conflicts with most other uses.

Significance

The St. Arnaud Range is a valuable source of durable timber and honey. The Teddington Reservoirs are valuable for recreation.

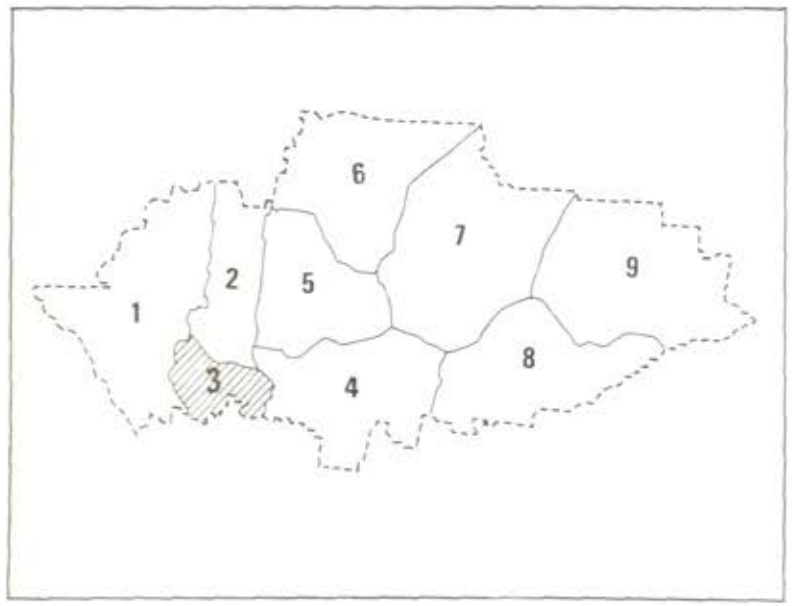
3. PYRENEES

General

As its name implies, this block in the south-west of the study area covers the Pyrenees and surrounding land.

Avoca, on its eastern boundary, and Landsborough, in the west, are the only significant towns.

The Pyrenees are mainly public land, virtually all of which is reserved forest, while the surrounding land is almost all privately owned. Public land occupies a total area of about 21,000 ha (31% of the block).



Nature of the Land

Climate

Rainfall ranges from about 500 mm in the west to an estimated 750 mm or more in the higher parts of the Pyrenees. Data on temperature, frost, actual rainfall, and effective rainfall probability for Avoca are listed in the climate chapter (Tables 2--5).

Geology and physiography

The Ordovician sediments forming the Pyrenees dominate here, with steep slopes and some rocky cliffs. Most of the range is public land, including Mount Avoca (760 m), which is the highest point in the study area. The surrounding areas of recent colluvium and fan deposits on the undulating lower slopes are predominantly private land.

Soils

This block has mainly red shallow gradational soils on steep slopes. Where

the steep areas are of granitic origin, the soils are uniform coarse sands, but a brown duplex soil with a coarse structure occurs in the drainage lines.

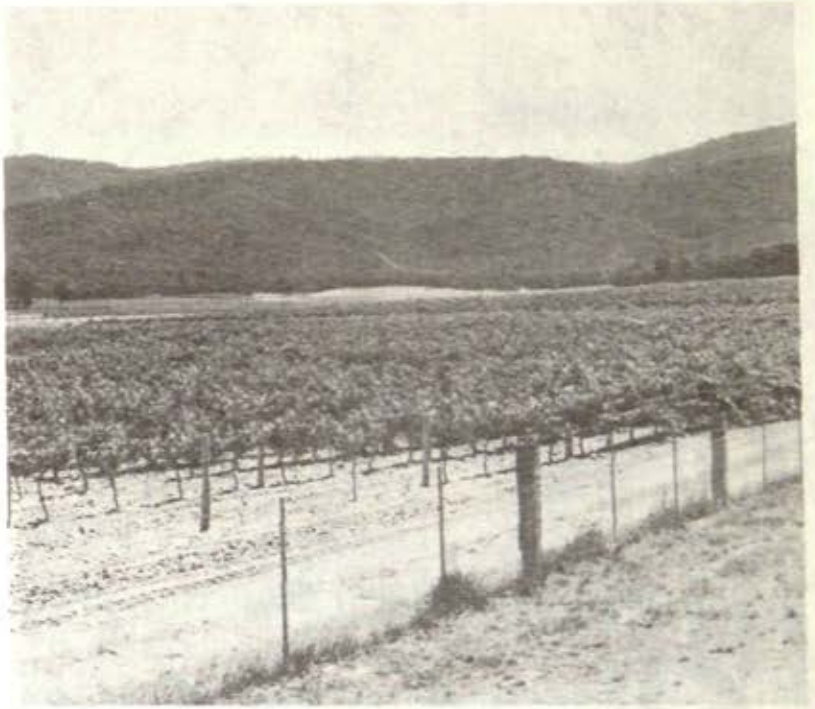
A red sodic duplex soil is found on the gentler topography associated with Ordovician sedimentary rock, and a mottled duplex soil occurs on the remnants of Tertiary river gravel deposits. The flat land adjacent to the Avoca River and its tributaries is predominantly a red calcareous duplex soil.

Vegetation

Messmate--gum open forest III dominates the vegetation of the higher parts of the block, which receive the greatest rainfall. A distinctive feature of the vegetation is the open woodland of yellow box that occurs along the top of the Landsborough Ridge in the west. The lower slopes carry red stringybark--long-leaf box--red box open forest I, while grey box and yellow gum occur in the north-west. Appendix 1 lists other species commonly occurring in association with the dominant eucalypts.

Fauna

The following habitats are represented: tall open forest, open forest, woodland, pasture--grassland, and aquatic. Most of the tall open forest of the study area is on public land within the block. Appendix 2 lists the common animals of these habitats.



Vineyard at the foot of the Pyrenees

Land systems groups

Geomorphic groups of land systems (which are described in chapter 12) are distributed in the block as follows: alluvial 13%; Tertiary sediments 8%; Palaeozoic sediments (1) 42%; Palaeozoic sediments (3) 31%; metamorphics 6%; granite (1) <1%; granite (2) <1%.

Most of the public land, approximating the Pyrenees, is composed of Palaeozoic sediments (3). Some of the lower-slope areas remaining as public land are Pal-

Messmate--gum open forest, on the Pyrenees

aeozoic sediments (1) and Tertiary sediments.

Capabilities

Nature conservation

This block differs from the rest of the study area, containing the most extensive stands of messmate--gum open forest III, although this vegetation type also occurs in neighbouring areas, such as at Mount Cole. The ridge-top occurrence of mature yellow box on the Landsborough Ridge is unusual.

Recreation

Generally the public land is not highly valued for recreation. A picnic area and walking tracks at Number 2 Creek near Avoca are quite popular. The Landsborough Ridge is attractive for bushwalking, although not well known.

Agriculture

Capability of public land for agriculture is low. Although the Pyrenees receive greater rainfall than the rest of the study area, slopes are mostly too steep to be cleared without the likelihood of severe erosion. Very little of the public land supports forest grazing.

Apiculture

Capability of most of the public land is moderate, although the grey box--yellow

gum forest in the north-west has high capability. Mature yellow box growing on public land in the western half of the block is not readily accessible.

Eucalyptus-oil production

Capability is low due to the lack of species suited to mechanical harvesting.

Timber production

The messmate--gum forests of the Pyrenees have a lower growth rate than similar forests in some other study areas, but are nevertheless important as a source of scantling timber. Their productivity is greater than that of the more durable but slower-growing species of the box--ironbark forests. The red stringybark forests of the foothills have only low to moderate capability for timber production.

Mining

Most of this block, making up part of the Pyrenees gold-field, was extensively mined and prospected for gold last century. Many reefs were worked for a short time, many only to the water table. Alluvial mining was extensive near Landsborough, with deep-lead mining along the Avoca River.

Water

The Pyrenees forms the eastern limit of the Wimmera catchment. The eastern slopes of the Pyrenees drain into the Avoca River and include the Sugarloaf catchment, which supplies water to the town of Avoca. Run-off varies from around 40 mm at Landsborough to approximately 75mm in the south.

The Landsborough and Avoca Waterworks Trusts supply their respective towns.

Hazards and Conflicts

Clearing vegetation on the steep slopes can upset the hydrological balance of the soil and results in landslips, severe sheet erosion, and increased movement of salt into the surface springs and deeper groundwater.

The potential uses of the public land present few conflicts.

Significance

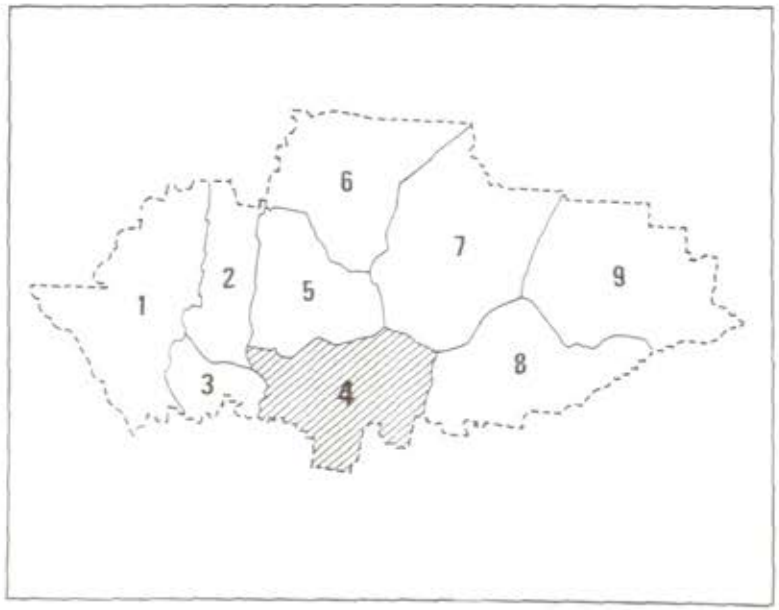
Although differing from the rest of the study area, this block has similarities to other parts of the State. It is not of outstanding value for any particular use, but is an important source of scantling timber in western Victoria.

4. MARYBOROUGH

General

The city of Maryborough lies in the centre of this block, which occupies the south-central part of the study area. Other towns include Avoca on the western boundary, Talbot and Clunes in the south, Carisbrook, and Maldon and Newstead near the eastern boundary.

Public land, although scattered throughout the block, mainly occupies the hillier country. Its total area (including Cairn Curran and Tullaroop Reservoirs) is 38,000 ha (17% of the block), most of which is reserved forest.



Nature of the Land

Climate

Annual rainfall averages about 450 mm in the north, increasing to approximately 580 mm in the south. Data on temperature, frost, actual rainfall, and effective rainfall probability for Avoca are listed in the climate chapter (Tables 2--5).

Geology and physiography

Most of the public land in this block - such as around Maryborough, Homebush, or Strathlea - comprises hilly to undulating Ordovician sediments. Streams dissecting these hills have laid down broad areas of Quaternary alluvium exemplified in the Avoca, Bet Bet, and Loddon valleys. Virtually no public land remains in areas like Moolort and Lillicur, where basaltic flows inundated river valleys during the Pliocene and Pleistocene epochs. Extinct volcanoes such as

Mount Moolort and Mount Greenock (the only volcano remaining on public land in the study area) provide topographical variation, but it is the granite intrusions (like Mount Beckworth) and contact metamorphosed sediments (like Mount Tarrengower) that form prominent peaks in this block.

Major deep leads pass northwards beneath the basalt and alluvial sediments.

Soils

In the south the granite outcrops have a uniform coarse sand soil. Most of the block has parent material of Ordovician sedimentary rock - the sequence of soils is a red gradational soil on the steeper areas with a red sodic duplex on the gentle slopes and a yellow duplex soil in the drainage lines.

To the east and west of Maryborough lie old basalt flows, where the main soil type is a heavy grey uniform clay subject to swelling when wet and cracking open when dry.

To the north-west the alluvial terraces associated with the Avoca River are composed of heavy gilgaied calcareous grey uniform clay and a red calcareous duplex soil.

Vegetation

The vegetation of this block is dominated by open forest of red ironbark, yellow gum, and grey box, with scattered stands of red stringybark, red box, and long-leaf box. On Mount Beckworth, woodland of messmate and manna gum occurs. Appendix 1 lists other species commonly associated with these eucalypts.

The brilliant sun-orchid, very localized and rare in Victoria, has been found in the Maryborough district. Whorled zieria, another rare species, has been recorded at Mount Tarrengower.

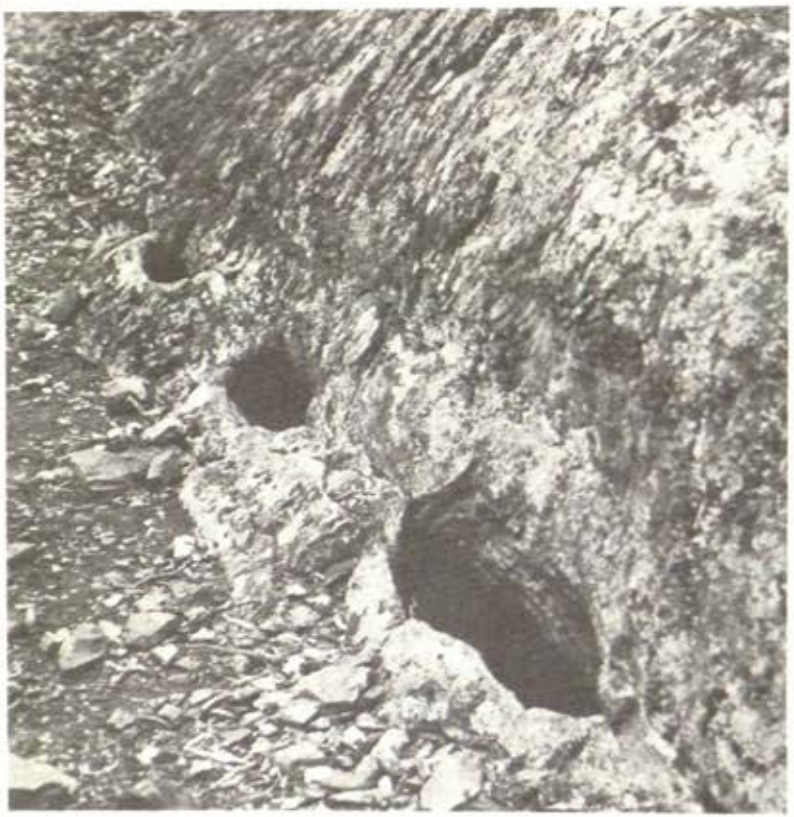
Fauna

The following habitats are represented: open forest, woodland, pasture--grassland, and aquatic. The public land is mainly open forest, but it also includes valuable aquatic habitat. The turquoise parrot, a rare species in Victoria, occurs at the south-west limit of its range near Maldon. Appendix 2 lists the common animals of these habitats.

Land systems groups

Geomorphic groups of land systems (which are described in chapter 12) are distributed in the block as follows: alluvial 10%; Tertiary sediments 7%; basalts 32%; Palaeozoic sediments (1) 35%; Palaeozoic sediments (2) 6%; metamorphics 3%; granite (1) 7%; granite (2) <1%.

Most of the public land is composed of Palaeozoic sediments (1), but while they cover a similar area of the block (32%),



Aboriginal rock wells near Maryborough

the actual extent of basalts remaining as public land is minimal.

Capabilities

Nature conservation

The box--ironbark forests around Maryborough, especially in the Paddy Ranges, are valued for their profusion of wildflowers and diversity of bird life. Two rare plant species, (the brilliant sun-orchid and the whorled zieria) have been recorded in the block. The colony of turquoise parrots near Maldon is especially important. Merin Merin and Middle Swamps near Clunes provide valuable wetland habitat.

The Big Reef, near Amherst, is one of the largest quartz outcrops remaining in Victoria.

The public land at Mount Beckworth has interesting vegetation and is of value for nature conservation.

The block also contains several sites of archaeological significance - three Aboriginal water wells on public land near Maryborough, and a ceremonial stone arrangement near Carisbrook on land recently purchased by the government.

Recreation

Wildflower displays in the box--ironbark forests around Maryborough, particularly in the Paddy Ranges, are a recreational feature of public land (Maryborough holds an annual Golden Wattle Festival).

Mount Tarrengower is popular as a viewpoint and for picnicking and trail-bike riding. Both Cairn Curran and Tullaroop Reservoirs are used for picnicking and fishing, and Cairn Curran is also used for boating and swimming. The Clunes swamps are popular for duck-shooting and bird-watching.

Agriculture

Capability of the public land for agriculture is generally low. Very little public land is used for forest grazing.

Apiculture

Capability of the public land for apiculture is high. Maryborough is the base for a substantial apiary industry, with one of the largest honey-processing and packing plants in Australia being situated there.

Eycalyptus-oil production

Some of the public land is used for the small-scale production of eucalyptus oil from yellow gum, red ironbark, and long-leaf box. Capability is low.

Timber production

The public land generally has high capability for production of durable hardwood timber and firewood. A small pine plantation at Mount Beckworth produces minor quantities of timber, but capability for softwood production is low.

Mining

Most of this block was worked in some form for gold from the 1850s until early this century. Numerous deep leads enter the study area along the southern boundary of this block and head north, eventually feeding into the Avoca and Loddon deep-lead systems. Some of the leads were only partly worked and delineated, and warrant further investigation.

Major reef gold-fields include the Maldon, Maryborough, and Clunes gold-fields. At Maryborough the reef industry generally suffered as mining activity was predominantly directed towards profitable deep-lead ventures, while at Clunes the mines closed due to inadequate mining techniques. The Maldon gold-field contained a large number of significant mines, usually with high grades of ore. These fields have potential for future gold production.

Three major hardrock quarries produce aggregate supplying much of the southern and central parts of the study area. Basalt is worked at Talbot and Caris-

Hornfels quarry on public land on Mount Tarrengower

brook, and hornfels from public land at Mount Tarrengower.

Scoria cones are numerous in the south of the block. Mount Greenock is the only scoria cone on public land within the study area and, although devoid of trees, it has remained intact from quarrying.

Tailings dumps from deep-lead operations are numerous and provide local aggregate, road gravel, and pebbles for garden use in Melbourne.

Granitic sand is extracted at Mount Beckworth.

Water

Except for the western portion, which drains into the Avoca River, most of this block falls within the catchment of the Loddon River.

Average annual run-off varies from 25 mm in the north to about 70 mm in the south.

The main water storages in the block are Cairn Curran Reservoir (148,800 Ml) and Tullaroop Reservoir (73,690 Ml).

Some towns (Avoca, Carisbrook, and Maryborough), are supplied by Waterworks Trusts, some (Talbot and Clunes) by Shire Councils, while others (Maldon and Newstead) are supplied by the State Rivers and Water Supply Commission.

Groundwater occurring in the deep-lead formations is utilized by irrigation bores.

Hazards and Conflicts

The shallow red gradational soils so common in this block are susceptible to severe sheet erosion if the surface is cultivated or left unprotected. Increased run-off into drainage lines leads to extensive gully erosion because of the dispersible red duplex soils.

Landslips are associated with cleared steep granite hills.

Trail-bike riding, popular at Mount Tarrengower, conflicts with some forms of recreation and with nature conservation.

Significance

The forests are a valuable source of durable timber and honey, while the Paddy Ranges are also highly regarded for their wildflowers and birdlife. The occurrence of the turquoise parrot near Maldon is notable.

5. DUNOLLY

General

Dunolly block includes the towns of Bealiba, Dunolly, and Tarnagulla, as well as many smaller settlements.

The public land, amounting to 38,000 ha (22% of the block), is generally more hilly than the freehold land. Almost all of it is reserved forest.

Nature of the Land

Climate

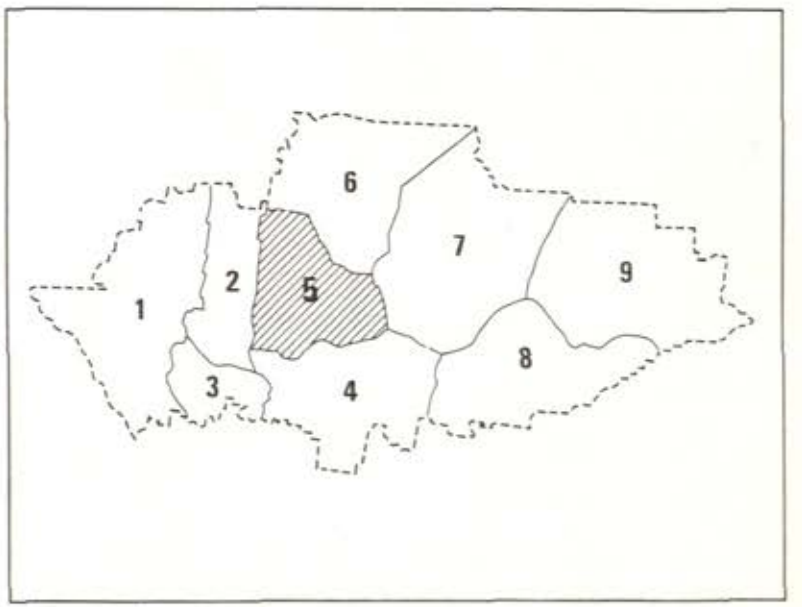
Average annual rainfall decreases from about 500 mm in the south to about 440 mm in the north.

Geology and physiography

Much of the public land is undulating country formed on Lower Ordovician sediments dissected by a network of streams, which have deposited Quaternary sediments. Two intrusive areas of Lower Devonian granodiorite around Dunluce and Murphy's Creek are deeply weathered with scattered remnants of an Early Tertiary erosion surface preserved on the granodiorites. Associated contact metamorphic ridges (Bealiba Range, and Green Valley Range) form prominent ridges partially enclosing these weathered intrusions. Throughout, the block also contains scattered occurrences of Tertiary sand, including deep-lead material, but this is mostly private land.

Soils

The Black Range, Green Range, and Bealiba Range have shallow stony gradat-



View from Mount Moliagul towards the north-east

ional soils. The granitic areas have red duplex soils overlying a silica-rich hardpan at approximately 1 metre depth. The Ordovician sandstones and mudstones with their soil sequence of red gradational soils on the crests and upper slopes grade through to red sodic duplex soils on the lower slopes and yellow duplex soils in the drainage lines. The red calcareous duplex soils of the river alluvium are associated with the flat land adjacent to the Loddon and Avoca Rivers.

Vegetation

This block is forested mainly with red ironbark, yellow gum, and grey box. Red stringybark, red box, and long-leaf box occur in scattered stands. Patches of mallee - mainly green mallee - are found near Tarnagulla, particularly to the north-east. Other species commonly associated with the dominant eucalypts are listed in Appendix 1.

Fauna

The following habitats are represented: open forest, woodland, mallee, pasture--grassland, and aquatic. The public land is predominantly open forest. Appendix 2 lists the common animals of these habitats.

Land systems groups

Geomorphic groups of land systems (which are described in chapter 12) are distributed in the block as follows: alluvial 22%; Tertiary sediments 19%; Palaeozoic sediments (1) 46%; metamorphics 4%; granite (1) 8%; granite (2) 1%.

Most of the public land is composed of Palaeozoic sediments (1), but there are also small areas of Tertiary sediments, granite (1), granite (2) and metamorphics.

Capabilities

Nature conservation

The extensive box--ironbark forests provide habitat for plant and animal species typical of the area, although no rare species are known to occur here.

Recreation

The public land of this block, more than many others, is used for prospecting. The Bealiba Range provides attractive bush-walking country, although it is not often used. The block contains towns and features representative of the gold-mining era. Laanecoorie Reservoir is used for picnicking, swimming, boating, fishing, and duck-shooting.

Agriculture

Most of the public land has low capability for agriculture, but some areas, mainly those under grey box, have moderate capability. About 20% of the public land, mainly near Bealiba and Moliagul, is licensed for forest grazing.

Apiculture

The public land has high capability for apiculture.

Eucalyptus-oil production

Some of the public land is used for the small-scale production of eucalyptus oil from yellow gum, red ironbark, and long-leaf box. Areas of green mallee near Tarnagulla are not used. Capability of public land for eucalyptus-oil production is generally low.

Timber production

Capability of public land for the production of durable hardwood timber and firewood is high.

Mining

This block contains numerous gold-fields famous for their alluvial gold and nuggets, which are still occasionally found.

The Tarnagulla gold-field is of interest as most production came from only one mine, with a large ore production from

The Coster gold-mine, on public land near Tarnagulla

essentially one ore shoot. Numerous mining leases are current on public land, some of which support small-scale mining operations.

Extensive areas of granitic sand provide a source of road-making material.

Areas of Tertiary sediments could contain large reserves of sand and gravel; if worked, gold could be a by-product, depending on the mode of operation.

Water

The western part of this block lies within the Avoca River catchment, while the eastern part drains into the Loddon.

Run-off ranges from negligible around Berrimal to about 40 mm near Natte Yallock.

Laanecoorie Reservoir (7,700 Ml) on the Loddon River lies in the south-eastern corner.

The Bet Bet Shire Council supplies water for the towns of Dunolly, Tarnagulla, and Laanecoorie, while the Bealiba Waterworks Trust serves Bealiba.

Groundwater from the deep-lead systems of the Calivil Formation is used for stock and domestic purposes.

Hazards and Conflicts

The shallow gradational soils on the metamporhic aureoles and the crests of the Ordovician parent material are very prone to sheet erosion if the soil surface is not protected by vegetation. The dispersible red duplex soils on the lower slopes are renowned for gully erosion.

For soils on gently sloping granitic parent material, root penetration and water-holding capacity are restricted to the shallow clay layer on top of a silica-rich hardpan.

Clearing may result in increased salinity in the groundwater.

Significance

Public land of this block is important mainly for the production of durable timber and firewood, and for apiculture. It is also important to part-time prospectors.

6. WEDDERBURN

General

Situated in the north of the study area, the block contains two large towns, Wedderburn and Inglewood, and several smaller settlements such as Wychitella, Kingower and Calivil.

The public land amounts to 24,000 ha (11% of the block) and is concentrated in the Wychitella--Wedderburn and Glenalbyn--Inglewood areas. Less than half of it is reserved forest; much of the rest is reserved for specific purposes, principally eucalyptus-oil production.

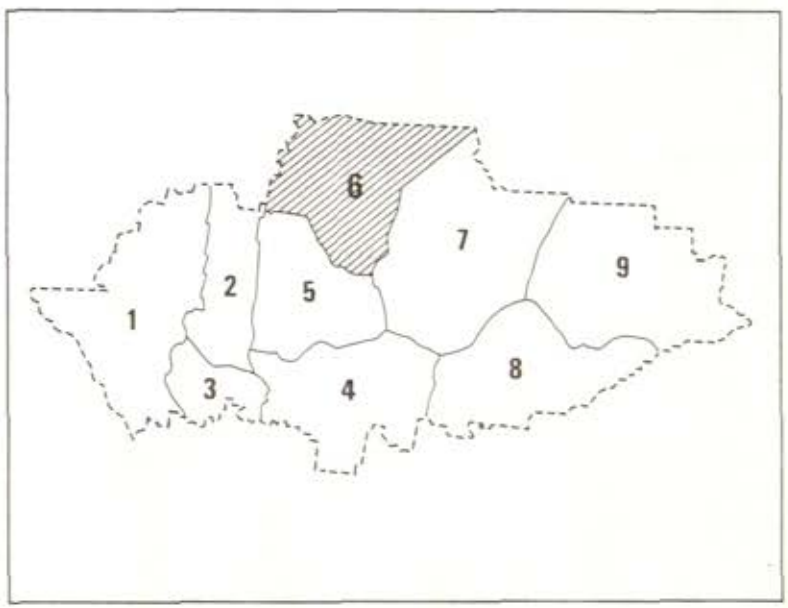
Nature of the Land

Climate

Annual rainfall ranges from about 470 mm to about 380 mm. Data for Charlton and Boort, listed in the climate chapter (Tables 2--5), may indicate conditions within the block, although these stations are to the west and north of it and outside the study area.

Geology and physiography

The northern part of this block is comprised of flat Quaternary alluvial plains and undulating areas of Tertiary Parilla Sand. Broad areas of Quaternary alluvium penetrate back into the highlands at Richmond Plains and Glenalbyn. In contrast, the central and southern parts comprise granitic intrusions of Lower Devonian age, which form peaks such as Mount Korong, Mount Kooyoora, and Mount Egbert. Metamorphic rocks associated with these areas form hilly landscapes like Mount Kerang and the Brenanah Range. Most of the public land is confined to areas of Lower Ordovician



Mallee fowl nest mound near Wychitella

sediments, although some, including the Melville Caves, is located on Devonian granites.

Soils

The dominant soil types in this block are those in the sequence on Ordovician sedimentary rock - shallow red gradational soils on the crests and upper sloper with sodic red duplex soils in the drainage lines. Where the sedimentary rock has been metamorphosed by granitie intrusions, the steep aureoles have a shallow stony gradational soil.

Uniform coarse sands occur on the steep granitic outcrops, and the adjacent gentler country has a red duplex soil over a silica-rich hardpan. Across the northern section, on the plains and the gentle slopes up to the hills, a red calcareous duplex soil predominates.

Vegetation

This block contains much of the mallee vegetation of the study area, with extensive stands of blue mallee and green mallee around Wedderburn--Wychitella and Inglewood and near Glenalbyn, and patches of bull mallee in the Inglewood area. In the Kingower--Brenanah area the vegetation is dominated by grey box and yellow gum with some red ironbark. Blakely's red rum is confined to the wash from the granite country, a restricted land type of which parts have been cleared. Appendix 1 lists species commonly associated with the dominant eucalypts.

North of Wedderburn and Inglewood, quite extensive areas are dominated by shrub species - *Melaleuca, Acacia, Casuarina,* and others. Kamarooka mallee, a rare eucalypt, and velvet daisy bush, another rare species, are found near Wedderburn. Dainty phebalium, a plant with very localized distribution, occurs at Kingower.

Fauna

The following habitats are represented: open forest, woodland, mallee, pasture--grassland, and aquatic. The public land includes the most extensive and least disturbed mallee habitat in the study area. Most of the other public land supports open forest. Appendix 2 lists the common animals of these habitats. The occurrence of the mallee fowl in the Wychitella Forest is notable - it is the last natural population in the area.

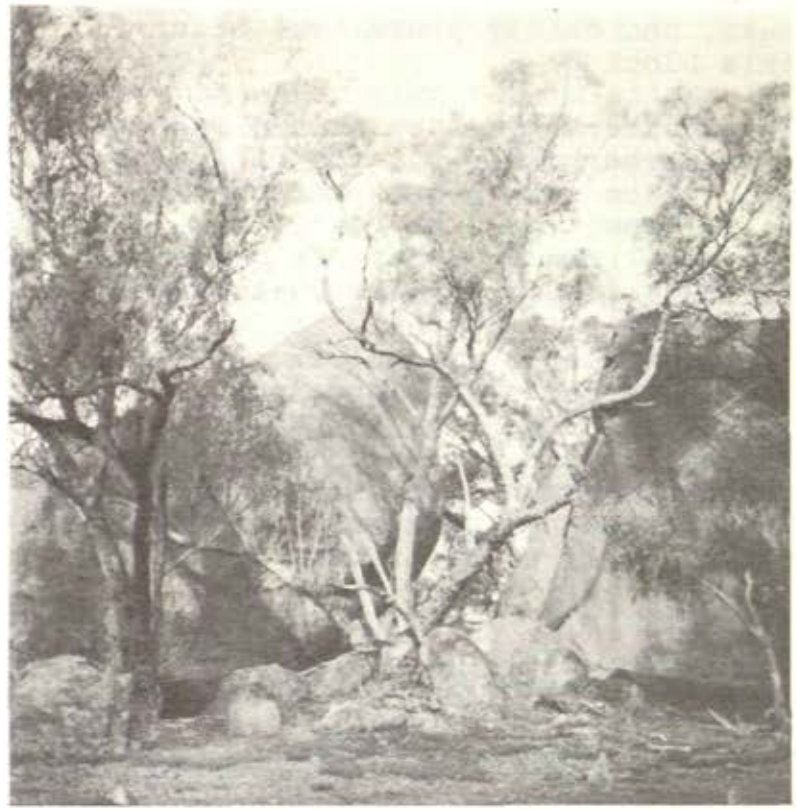
Land systems groups

Geomorphic groups of land systems (which are described in chapter 12) are distributed in the block as follows: alluvial 53%; Tertiary sediments 19%; Palaeozoic sediments (1) 21%; metamorphics 5%; granite (1) 1%; granite (2) 2%. Collectively, the alluvial and Tertiary sediment land systems cover a large part of this block (72%), but again have relatively little representation in public land. Most of the public land around Wedderburn and Inglewood is Palaeozoic sediments (1), but there are also small areas of granites (1) and (2) (Melville Caves and Mount Korong), and metamorphics.

Capabilities

Nature conservation

This block includes extensive areas of mallee vegetation, particularly blue



Huge granite tors, Melville Caves

mallee, which is less common elsewhere in Victoria. The stands of Blakely's red gum at Melville Caves are also of interest, identifying a vegetation type that has been extensively cleared, as well as being at the western limit of the range of this species. The ridge-top stands of long-leaf box and the huge granite tors and caves in this area are also of interest. Three rare plant species (Kamarooka mallee, velvet daisy-

bush, and dainty phebalium) occur in this block.

The mallee vegetation around Wychitella --Wedderburn supports the only natural population within the study area of the mallee fowl.

Recreation

The Melville Caves area is very attractive and interesting, and is used for picnicking, camping, and nature study. The Wychitella Forest is valued by local residents for nature study activities. The granite boulders at Mount Korong are occarionally used for rock climbing.

Mount Korong

Agriculture

Capability of most of the public land for agriculture is low, but areas carrying Blakely's red gum have moderate capability. About half the box--ironbark forest, and almost all the land under Blakely's red gum, is held under grazing licences.

Apiculture

Capability of the box--ironbark forests near Kingower is high; the remainder of the public land has moderate capability.

Eucalyptus-oil production

More than half the eucalyptus oil produced in Victoria comes from this block, mainly from blue mallee stands around Inglewood. Capability of current production areas is high; other mallee areas carrying commercial species have a moderate capability, and the rest of the public land has low capability.

Timber production

The box--ironbark forests near Kingower have high capability for the production of durable hardwood timber and firewood. The remainder of the public land has low capability for timber production.

Mining

The southern part of this block covers numerous gold-mining areas centred on

Wedderburn, Inglewood, and Kingower. Several mining leases are current on public land, with gold-mining operations carried out on a small scale.

Sand and gravel resources are large in the centre of the block, associated with the Wedderburn pluton, and in the east, associated with the alluvial sediments of the Murray basin plains.

Water

Most of this block is within the catchment for the Loddon River.

Run-off is negligible in the north, increasing to around 10 mm in the south.

The Warange Western Main Channel traverses the north of the block.

Urban supplies at Wedderburn, Borung, Wychitella, Korong Vale, and Mysia are provided by the Korong Shire Council; Mitiamo is supplied by a State Rivers and Water Supply Commission channel, while Serpentine's supplies are controlled by the East Loddon Shire Council.

Reserves of groundwater occur in the deep-lead systems of the Calivil Formation, particularly between Bridgewater and Serpentine. Many bores are used to provide irrigation, stock, and domestic water.

Hazards and Conflicts

A severe sheet erosion hazard exists for the shallow gradational soils, and a moderate gully erosion hazard applies to the red or yellow dispersible clays in the drainage lines, in the Ordovician sandstone and mudstone. Landslips occur on steep cleared granite hills, whereas the gently sloping land has a hardpan at a depth of approximately 1 m, which restricts root penetration and water storage capacity.

Clearing may result in increased salinity of the groundwater.

The modern mechanical methods of eucalyptus-oil harvesting conflict with nature conservation and some other uses, although the tendency to harvest only parts of an area moderates this. Forest grazing by sheep may conflict with nature conservation, particularly in the remnants of Blakely's red gum woodland, which are almost entirely within areas licensed for grazing. Gravel extraction at Mount Korong conflicts with scenic and recreation values.

Significance

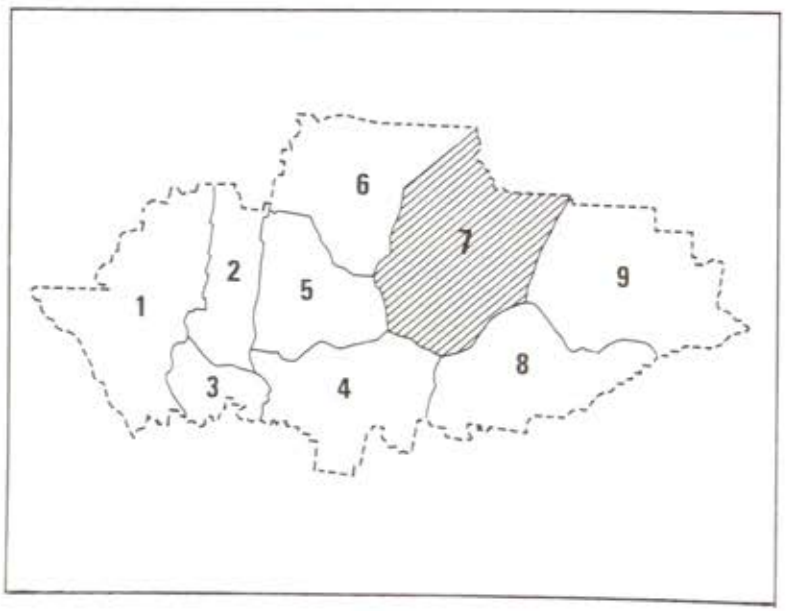
The public land of this block is important for nature conservation and recreation, particularly at Melville Caves and Wychitella, and for production of eucalyptus oil.

7. BENDIGO

General

This block surrounds Bendigo, the largest city in the study area. It also includes a number of smaller towns, such as Bridgewater, Marong, Huntly, and Elmore.

The public land is almost confined to the eastern half, and covers a total area of about 34,000 ha (11% of the block). Most of it is reserved forest.



Nature of the Land

Climate

Average annual rainfall decreases from about 550 mm in the south to about 390 mm in the north. Data on temperature, frost, actual rainfall, and effective rainfall probability for Bendigo are listed in the climate chapter (Tables 2--5).

Geology and physiography

Geological investigations in this block during the last 100 years have shown the complexity of folding and faulting within Ordovician sediments in western Victoria. Part of the Harcourt Batholith, a Devonian granitic mass, has intruded these sediments in the southern part around Ravenswood, but is all on private land. The metamorphic aureole forms a prominent ridge around the northern margin of the Batholith. In the north of the block and in the Loddon valley the Ordovician sequence is buried beneath Quaternary alluvial sediments with extensive flat areas developed. Undulating areas of Newer Volcanic basaltic flows outcrop at Bridgewater. Again,

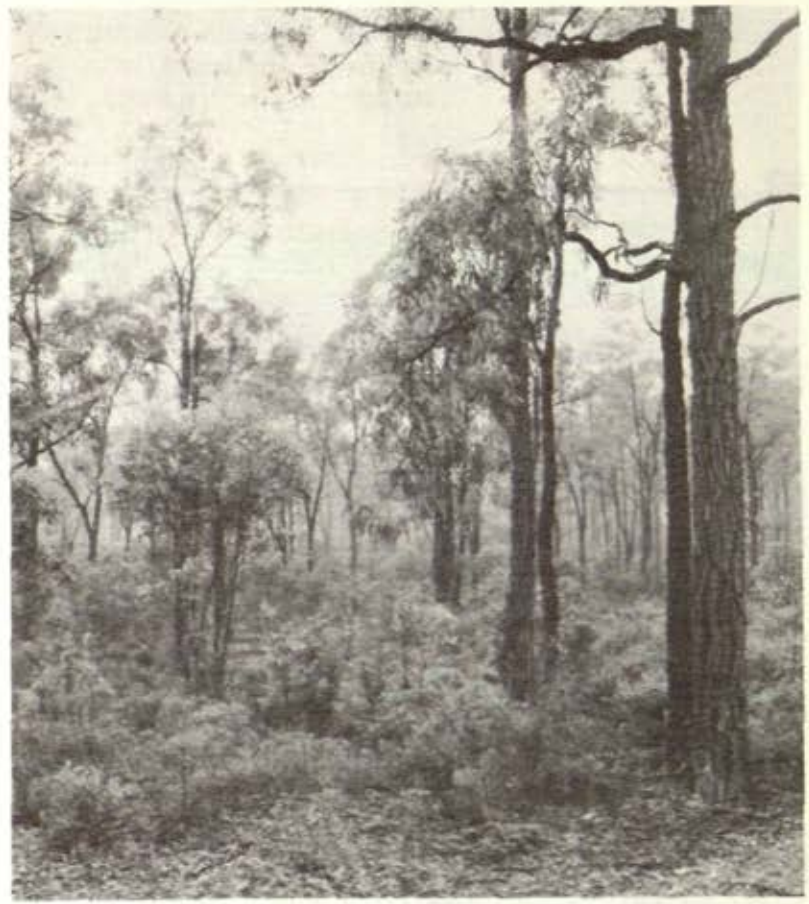
most of the public land is confined to the areas of Ordovician sediments.

Soils

Shallow red gradational soils are associated with the red box, red stringybark, red ironbark, and mallee vegetation so common in this block. Other soils of importance include the uniform coarse sands and the grey duplex soils on granite in the south and the mottled duplex soils on Tertiary gravel deposits along Axe Creek in the south-east. Red sodic duplex and yellow sodic duplex soils are associated with the mid and lower slopes on Ordovician parent material. Red duplex soils predominate on the Campaspe alluvial flats, whereas red calcareous duplex soils are associated with the Loddon alluvial flats. A red uniform friable clay with large basalt boulders occurs on the basalt between Bridgewater and Woodstock.

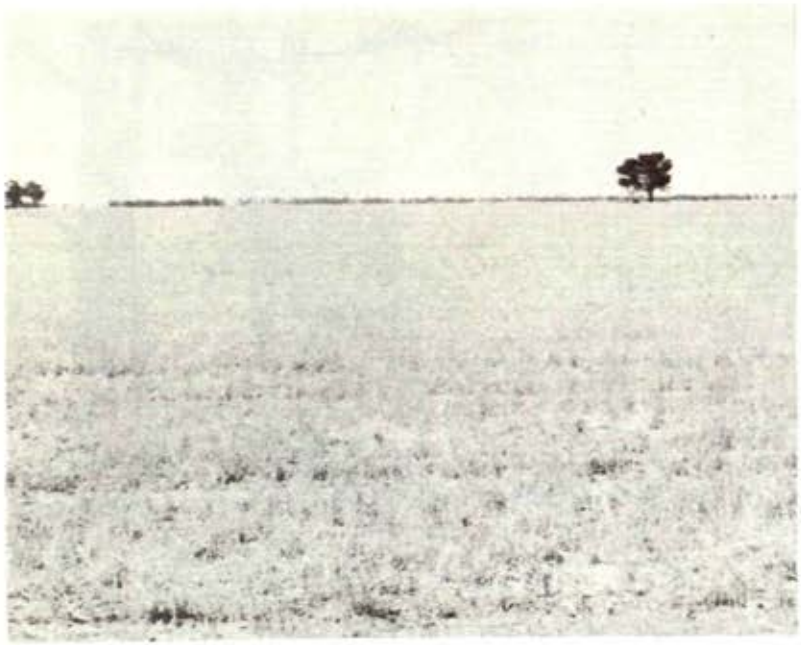
Vegetation

Most of the public land here is dominated by forest of red ironbark, yellow gum, and grey box, although red stringybark, red box, and long-leaf box are also common in the south. An extensive belt of mallee occurs in the Sebastian--Neilborough--Kamarooka area; this is dominated mainly by green mallee and bull mallee but includes patches of blue mallee. Appendix 1 lists other species commonly occurring in association with the dominant eucalypts.



Red ironbark forest north of Eaglehawk

Whirrakee wattle *(Acacia williamsonii)* has recently been described as a new species - it occurs only within this block. The rare eucalypt, Kamarooka mallee, is found here, as are dainty phebalium, Whipstick westringia, and chariot wheels, the latter being known only on private property.



Virtually no public land remain in the north-west of the block, which is plains country developed on Recent alluvium

Fauna

The following habitats are represented: open forest, woodland, mallee, pasture--grassland, and aquatic. Most of the public land is open forest, but extensive areas of mallee habitat occur north of Bendigo. Appendix 2 lists the common animals of these habitats.

Land systems groups

Geomorphic groups of land systems (which are described in chapter 12) are distributed in the block as follows: alluvial 59%; Tertiary sediments 2%; basalts 5%; Palaeozoic sediments (1) 23%; Palaeozoic sediments (2) 4%; Palaeozoic sediments (3)< 1%; metamorphics 1%; granite (1) 4%; granite (2)< 1%.

Although the alluvial land system comprises nearly 60% of the block, very little remains as public land. Most of the public land north of Bendigo is Palaeozoic sediments (1), while that south of Bendigo is Palaeozoic sediments (2). Small areas of Palaeozoic sediments (3), Tertiary sediments, and metamorphics also occur on public land.

Capabilities

Nature conservation

Public land in this block is valuable for nature conservation, particularly around Whipstick--Kamarooka, where extensive areas of mallee vegetation provide colourful displays of wildflowers. Four rare plant species have been recorded here and a fifth, although common here, occurs nowhere else.

The Sugarloaf Range provides a valuable example of a strike ridge; it contains very large outcrops of sandstone and is important for environmental education.

Recreation

The public land of this block, surrounding the city of Bendigo, is valuable for

recreation. The Whipstick Forest is the best known, but the other forested areas are also well used. Wildflower displays are a feature, and there is much of historical interest. One Tree Hill, on the outskirts of Bendigo, is a popular look-out point.

Agriculture

Capability of the public land for agriculture is generally low, but some areas, mainly those under grey box, have moderate capability. Only a small proportion of the public land, mainly in the grey box stands of the Kamarooka Forest, is licensed for grazing.

Apiculture

The public land has high capability for apiculture.

Eucalyptus-oil production

The mallee vegetation of this block is dominated mainly by bull mallee, which is not used for oil distillation, and green mallee, which is less productive than blue mallee. Thus the extensive areas of mallee here have less capability for eucalyptus-oil production than those in Wedderburn block. The rest of the public land has low capability.

Timber production

The box--ironbark forests have high capability for the production of durable hardwood timber and firewood. The rest of the public land has low capability for timber production.

Mining

This block contains the major Bendigo gold-field. The potential for further reef mining is high, both within the field and in adjoining areas.

As the block contains the largest population, demands for extractive-industries

An area north of Bendigo used for eucalyptus-oil production

materials are high. Source areas can constitute any rock type, but current activities are concentrated on obtaining washed sand and gravel from Tertiary sediments. Gold is recoverable as a by-product. Future resources of sand and gravel exist in shoestring sands contained within the extensive alluvial deposits in the north.

Clays are widespread and suitable for both brick-making and pottery purposes. Numerous deposits, both weathered Ordovician sediment and Tertiary clays, have been worked or exist in the forests north and north-east of Bendigo.

Large bands of hornfels in the prominent contact metamorphic ridge in the south have been used for road-metal.

Water

Most of this block comprises the headwaters of the Bendigo Creek catchment, although it also includes part of the Loddon River catchment. Urban supplies in the Bendigo area are provided by State Rivers and Water Supply Commission from the Coliban system. To the north, Dingee is also served by the Commission, using water pumped from the irrigation supply channel.

Groundwater reserves again occur in the Loddon and Campaspe deep leads, and many bores (particularly around Dingee) provide irrigation, stock, and domestic supplies.

Hazards and Conflicts

A severe sheet erosion hazard exists for all the shallow gradational soils in this block. Gully erosion in the dispersible clays of the drainage lines and salting on the lower slopes are common problems.

The problem of saline groundwater is extending southwards.

Public land around Bendigo is subjected to many conflicting uses due to its proximity to a large population. Uses that cause conflict include trail-bike riding, rubbish disposal, and gravel extraction. Some conflict has occurred with some public land being used for industrial development. Eucalyptus-oil harvesting may conflict with nature conservation, and timber production may conflict with apiculture.

Significance

The public land is important for recreation, apiculture, timber production, and nature conservation. Areas of mallee have significance for the production of eucalyptus oil. There is likely to be increasing pressure to use some of the public land near Bendigo for new industrial or housing development.

8. EPPALOCK

General

This block covers the south-east of the study area, stretching from Castlemaine to Puckapunyal and north as far as Axedale.

Public land is scattered through the block, but is concentrated mainly in the Castlemaine--Glenluce and Heathcote--Puckapunyal areas and north and west of Lake Eppalock. Including Lake Eppalock, it covers 46,000 ha (21% of the block), but 11,000 ha of this, south-east of Costerfield, is being transferred to the Commonwealth government for the use of the Army. Most of the public land is reserved forest.

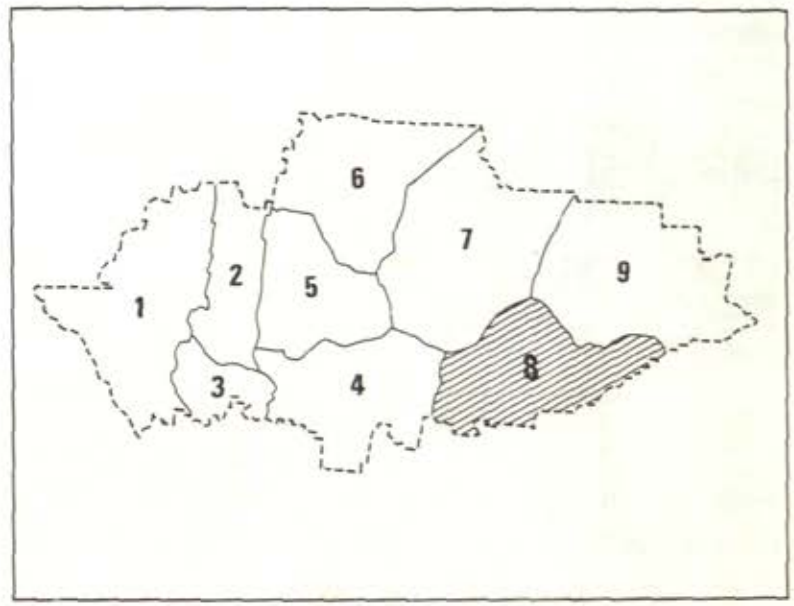
Nature of the Land

Climate

Average annual rainfall varies across the block from about 520 mm in the north to around 600 mm in the south. Because of its height, Mount Alexander receives greater rainfall than the surrounding land, with the annual total probably being about 700 mm. Data on temperature, frost, actual rainfall, and effective rainfall probability for Castlemaine are listed in the climate chapter (Tables 2--5).

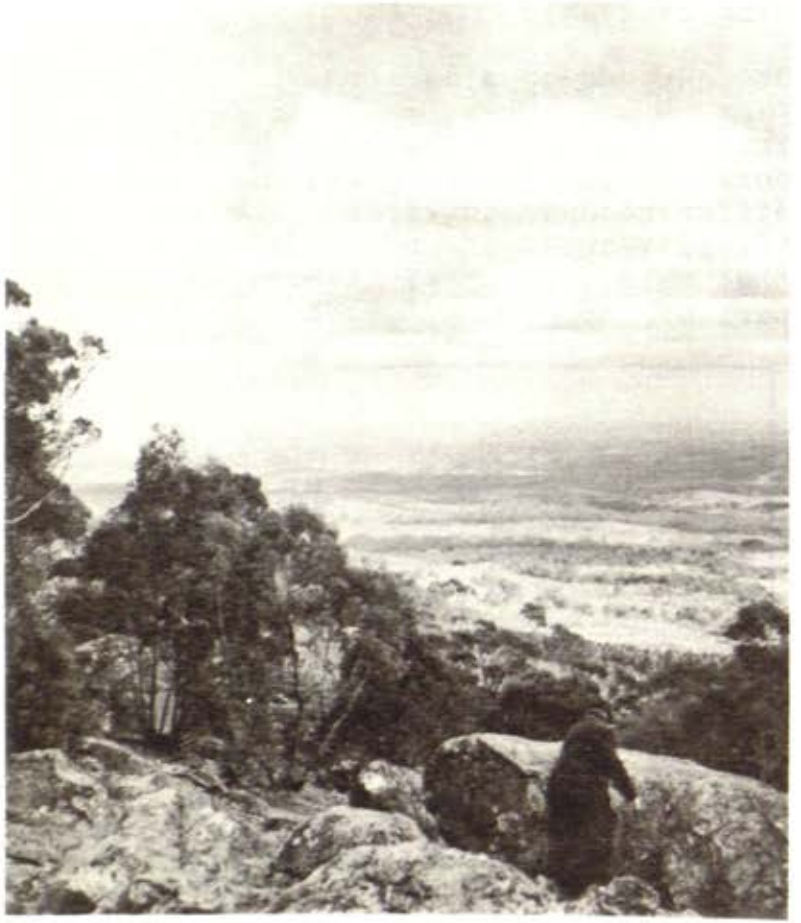
Geology and physiography

This block is geologically complex, with considerable faulting bringing rocks of different ages together. The undulating to hilly areas of Ordovician sediments that make up much of it are intruded by part of the Harcourt Batholith in the



south-western corner, which forms prominent granitic hills (such as Mount Alexander).

A complex series of Cambrian rocks runs south-east from Heathcote, separating tightly folded Ordovician sediments to the west from more gently folded Silurian--Devonian sediments to the east.



View from Mount Alexander

Two other rock types provide contrasting features. The Permian tillites around Knowsley and Derrinal form smoothly rounded slopes. The Newer Volcanic basalt flows form broad undulating plains, as in the valley of the ancestral Campaspe River, or plateau-like features were left as remnants by the present drainage system (Guildford plateau).

Most of the public land around Castlemaine and Lake Eppalock is confined to Ordovician sediments, but some sizeable parcels of public land, like the Harcourt area, are situated on other rock types.

Soils

The shallow stony red gradational soils and the red sodic duplex soils predominate on the relatively steep country based on Ordovician and Silurian sedmentary rock.

Other soils that warrant mention are the uniform coarse sandy soils and the grey duplex soils on granite at Sutton Grange, the uniform grey clays of coarse structure on basalt to the north and south of Redesdale, and the yellow sodic duplex soils on the lower slopes of Ordovician parent material and also on the Permian tillites at Knowsley.

Vegetation

Much of the public land is forested with red stringybark, red box, and long-leaf

box, although red ironbark, yellow gum, and grey box are also important, particularly in the north and east. Mount Alexander, being wetter than the rest of the block, carries an open forest of messmate and manna gum. Appendix 1 lists other species commonly associated with these dominant eucalypts.

Fauna

The following habitats are represented: tall open forest, open forest, woodland, pasture--grassland--suburban, and aquatic. The public land is mainly open forest. Appendix 2 lists the common animals of these habitats.

Land systems groups

Geomorphic groups of land systems (which are described in chapter 12) are distributed in the block as follows: alluvial 6%; tillites 3%; basalts 12%; Palaeozoic sediments (1) 28%; Palaeozoic sediments (2) 30%; Palaeozoic sediments (3) 2%; metamorphics 6%; granite (1) 9%; granite (2) 5%.

Most of the public land west of Lake Eppalock and around the Castlemaine--Fryerstown area is composed of Palaeozoic sediments (2), whereas most of that north-east of Tooborac is Palaeozoic sediments (1). A small area of glacial tillites occurs on public land south of Derrinal, while the public land at Mount Alexander comprises a relatively large area of granite (2) land system.

Capabilities

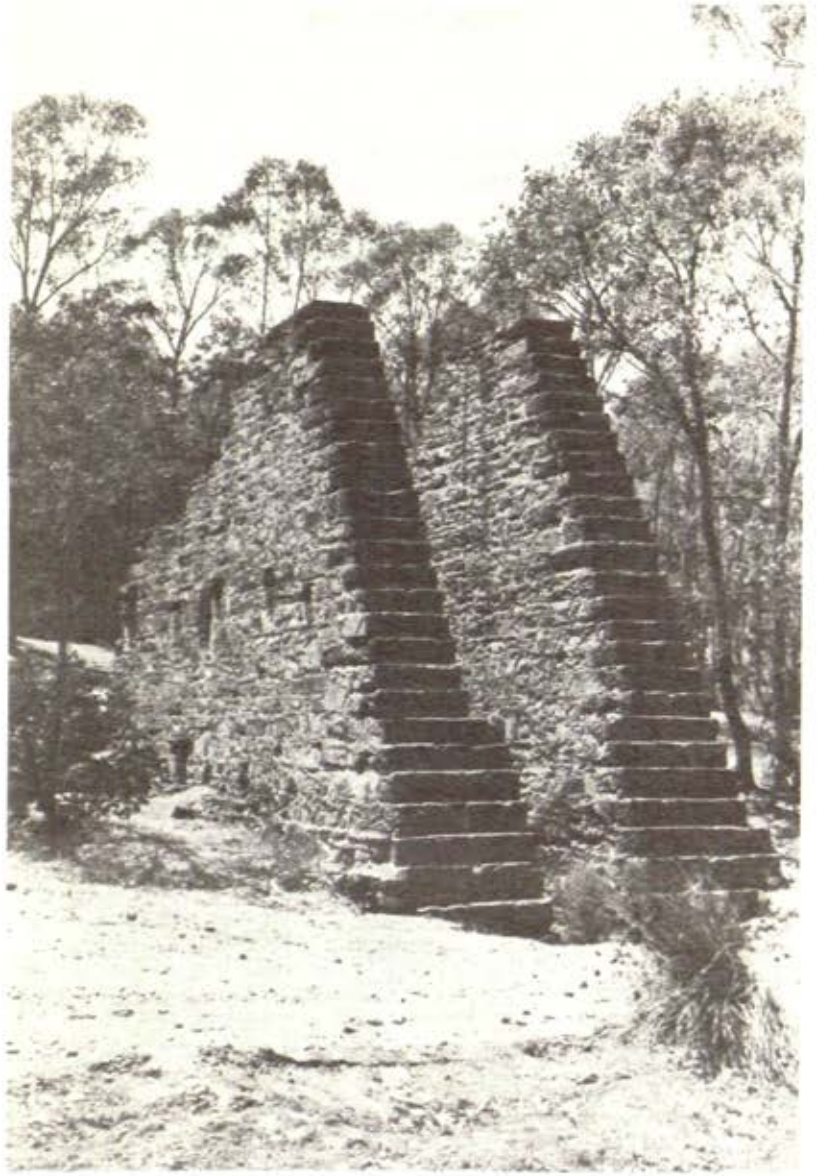
Nature conservation

The messmate--manna gum forest of Mount Alexander is rather unusual, having an open understorey, and the Fryers Ridge area is renowned for its floral diversity.

An exposed sequence of Permian glacial rocks on the shore of Lake Eppalock is regarded as one of the finest examples of such rocks in the world. A particularly valuable example of a glaciated pavement lies 5 m below the full-supply level of the Lake.

Recreation

Lake Eppalock, the main recreational feature in this block, is used intensively for boating (including speed-boat racing), water-skiing, and fishing, and has numerous club camp sites around the shores. Mount Alexander, an attractive and accessible area, provides views and has the added attraction of a koala park. The forest around and south of Castlemaine is also important for recreation, containing many relics of the mining era, and providing impressive displays of wildflowers. Of the waterfalls on the Campaspe River, Turpins Falls is the only accessible one, with foot access through a public reserve. The Coliban Falls near Metcalfs, discovered by Major Mitchell, are interesting and attractive. Mineral springs at



The stone supports for the old Garfield water wheel near Chewton, shown (right) in operation.

Vaughan, Glenluce, and Taradale provide an unusual source of recreational interest.

Agriculture

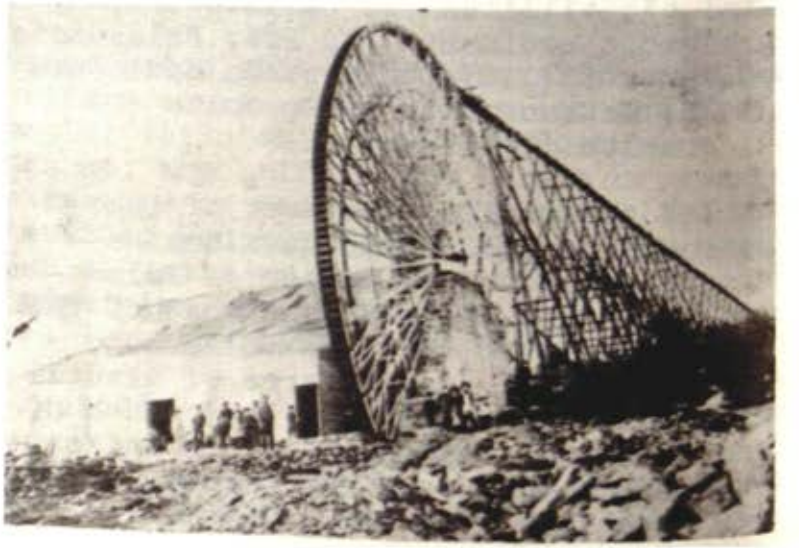
Most of the public land has low capability for agriculture. Grazing licences cover about one-quarter of the box--ironbark forest here.

Apiculture

The capability for apiculture of the public land in the north and east of the block is high. The public land in the south has moderate capability.

Eucalyptus-oil production

Capability is low due to the absence of species suited to mechanical harvesting.



Timber production

The box--ironbark forests in the north of this block have moderate capability for the production of durable hardwood timber and firewood. The stringybark forests have low capability. Pine plantations near Harcourt supply two small local mills, although capability is lower than at major softwood-growing areas elsewhere in Victoria.

Mining

This block contains the major Castlemaine--Fryerstown--Chewton gold-field. Mining operations on public land have been active until 1976, and the area has some potential for further mining. Of the several mining leases current on public land, some are worked on a small scale.

In the Heathcote area, Cambrian and associated rocks contain low-grade base-metal mineralization. Magnesite and manganese have been mined from these rocks in the past.

Small deposits of iron are recorded near Heathcote. Gemstones are recorded in the Permian rocks at Derrinal and different-coloured jaspers are associated with the Cambrian rocks.

Large quantities of plastic clay east of Axedale are used in brick production in Melbourne. Higher-quality clay in this area is used for pottery and ceramics.

Basalt at Axedale is a major aggregate source for Bendigo.

Granite at Mount Alexander is used in the building and monumental stone industries.

Tertiary sediments are a source of washed sand and gravel for Castlemaine.

Water

This block contains parts of a number of catchment basins. West of Mount Alexander is the Loddon River catchment; the bulk of the block comprises part of the Campaspe--Coliban catchment; and land east of Heathcote is in the Goulburn River catchment.

Average annual run-off varies from about 50 mm in the high-rainfall areas to about 25 mm in the drier more northerly areas.

The main storage in this block is Lake Eppalock (311,900 Ml).

Urban supplies for Heathcote and Toobora-ac are provided by the Heathcote Waterworks Trust; Elphinstone, Taradale, Chewton, Castlemaine, Harcourt, Axe Creek, Guildford, and Yapeen are supplied from the Coliban system (State Rivers and Water Supply Commission); and Axedale has its own Waterworks Trust.

Mineral springs occur in this block, mostly on Ordovician bedrock. The pub-

lic land around Vaughan and Glenluce probably acts as a local recharge area for the springs.

Hazards and Conflicts

The steep hills of outcropping granite are prone to landslips if the stabilizing tree cover is removed.

A high sheet erosion hazard applies to the large areas of shallow gradational soils.

Clearing of hilly country upsets the hydrological equilibrium, resulting in salt accumulation in land lower down.

The transfer to the Army of 11,000 ha of public land will conflict with other uses of the land, including recreation, timber production, and apiculture. Recreation on and adjacent to Lake Eppalock conflicts with the maintenance of water quality.

Significance

Lake Eppalock is an important water storage and is highly valued for recreation. Forested areas are also valuable for recreation, particularly at Mount Alexander and around Lake Eppalock and Castlemaine. Some areas have significance for nature conservation.

9. RUSHWORTH

General

Rushworth block occupies the eastern end of the study area. Its main towns are Rushworth, Murchison, and Nagambie.

Most of the public land is in one large stand of reserved forest stretching from Rushworth to Heathcote, but other major areas include Reedy Lake, Waranga Reservoir, and lakes and swamps near Corop. These cover a total of 51,000 ha (17% of the block), which includes several areas recently purchased by the government because of their value as wetland habitat.

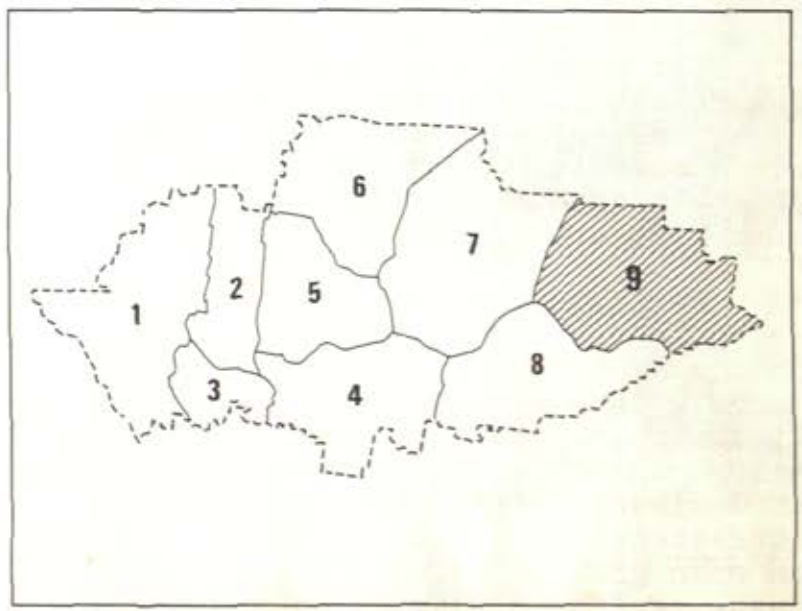
Nature of the Land

Climate

Annual rainfall varies from about 560 mm in the south to around 430 mm in the north. Data on temperature, frost, actual rainfall, and effective rainfall probability for Murchison are listed in the climate chapter (Tables 2--5).

Geology and physiography

The most obvious geological feature is the prominent strike ridge of Cambrian rocks called the Mount Camel Range, which extends north--south through the block from Corop to Mount Ida. This range separates structurally complex Ordovician sediments to the west from Silurian--Devonian sediments to the east, where broad north--south folds can be traced for many kilometres. Around Rushworth the strike of these sediments swings east--west. Permian glacial rocks outcrop in a restricted area near Muskerry East. To the north and in the east, the block contains large flat areas of Quaternary sediments. Lake-



lunette features have developed near Corop and Bailieston East.

Soils

Shallow stony red gradational soils and red sodic duplex soils predominate in this block. The only other significant soils are the red calcareous uniform clays of the Colbinabbin Range and the red calcareous duplex soils of the riverine plain.

Vegetation

Red ironbark, yellow gum, and grey box dominate the vegetation. Red stringybark, red box, and long-leaf box are scattered throughout, and mallee (mainly green mallee with some blue mallee) occurs in pockets in the Rushworth--Whroo area. This block also contains the most extensive stands of river red gum forest in the study area - at Reedy Lake, Wallenjoe Swamp, Doctor Swamp, and along the Goulburn River. Other species commonly associated with the dominant eucalypts are listed in Appendix 1.

Five rare plant species are known to occur in the block: bald-tip beard orchid (known only from two records at Whroo), long-tailed greenhood (known in Victoria only from a single collection near Rushworth), water shield (occurring at Goulburn Weir), three-part crassula (threatened with extinction as it occurs on open grazing country), and scented bush-pea (found near Bailieston).

Fauna

The following habitats are represented: open forest, woodland, mallee, pasture --grassland, and aquatic. Most of the public land supports open forest, but the various lakes and swamps provide valuable aquatic habitat. Appendix 2 lists the common animals of these habitats. The squirrel glider, a rare species, was recorded in the Rushworth Forest in 1961.

Land systems groups

Geomorphic groups of land systems (which are described in chapter 12) are distributed in the block as follows: alluvial 29%; tillites 23%; Palaeozoic sediments (1) 41%; Palaeozoic sediments (3) 1%; metamorphics 1%; granite (1) <1%; Cambrian greenstones 5%.

The bulk of the public land is Palaeozoic sediments (1), although Mount Ida occurs on a small area of Palaeozoic sediments (3). There are also scattered occurrences of the alluvial land system on public land throughout.

Capabilities

Nature conservation

This block contains a major representation of the box--ironbark forest. Five rare plant species occur here. Several swamps provide particularly valuable wetland habitat. The block also con-

tains features of historical interest, of which the best known are at Whroo.

Recreation

Water bodies provide for most of the recreation on public land - the Corop Lakes, Waranga Reservoir, and Goulburn Weir are all popular. Rushworth Forest is also used quite intensively for pleasure driving and picnicking, particularly around the old township of Whroo with its historical features.

Agriculture

Capability of the public land for agriculture is generally low, but some areas, mainly those under red gum or grey box, have moderate capability. Most of the public land carrying red gum is used for forest grazing, but little of the remainder is grazed.

Apiculture

The capability of the public land for apiculture is high. The Rushworth Forest is an area particularly valued by beekeepers.

Ecucalyptus-oil production

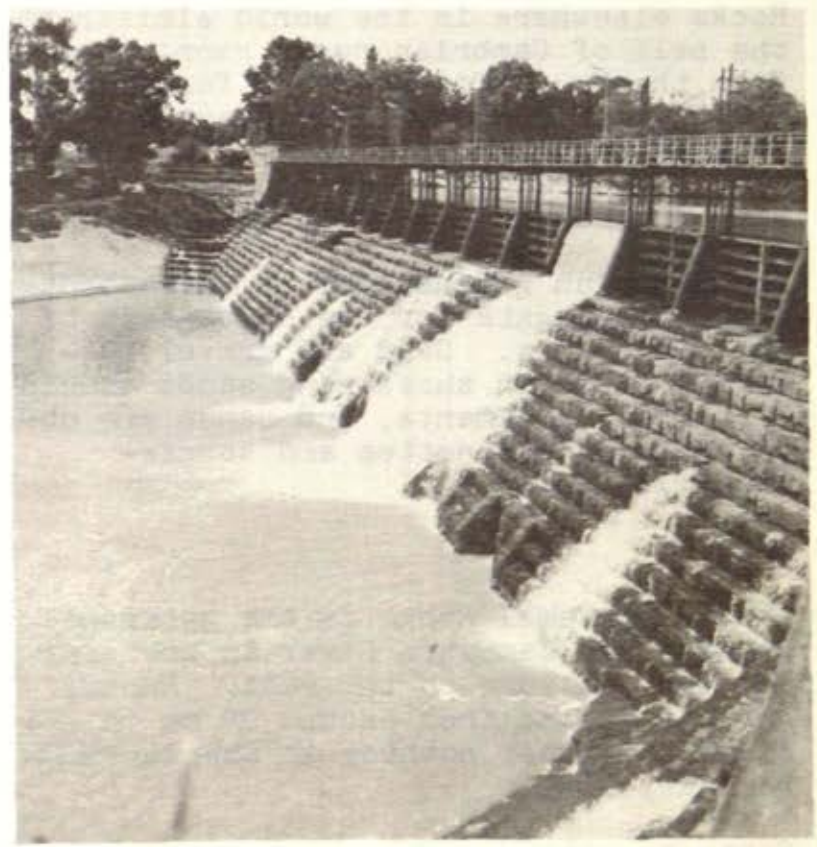
Capability of most of this block for eucalyptus-oil production is low, although small scattered stands of blue mallee in the Rushworth--Whroo area are used and have high capability. Larger stands of green mallee are not used.

Timber production

The public land generally has high capability for the production of durable hardwood timber and firewood.

Mining

This block contains broad areas of public land that have been worked for all-



Goulburn Weir, constructed from granite blocks quarried from Mount Black.

uvial and reef gold, and includes the major Rushworth--Whroo gold-field.

At Costerfield, quartz--gold--antimony veins have yielded 92% of Victoria's recorded antimony production. Interest in the area is considerable, with both exploration and mining taking place over the last decade. The area has potential for further production.

Rocks elsewhere in the world similar to the belt of Cambrian rocks running north from the Mount Ida area and forming the Mount Camel Range, have presented a favourable host for base-metal mineralization. This range is subject to a continuing program of base-metal exploration.

The Cambrian greenstones at Burramboot supply aggregate for the north-east of the study area. Sand and gravel resources exist in shoestring sands within Quaternary sediments, and sands are obtainable from lunettes and source-bordering dunes.

Water

The Mount Camel Range is the watershed between the Campaspe River to the west and the Goulburn to the east. Annual run-off varies from around 50 mm in the south to almost nothing at the northern boundary.

Separate waterworks trusts provide urban supplies for Nagambie, Rushworth, Colbinabbin, and Murchison, while Stanhope and Corop are supplied by water pumped from State Rivers and Water Supply Commission channels.

Groundwater reserves, particularly in the Goulburn deep lead, provide water for various uses (including irrigation at Murchison).

Much of the north of the block is within the Goulburn--Murray Irrigation District or the Campaspe Irrigation District.

Hazards and Conflicts

The major soil hazard is the potential degradation of the country by sheet erosion and salting as a result of clearing trees and removing the protective vegetation from the soil surface.

Production of eucalyptus oil using the present technique of harvesting at ground level conflicts with nature conservation in the small stands of blue mallee. Cutting mature trees for timber may conflict with apiculture.

Significance

The swamps in the north are significant for nature conservation. The various lakes, and also the Whroo area, are important for recreation. The forest is important for production of durable timber and firewood, and is also highly valued for apiculture.

PART V

APPENDICES

Appendix 1

LIST OF FREQUENTLY OCCURRING PLANT SPECIES IN THE NORTH CENTRAL AREA
(Arranged in columns according to the vegetation associations described in the Vegetation chapter)

Any symbol within a column indicates that the species concerned occurs frequently in that particular association. If the symbol is a letter, the species is characteristic of the association, and its growth form is denoted as follows:

T = Tree
L = Large shrub 1--3 m tall
S = Small shrub 0--1 m tall
F = Forb (dicotyledon herb or fern)
M = Monocotyledon herb (sedges, grasses, etc.)

Note: The absence of a recording does not mean the species does not occur in that association.

Botanical name	Common name	1A	1B	1C	2A	2B	3A	3B	4	5A/5B	5C	6
Acacia acinacea	Gold-dust Wattle				+	+	S	S	S			S
A. aculeatissima	Thin-leaf Wattle				S	S						
A. armata	Hedge Wattle				S	S	L		L			
A. aspera	Rough Wattle					+	S	S				
A. ausfeldii	Ausfeld's Wattle					L						
A. calamifolia	Wallowa											L
A. dealbata	Silver Wattle	T	T			L						
A. flexifolia	Bent-leaf Wattle		L									S
A. genistifolia	Spreading Wattle				+	+	+	+	+			+
A. gunnii	Ploughshare Wattle											+
A. implexa	Lightwood										T	
A. lanigera	Woolly Wattle					S	S					
A. mearnsii	Black Wattle				+							
A. mitchellii	Mitchell's Wattle					S						
A. montana	Mallee Wattle							+	+			S
A. oxycedrus	Spike Wattle						L					
A. paucijuga	Wattle										T	
A. pycnantha	Golden Wattle				L	L	L	L	L			L
A. verniciflua	Varnish Wattle	L							+		+	
A. wilhelmiana	Dwarf Nealie											S
A. williamsonii	Whirrakee Wattle											L
Acaena anserinifolia	Bidgee-widgee	F	F	F			+					
A. echinata	Sheep's burr		F	F	+	+			+		+	
Acetosella vulgaris	Sheep Sorrel			+								
Actinthus reniformis	Mosquito Orchid				+	+		+				
Acrotriche serrulata	Honey-pots		S		S	S	S					
Adiantum aethiopicum	Common Maidenhair		F									
Actinobole uliginosum	Flannel Cudweed								F			
Agropyron scobrum	Common Wheat-grass					M	M		M			
Agrostis avenacea	Blown Grass					+			M	M		
A. tenuis	Brown-top Bent			M								
Aira caryophyllea	Silvery Hair-grass			M		+	+	+	M		M	M
Ajuga australis	Austral Bugle		+	+					+			
Amphibromus neesii	Swamp Wallaby-grass									M		
Amphipogon strictus	Grey-beard grass							M				
Amyema miquelii	Box Mistletoe				+	+	+	+	+		+	
A. miraculosum	Fleshy Mistletoe		+									
A. quandang	Grey Mistletoe										+	

Botanical name	Common name	1A	1B	1C	2A	2B	3A	3B	4	5A/5B	5C	6
Anagallis arvensis	Pimpernel			+							+	
Angianthus strictus	Stiff Angianthus								+			F
Anguillaria dioica	Early Nancy		+	+	+	+	M		+		+	
Aphanes arvensis	Parsley Piert			+					+		+	
Aptenia cordifolia	Heat-leaf Ice-plant								+			
Araujia hortorum	White Bladder-flower								+			
Arctotheca calendula	Cape Weed			+		+	+				+	
Arthropodium milleflorum	Pale Vanilla-Lily			M			+					
A. minus	Small Vanilla-Lily						M		M			
Asparagus officinalis	Asparagus		+									
Asperula conferta	Common Woodruff									+		
Asplenium flabellifolium	Necklace Fern		+	+							F	
Asterolinan linum-stellatum	Asterolinon											+
Astroloma conostephioides	Flame Heath				+	+	+	+		+		+
A. humifusum	Cranberry Heath				+	+	+	S	+			+
Avena fatua	Wild Oats					+	+				+	
Baeckea behrii	Broom Baeckea											L
B. ramosissima	Rosy Baeckea							+				+
Boronia caerulescens	Blue Boronia						S					
Brachycome multifida	Cut-leaf Daisy						+	+				
B. perpusilla	Rayless Daisy						F		F			
Brachycome sp.	Daisy								+			
Brachyloma daphnoides	Daphne Heath				S	S	+	S	+			S
B. ericoides	Brush Heath						+					
Brassica tournefortii	Mediterranean Turnip		+									
Briza maxima	Large Quaking-grass		+		+	+	+	+	+		+	+
B. minor	Lesser Quaking-grass								+		+	
Bromus diandrus	Great Brome						+					
B. mollis	Soft Brome								+			
B. unioloides	Prairie Grass			+			+					
Bromus sp.	Brome		+						+		+	
Brunonia australis	Blue Pincushion		+		+	+	+	+	+			
Brunonia sp.	Pincushion								+			
Burchardia umbellata	Milkmaids		+		+	M	+	M				+
Bursaria spinosa	Sweet Bursaria						+	L	+			+
Caladenia angustata	Musky Caladenia				+							
C. caerulea	Blue Caladenia						+					
C. dilitata	Green-comb Spider-orchid						+					
Calandrinia calyptrata	Pink Purslane			+								
Calytrix tetragona	Fringe-myrtle				L	+			+			
Cardamine hirsuta	Common Bitter-cress								+			
Carduus pycnocephalus	Slender Thistle										+	
C. tenuiflorus	Slender Thistle		+	+		+			+			
Carex appressa	Tall Sedge											+
C. tereticaulis	Sedge									M		
Carthamus lanatus	Saffron Thistle								+			
Cassinia arcuata	Drooping Cassinia	+			+	L	+	L	L			L
C. uncata	Sticky Cassinia					+		+				+
Cassytha glabella	Slender Dodder-laurel					+	+	+				+
C. melantha	Coarse Dodder-laurel						+	+	+			+
Casuarina muellerana	Slaty Sheoak								+			L
Catapodium rigidum	Fern Grass								+			

Botanical name	Common name	1A	1B	1C	2A	2B	3A	3B	4	5A/5B	5C	6
Centaurea melitensis	Malta Thistle										+	
Centaurium tenuiflorum	Centaury	F			+	+	+	+	F			F
Centella cordifolia	Centella								+		+	+
Cerastium glomeratum	Mouse-ear Chickweed	+		F		+						
Chamaescilla corymbosa	Blue Stars		+		+	M	M	+	+			
Cheilanthes tenuifolia	Rock Fern	+	+	+	+	F	+		+		+	F
Cheiranthera linearis	Finger-flower						S					
Cirsium vulgare	Spear Thistle	+	+	+					+		+	
Correa reflexa	Common Correa						+	+				+
Corybas diemenicus	Slaty Helmet-orchid					+	+				M	
Cotula australis	Common Cotula			F			+		+		+	
C. bipinnata	Ferny Corula								+			
Craspedia glauca	Common Billy-buttons						+		F			
Crassula colorata	Dense Crassula						+		+		+	
C. macrantha	Spreading Crassula		+				+					
C. sieberana	Sieber Crassula			+		+	+		+			
Crowea exalata	Small Crowea							S				
Cymbonotus preissianus	Austral Bear's-ear		+	F	+	F			+		F	
Cyperus brevifolius	Globe Kyllinga						+					
C. eragrostis	Drain Flat-sedge						+					
Dampiera lanceolata	Grooved Dampiera						+	+			+	
Danthonia pallida	Silvertop Wallaby-grass	+	+		+	+	+	+	+			
D. racemosa	Wallaby-grass		+						+			
D. richardsonii	Wallaby-grass											+
Danthonia sp.	Wallaby-grass		+	M	+	+	+	M	+	+	+	+
Daucus glochidiatus	Austral Carrot						F		F		F	
Daviesia ulicifolia	Gorse Bitter-pea				+	S	S	+	+			+
D. genistifolia	Broom Bitter-pea											+
D. virgata	Narrow-leaf Bitter-pea						+	+	+			
Dianella revoluta	Black-anther Flax-lily		+		+	M	+	M	+			
Dichelachne sciurea	Shorthair Plume-grass				+	+	+		+			
Dichondra repens	Kidney-weed		F								F	
Dichopogon fimbriatus	Nodding Chocolate Lily					+	+	+	+		+	
D. strictus	Chocolate Lily		+		+	+	+	+	+		M	+
Dillwynia cinerascens	Grey Parrot-pea		+		+	+		+	+			
D. hispida	Red Parrot-pea					S						
D. retorta	Small-leaf Parrot-pea					+						
D. sericea	Showy Parrot-pea				+	+	+	+	+			+
Diuris maculata	Leopard Orchid						+					
D. pedunculata	Golden Moths						+					
Dodonaea cuneata	Wedge-leaf Hop-bush								+		+	+
Drosera auriculata	Errienellam		+		F	+	+				+	
D. peltata	Pale Sundew						+					+
D. planchonnii	Climbing Sundew				+	+	+	+	+			+
D. whittakeri	Scented Sundew		+		+	+	+	+	+		+	+
Echinopogon ovatus	Hedgehog-grass			M								
Eleocharis acuta	Common Spike-rush									M	M	
E. pusilla	Small Spike-rush									+		
Epacris impressa	Common Heath	S	S			+						
Epilobium ciliatum	Willow-herb										+	
E. cinereum	Variable Willow-herb			F								
Eragrostis brownii	Common Love-grass										M	

Botanical name	Common name	1A	1B	1C	2A	2B	3A	3B	4	5A/5B	5C	6
Eriochilus cucullatus	Parson's bands					+						
Eriostemon angustifolius	Small-leaf Wax-flower											S
E. verrucosus	Fairy Wax-flower					S	S					
Erodium botrys	Big Heron's-bill										+	
E. cicutarium	Common Heron's-bill			+								
E. crinitum	Blue Heron's-bill										+	
Erophila verna	Whitlow Grass					+						
Eucalyptus aromaphloia	Scent-bark	+										
E. baxteri	Brown Stringybark	+										
E. behriana	Bull Mallee											T
E. blakelyi	Blakely's Red Gum										T	
E. globulus	Blue Gum	T	T									
E. goniocalyx	Long-leaf Box		+		T	T	+				+	
E. leucoxylon	Yellow Gum					+	+	T	T			
E. macrorhyncha	Red Stringybark	+	+		T	T	T				+	
E. melliodora	Yellow Box		T		+	+					+	
E. microcarpa	Grey box							T	T			
E. obliqua	Messmate Stringybark	T		T								
E. polyanthemos	Red Box		+		+	T	T	+				
E. polybractea	Blue Mallee								+			T
E. rubida	Candlebark	T	T									
E. sideroxylon	Red Ironbark					+	T	T				
E. viminalis	Manna Gum			T				+				
E. viridis	Green Mallee											T
Exocarpos cupressiformis	Cherry Ballart						+	+				
Gahnia deusta	Saw-sedge		M									
Galium gaudichaudii	Rough Bedstraw						+					
G. murale	Small Goosegrass		+			+	+		+			
G. tricornutum	Rough Corn Bedstraw	+										
Geranium molle	Dove's-foot										+	
G. solanderi	Austral Crane's-bill	+	+	+	+	+	+		+			+
Glossodia major	Wax-lip Orchid				+	+	M	M	+			M
Gnaphalium gymnocephalum	Creeping Cudweed	+		+	+	+	+		+			
Gompholobium huegelii	Common Wedge-pea				+	+	S					
Goodenia sp.	Goodenia		+		+	+	+	+				
G. Hederacea	Ivy Goodenia					+		+	+			
G. humilis	Swamp Goodenia									F		
G. pinnatifida	Cut-leaf Goodenia								F			
G. varia	Sticky Goodenia											S
Grevillea alpina	Mountain Grevillea				+	S	S	+	+			S
G. aquifolium	Variable Prickly Grevillea						S					
G. dryophylla	Goldfields Grevillea						S	S				
G. parviflora	Small-flower Grevillea					+						+
Hakea sericea	Silky Hakea		L			L	+	+	+			+
Haloragis elata	Raspwort					+	F		F		F	F
H. heterophylla	Raspwort		+									
H. rubra	Raspwort								F			
H. tetragyna	Common Raspwort	F	F		+	+	+	+	F			F
Hardenbergia violacea	Purple Coral-pea					+	+				+	
Helichrysum apiculatum	Common Everlasting					+			+			
H. baxteri	White Everlasting						+					
H. obcordatum	Grey Everlasting				S	+	S	+	+			
H. scorpioides	Button Everlasting				P	P						

Botanical name	Common name	1A	1B	1C	2A	2B	3A	3B	4	5A/5B	5C	6
Helichrysum semipapposum	Clustered Everlasting	+	+			F	+	+	+		+	
H. bracteatum	Golden Everlasting				+		+	+	+			+
Helipterum auetrale	Common Sunray		+		+	+			+		+	
Hibbertia exutiacies	Guinea-flower				+	+	+	S	+			+
H. fasciculata	Bundled Guinea-flower					S						
H. humifusa	Grampians Guinea-flower						S					
H. stricta	Erect Guinea-flower				+	+	+	+				
H. virgata	Guinea-flower											S
Holcus lanatus	Yorkshire Fog			M								
Hovea heterophylla	Common Hovea						+					
Hydrocotyle laxiflora	Stinking Pennywort	F	F	F	F	F	+		+		F	
Hypericum elatum	Tall St. John's Wort										+	
H. gramineum	Small St. John's Wort	F	F	F	F	+						
H. triquetrifolium	Wavy-leaf St. John's Wort								+			
Hypochoeris glabra	Smooth Cat's-ear		+	+	+	+	+	+	+		+	+
H. radicata	Cat's-ear				+		+					
Hypoxis pusilla	Tiny Star						+		M		+	
Inula graveolens	Stinkwort										+	
Isotoma fluviatilis	Swamp Isotome				+					+		
Juncus amabilis	Rush		+							+		
J. bufonius	Toad Rush		+		+	+	+	+	M		+	
J. capitatus	Capitate Rush		+		+	+	+	+	+			+
J. holoschoenus	Joint-leaf Rush				+					+	+	
J. homalocaulis	Wiry Rush										M	
J. pallidus	Pale Rush										M	
J. planifolius	Broad-leaf Rush										M	
J. subsecundus	Finger Rush		+		+	+			+		+	
Juncus sp.	Rush		+		+	+	+	+	+		+	+
Lactuca serrida	Prickly Lettuce						+					
Lagenophora huegelii	Coarse Bottle-daisy		F		+		+		+			
Lepidosperma laterale	Variable Sword-sedge				M	+	+		+			
L. lineare	Little Sword-sedge				+	+	+		+			
L. semiteres	Wire Rapier-sedge				M	M						
L. viscidum	Sticky Sword-sedge								+			
Leptomeria aphylla	Leafless Currant-bush						S					
Leptorhynchos squamatus	Scaly Buttons		+		+	+	+	+	+		F	
L. tenuifolius	Wiry Buttons				+	+	+	+	+			
Leptospermum myrsinoides	Heath Tea-tree				+	+	+					
Leucopogon ericoides	Pink Beard-heath					S						
L. rufus	Ruddy Beard-heath						+	+				+
L. virgatus	Common Beard-heath				+	+	+					
Levenhookia dubia	Hairy Stylewort				+	+			+			
Lissanthe strigosa	Peach Heath					+	+	+	+			
Logania linifolia	Flax-leaf Logania											S
Lomandra filiformis	Wattle Mat-rush	+	+		M	+	+	M	M		M	M
L. longifolia	Spiny-headed Mat-rush					+						
L. micrantha	Small-flower Mat-rush						+		+			
L. multiflora	Many-flower Mat-rush				+	+	+	+	+			+
L. sororia	Small Mat-rush				+	+	+		+			
Loudonia behrii	Golden Pennants						+	+				+
Luzula meridionalis	Field Woodrush	+	+	M	+	+					+	
Marianthus procumbens	White Marianth				+		+					

Botanical name	Common name	1A	1B	1C	2A	2B	3A	3B	4	5A/5B	5C	6
Melaleuca decussata	Cross-leaf Honey-myrtle											L
M. uncinata	Broom Honey-myrtle											L
M. wilsonii	Violet Honey-myrtle											L
Micromyrtus ciliata	Heath-Myrtle								+			+
Microseris scapigera	Yam-daisy	+			+	+	+	+	P			
Microtis unifolia	Common Onion-orchid							+				
Microtis sp.	Onion-orchid		+		+	+			+		+	
Millotia tenuifolia	Soft Millotia							F	P			
Moenchia erecta	Erect Chickweed					+						
Monotoca scoparia	Prickly Broom-heath					S						
Myriophyllum propinquum	Water-milfoil									P		
Olearia decurrens	Daisy-bush								+			+
O. ramulosa	Twiggy Daisy-bush		S									
O. teretifolia	Cypress Daisy-bush								+	+		+
Olearia sp.	Daisy-bush									+		
Opercularia varia	Variable Stinkweed				+	+	+					
Ophioglossum coriaceum	Austral Adder's tongue		+	+		+	+		+		+	
Oxalis corniculata	Yellow Wood-sorrel	+	F	+		+	+		+		+	+
O. pes-caprae	Soursob						+					
Parentucellia latifolia	Common Bartsia		+		+	+	+		+		+	
P. viscosa	Sticky Bartsia			+								
Parietaria debilis	Shade Pellitory										+	
Pelargonium rodneyanum	Magenta Stork's-bill				+	+	+		+			
Petrorhagia velutina	Hairy Pink								+			
Phebalium obcordatum	Dainty Phebalium											+
Picris hieracioides	Hawkweed Picris		+									
Pimelea humilis	Common Rice-flower		+		+	+	+	+	+			
P. linifolia	Slender Rice-flower					+		+		S		
Pittosporum phillyreoides	Weeping Pittosporum										L	
Plantago varia	Variable Plantain		F		P	+			P		+	F
Platylobium formosum	Handsome Flat-pea					L		L				
Pleurosorus rutifolius	Blanket Fern			F								
Poa annua	Annual Meadow-grass		+			+	+					
P. labillardieri	Grass	M	M							M		
P. sieberana	Grass										M	+
Poa sp.	Grass	+	+		+	+	+	+	+			
Podolepis jaceoides	Showy Podolepis					+	+		+		+	+
Prostanthera aspalathoides	Scarlet Mint-bush											S
P. denticulata	Rough Mint-bush					+	L					S
P. saxicola	Slender Mint-bush					L	L					
Pseudanthus ovalifolius	Oval-leaf Pseudanthus											+
Pteridium esculentum	Austral Bracken	F	F	F							+	
Pterostylis curta	Blunt Greenhood										M	
P. longifolia	Tall Greenhood						+					
P. nana	Dwarf Greenhood				+	+			+			
P. nutans	Nodding Greenhood					+						
P. parviflora	Tiny Greenhood					M						
P. revoluta	Autumn Greenhood					+						
Pultenaea daphnoides	Large-leaf Bush-pea					+						
P. humilis	Bush-pea				+	+						+
P. largiflorens	Bush-pea						S	S	S			
P. pedunculata	Matted Bush-pea						+	S	+			S
Pultenaea sp.	Bush-pea				+	+			+			
Ranunculus pachycarpus	Thick-fruit Buttercup		+		+		+		+		+	

Botanical name	Common name	1A	1B	1C	2A	2B	3A	3B	4	5A/5B	5C	6
Ranunculus sessiliflorus	Australian Small-flower Buttercup		+	+		+			+			
Rhagodia nutans	Nodding Saltbush								S			
Romulea longifolia	Onion Grass					+			+			
Rumex brownii	Slender Dock		+	+		+			+		+	
Schoenus apogon	Common Bog-rush		+		S	+	M		+		M	
S. breviculmis	Matted Bog-rush						+					
Scirpus hystrix	Awned Club-rush											+
Sebaea ovata	Yellow Sebaea					+	+		+			
Senecio hispidulus	Fireweed				+	+	+	+	+			+
S. minimus	Fireweed	F										
S. quadridentatus	Cotton Fireweed	+	F	F	F	F	+	+	+		+	+
Solenogyne bellioides	Solenogyne		+	+	+	+	+	+	+	+		+
Sonchus asper	Rough Sow-thistle			+					+			
Spergularia rubra	Red Sand-spurrey								+			
Stackhousia monogyna	Creamy Candles				+	+			+			
Stellaria media	Chickweed			+		+			+		+	+
S. pungens	Prickly Starwort	F		S								
Stipa tuckeri	Spear-grass											+
S. variabilis	Variable Spear-grass			M				+	M		+	
Stipa sp.	Spear-grass		+	+	+	+	+	+	+		+	+
Stuartina muelleri	Spoon Cudweed		+			+	+		+		+	+
Stylidium graminifolium	Grass Trigger-plant					+	+		+			
Tetratheca ciliata	Pink Bells		S		+	+	+	+				
Thelymitra antennifera	Rabbit-ears					+						
T. pauciflora	Slender Sun-orchid							+				
T. rubra	Salmon Sun-orchid						M					
Thelymitra sp.	Sun-orchid				+	+			+			
Themeda australis	Kangaroo grass		+			+	M		M			
Thysanotus patersonii	Twining Fringe-lily				+	+	+	+	P		+	F
Toxanthes perpusilla	Tiny Bow-flower			+		+			P			
Tricoryne elatior	Yellow Rush-lily										+	
Trifolium angustifolium	Narrow-leaf Clover								+		+	
T. campestre	Hop Clover			+		+			+		+	
Trifolium sp.	Clover		+			+			+			
Triglochin centrocarpa	Dwarf Arrowgrass								M			
T. procera	Water-ribbons						+					
T. striata	Streaked Arrowgrass						+					
Triglochin turrifera	Turret Arrowgrass										M	
Typha orientalis	Bulrush										M	
Velleia paradoxa	Spur Velleia										+	
Verbascum virgatum	Twiggy Mullein			+							+	
Verbascum sp.	Mullein										+	
Veronica plebeia	Trailing Speedwell				+	+	+		+			+
Viola hederacea	Ivy-leaf Violet	F	F									
Vittadinia lanuginosa	New Holland Daisy								+			
V. triloba	Common New Holland Daisy								F			
Vulpia membranacea	Dune Fescue						+					
V. myuros	Rat's-tail Fescue								+			
Wahlenbergia communis	Tufted Bluebell								+			
W. stricta	Tall Bluebell	+				+	+		+			
Wahlenbergia sp.	Bluebell					+			+			
Westringia eremicola	Slender Westringia							+	L			
Xanthorrhoea australis	Austral Grass-tree							L				

Appendix 2A

BIRDS OF THE NORTH CENTRAL AREA

This Appendix contains a list of birds recently recorded in the study area, with an indication of the habitat(s) in which they are most likely to be observed. The species are listed by scientific and common names following the nomenclature of the CSIRO (1969). Horizontal lines are used to separate families. Species recorded in the study area as accidental or as vagrants have not been included in the list.

Habitat

1. tall open forest
2. open forest
3. woodland
4. mallee
5. pasture, grassland, suburban
6. aquatic
7. aerial

Scientific name	Common name	Habitat							Breeding in study area
		1	2	3	4	5	6	7	
Pelecanus conspicillatus	Australian Pelican						x		Uncertain
Anhinga rufa	Darter						x		Yes
Phalacrocorax carbo	Black Cormorant						x		Yes
Phalacrocorax sulcirostris	Little Black Cormorant						x		Yes
Phalacrocorax varius	Pied Cormorant						x		Yes
Phalacrocorax melanoleucos	Little Pied Cormorant						x		Yes
Podiceps novaehollandiae	Little Grebe						x		Yes
Podiceps poliocephalus	Hoary-headed Grebe						x		Yes
Podiceps cristatus	Great-crested Grebe						x		Yes
Ardea pacifica	White-necked Heron					x	x		Yes
Ardea novaehollandiae	White-faced Heron					x	x		Yes
Egretta alba	White Egret						x		Uncertain
Egretta garzetta	Little Egret						x		Uncertain
Egretta intermedia	Plumed Egret						x		Uncertain
Nycticorax caledonicus	Nankeen Night Heron						x		Yes
Botaurus poiciloptilus	Brown Bittern						x		Yes
Threskiornis molucca	White Ibis					x	x		Yes
Threskiornis spinicollis	Straw-necked Ibis					x	x		Uncertain
Plegadis falcinellus	Glossy Ibis						x		Uncertain
Platalea regia	Royal Spoonbill						x		Yes
Platalea flavipes	Yellow-billed Spoonbill						x		Yes
Dendrocygna arcuata	Water Whistling Duck						x		Uncertain
Dendrocygna eytoni	Grass Whistling Duck						x		Uncertain
Cygnus atratus	Black Swan					x	x		Yes
Stictonetta naevosa	Freckled Duck						x		Yes
Tadorna tadornoides	Mountain Duck					x	x		Yes
Anas superciliosa	Black Duck					x	x		Yes
Anas platyrhynchos	Mallard					x	x		Yes
Anas gibberifrons	Grey Teal					x	x		Yes
Anas castanea	Chestnut Teal						x		Uncertain
Anas rhynchotis	Blue-winged Shoveler					x	x		Yes

Scientific name	Common name	Habitat							Breeding in study area
		1	2	3	4	5	6	7	
Malacorhynchus membranaceus	Pink-eared Duck						x		Yes
Aythya australis	White-eyed Duck						x		Uncertain
Chenoetta jubata	Wood Duck					x	x		Yes
Oxyura australis	Blue-billed Duck						x		Uncertain
Biziura lobata	Musk Duck						x		Yes
Elanus notatus	Black-shouldered Kite					x		x	Yes
Milvus migrans	Fork-tailed Kite					x		x	Uncertain
Haliastur sphenurus	Whistling Eagle				x	x		x	Yes
Accipiter novaehollandiae	Grey Goshawk	x	x						Yes
Accipiter fasciatus	Australian Goshawk	x	x	x	x	x			Yes
Accipiter cirrocephalus	Collared Sparrowhawk		x						Yes
Hieraaetus morphnoides	Australian Little Eagle				x	x		x	Yes
Aquila audax	Wedge-tailed Eagle	x	x	x	x	x		x	Yes
Haliaetus leucogaster	White-breasted Sea-eagle						x		Yes
Circus assimilis	Spotted Harrier					x			Uncertain
Circus approximans	Swamp Harrier					x	x		Yes
Falco subniger	Black Falcon					x			Yes
Falco peregrinus	Peregrine Falcon		x			x		x	Yes
Falco longipennis	Little Falcon					x			Yes
Falco cenchroides	Nankeen Kestrel				x	x		x	Yes
Falco berigora	Brown Hawk		x	x		x			Yes
Leipoa ocellata	Mallee Fowl				x				Yes
Coturnix pectoralis	Stubble Quail					x			Yes
Synoicus ypsilophorus	Brown Quail					x	x		Yes
Turnix varia	Painted Quail		x	x	x				Yes
Turnix velox	Little Quail					x			Yes
Pedionomus torquatus	Plain Wanderer					x			Yes
Grus rubicunda	Brolga					x	x		Yes
Rallus philippensis	Banded Landrail						x		Yes
Porzana pusilla	Marsh Crake						x		Yes
Porzana fluminea	Australian Spotted Crake						x		Yes
Tribonyx ventralis	Black-tailed Native Hen						x		Yes
Gallinula tenebrosa	Dusky Moorhen						x		Yes
Porphyrio porphyrio	Swamphen						x		Yes
Fulica atra	Coot						x		Yes
Rostratula benghalensis	Australian Painted Snipe						x		Yes
Vanellus novaehollandiae	Spur-winged Plover					x	x		
Vanellus tricolor	Banded Plover					x	x		Yes
Charadrius cinctus	Red-kneed Dotterel						x		Yes
Charadrius alexandrinus	Red-capped Dotterel						x		Yes
Charadrius melanops	Black-fronted Dotterel						x		Yes

Scientific name	Common name	Habitat							Breeding in study area
		1	2	3	4	5	6	7	
Gallinago hardwickii	Japanese Snipe						x		No
Tringa nebularia	Greenshank						x		No
Calidris acuminata	Sharp-tailed Sandpiper						x		No
Calidris ruficollis	Red-necked Stint						x		No
Himantopus himantopus	White-headed Stilt						x		Yes
Cladorhynchus leucocephalus	Banded Stilt						x		Yes
Recurvirostra novaehollandiae	Avocet						x		Yes
Burhinus magnirostris	Southern Stone Curlew		x	x		x			Yes
Larus novaehollandiae	Silver Gull					x	x		Yes
Chlidonias hybrida	Whiskered Tern						x		Uncertain
Sterna nilotica	Gull-billed Tern						x		Yes
Cheramoeca leucosternum	White-backed Swallow			x	x	x			Yes
Hirundo neoxena	Welcome Swallow			x		x	x		Yes
Petrochelidon nigricans	Tree-martin			x		x			Yes
Petrochelidon ariel	Fairy-martin				x	x	x		Yes
Anthus novaeseelandiae	Australian Pipit					x			Yes
Coracina novaeseelandiae	Black-faced Cuckoo-shrike	x	x	x	x	x			Yes
Coracina robusta	Little Cuckoo-Shrike		x	x	x				Yes
Lalage suerii	White-winged Triller		x	x	x	x			Yes
Drymodes brunneopygia	Southern Scrub-robin				x				Yes
Zoothera dauma	Australian Ground-thrush		x		x				Yes
Turdus merula	Blackbird					x			Yes
Turdus ericetorum	Song Thrush					x			Yes
Cinclosoma punctatum	Spotted Quail-thrush	x	x						Yes
Pomatostomus temporalis	Grey-crowned Babbler		x	x		x			Yes
Pomatostomus superciliosus	White-browed Babbler		x	x	x	x			Yes
Cisticola exilis	Golden-headed Fantail-warbler						x		Yes
Megalurus gramineus	Little Grassbird						x		Yes
Acrocephalus stentoreus	Reed Warbler						x		Yes
Cinclorhamphus cruralis	Brown Songlark					x			Yes
Cinclorhamphus mathewsi	Rufous Songlark		x	x	x	x			Yes
Malurus cyaneus	Superb Blue Wren	x	x	x	x	x			Yes
Malarus lamberti	Variegated Wren				x				Yes
Gerygone olivacea	White-throated Warbler		x	x					Yes
Gerygone fusca	Western Warbler		x	x					Yes
Smicrornis brevirostris	Weebill		x	x	x				Yes
Acanthiza lineata	Striated Thornbill	x	x	x		x			Yes
Acanthiza nana	Little Thornbill		x	x	x				Yes
Acanthiza pusilla	Brown Thornbill	x	x	x	x	x			Yes
Acanthiza apicalis	Red-tailed Thornbill				x				Yes
Acanthiza uropygialis	Chestnut-rumped Thornhill		x		x				Yes

Scientific name	Common name	Habitat							Breeding in study area
		1	2	3	4	5	6	7	
Acanthiza reguloides	Buff-rumped Thornbill		x	x		x			Yes
Acanthiza chrysorrhoa	Yellow-rumped Thornbill				x	x			Yes
Sericornis frontalis	White-browed Scrub-wren	x	x						Yes
Hylacola pyrrhopygia	Heath Wren		h	e	a	t	h		Yes
Hylacola cauta	Mallee Heath-wren				x				Yes
Aphelocephala leucopsis	Whiteface			x	x	x			Yes
Chthonicola sagittata	Speckled Warbler		x	x		x			Yes
Epthianura albifrons	White-fronted Chat					x			Yes
Epthianura tricolor	Crimson Chat				x				Yes
Microeca leucophaea	Jacky Winter			x	x	x			Yes
Petroica multicolor	Scarlet Robin		x	x					Yes
Petroica goodenovii	Red-capped Robin		x		x				Yes
Petroica phoenicea	Flame Robin	x	x			x			Yes
Petroica rodinogaster	Pink Robin	x	x						Uncertain
Petroica rosea	Rose Robin	x	x						Uncertain
Petroica culcullata	Hooded Robin		x	x	x	x			Yes
Eopsaltria australis	Southern Yellow Robin	x	x	x					Yes
Rhipidura fuliginosa	Grey Fantail	x	x	x	x				Yes
Rhipidura rufifrons	Rufous Fantail	x	x						Uncertain
Rhipidura leucophrys	Willie Wagtail		x	x	x	x			Yes
Columbia livia	Domestic Pigeon					x			Yes
Streptopelia chinensis	Spotted Turtledove					x			Yes
Geopelia striata	Peaceful Dove		x	x	x				Yes
Ceopelia cuneata	Diamond Dove				x				Uncertain
Phaps chalcoptera	Common Bronzewing		x	x	x				Yes
Phaps elegans	Brush Bronzewing				x				Yes
Ocyphaps lophotes	Crested Pigeon				x	x			Yes
Trichoglossus haematodus	Rainbow Lorikeet			x					Uncertain
Glossopsitta concinna	Musk Lorikeet		x	x	x	x			Yes
Glossopsitta porphyrocephala	Purple-crowned Lorikeet		x	x	x	x			Yes
Glossopsitta pusilla	Little Lorikeet		x	x		x			Yes
Lathamus discolor	Swift Parrot		x	x		x			Uncertain
Cacatua galerita	Sulphur-crested Cockatoo	x		x	x	x			Yes
Cacatua sanguinea	Little Corella			x		x			Uncertain
Cacatua tenuirostris	Long-billed Corella			x		x			Uncertain
Cacatua roseicapilla	Galah			x	x	x			Yes
Numphicus hollandicus	Cockatiel			x	x	x			Yes
Platycercus elegans	Crimson Rosella	x	x	x		x			Yes
Platycercus eximius	Eastern Rosella			x		x			Yes
Psephotus haematogaster	Blue-Bonnet		x		x	x			Yes
Psephotus haematonotus	Red-rumped Parrot			x	x	x			Yes
Neophema chrysostoma	Blue-winged Parrot		x			x			Yes
Neophema pulchella	Turquise Parrot		x	x		x			
Melopsittachus undulatus	Budgerygah			x	x	x			Yes

Scientific name	Common name	Habitat							Breeding in study area
		1	2	3	4	5	6	7	
Cuculus pallidus	Pallid Cuckoo		x	x	x	x			Yes
Cacomantis variolosus	Brush Cuckoo		x						Uncertain
Caromantis pyrrhophanus	Fan-tailed Cuckoo	x	x	x	x	x			Yes
Chrysococcyx osculans	Black-eared Cuckoo		x	x	x				Yes
Chrysococcyx basilis	Horsfield Bronze Cuckoo	x	x		x				Yes
Chrysococcyx plagosus	Golden Bronze Cuckoo	x	x	x					Yes
Ninox strenua	Powerful Owl	x	x						Yes
Ninox novaeseelandiae	Boobook Owl	x	x	x	x	x			Yes
Ninox connivens	Barking Owl		x	x					Yes
Tyto alba	Barn Owl			x	x	x			Yes
Podargus strigoides	Tawny Frogmouth		x	x		x			Yes
Aegotheles cristatus	Owlet-nightjar		x	x	x				Yes
Eurostopodus guttatus	Spotted Nightjar				x				Yes
Hirundapus caudacutus	Spine-tailed Swift							x	No
Apus pacificus	Fork-tailed Swift							x	No
Alcyone azurea	Azure Kingfisher						x		Uncertain
Dacelo gigas	Laughing Kookaburra	x	x	x	x	x			Yes
Halcyon pyrrhopygia	Red-backed Kingfisher				x	x			Uncertain
Halcyon sancta	Sacred Kingfisher		x	x		x	x		Yes
Merops ornatus	Rainbow Bee-eater		x	x	x	x			Yes
Eurystomus orientalis	Dollar Bird			x		x			Uncertain
Mirafra javanica	Singing Bushlark					x			Uncertain
Alauda arvensis	Skylark					x			Uncertain
Myiagra rubecula	Leaden Flycatcher	x	x						Yes
Myiagra cyanoleuca	Satin Flycatcher	x	x						Yes
Seisura inquieta	Restless Flycatcher		x	x		x			Yes
Pachycephala pectoralis	Golden Whistler	x	x	x	x	x			Yes
Pachycephala rufiventris	Rufous Whistler	x	x	x	x				Yes
Pachycephala inornata	Gilbert Whistler		x		x				Yes
Colluricincla harmonica	Grey Shrike-thrush	x	x	x	x	x			Yes
Falcunculus frontatus	Shrike-tit	x	x	x		x			Yes
Oreoica gutteralis	Crested Bell-bird		x		x				Yes
Neositta chrysoptera	Orange-winged Sittella		x	x					Yes
Neositta pileata	Black-capped Sittella				x				Yes

Scientific name	Common name	Habitat							Breeding in study area
		1	2	3	4	5	6	7	
Climacteris picumnus	Brown Tree-creeper		x	x	x	x			Yes
Climacteris leucophaea	White-throated Tree-creeper	x	x	x		x			Yes
Dicaeum hirundinaceum	Mistletoe Bird		x	x		x			Yes
Pardalotus punctatus	Spotted Pardalote	x	x	x		x			Yes
Pardalotus xanthopygus	Yellow-rumped Pardalote				x				Yes
Pardalotus striatus	Yellow-tipped Pardalote		x						Uncertain
Pardalotus ornatus	Eastern Striated Pardalote		x	x		x			Yes
Pardalotus substriatus	Striated Pardalote	x	x	x	x	x			Yes
Zosterops lateralis	Grey-breasted Silvereye	x	x	x	x	x			Yes
Myzomela nigra	Black Honeyeater				x				Yes
Meliphaga virescens	Singing Honeyeater				x				Uncertain
Meliphaga fusca	Fuscous Honeyeater		x	x		x			Yes
Meliphaga chrysops	Yellow-faced Honeyeater	x	x	x		x			Yes
Meliphaga cratitia	Purple-gaped Honeyeater				x				Yes
Meliphaga penicilata	White-plumed Honeyeater			x	x	x			Yes
Meliphaga ornata	Yellow-plumed Honeyeater		x		x				Yes
Meliphaga leucotis	White-eared Honeyeater	x	x	x	x	x			Yes
Meliphaga melanops	Yellow-tufted Honeyeater		x	x		x			Yes
Melithreptus brevirostris	Brown-headed Honeyeater	x	x	x	x				Yes
Melithreptus lunatus	White-naped Honeyeater	x	x	x	x	x			Yes
Melithreptus gularis	Black-chinned Honeyeater		x	x	x				Yes
Entomyzon cyanotis	Blue-faced Honeyeater		x	x		x			Yes
Philemon citreogularis	Little Friar-bird		x	x	x				Yes
Philemon corniculatus	Noisy Friar-bird		x	x					Yes
Phylidonyris novaehollandiae	New Holland Honeyeater		x		x				Yes
Phylidonyris albifrons	White-fronted Honeyeater				x				Yes
Gliciphila melanops	Tawny-crowned Honeyeater				x				Yes
Plectorhyncha lanceolata	Striped Honeyeater				x				Yes
Conopophila picta	Painted Honeyeater		x	x					Yes
Zanthomiza phrygia	Regent Honeyeater		x			x			Yes
Acanthorhynchus tenuirostris	Eastern Spinebill	x	x		x	x			Yes
Manorina melanocephala	Noisy Miner		x	x	x	x			Yes
Anthochaera rufogularis	Spiny-cheeked Honeyeater				x				Yes
Anthochaera carunculata	Red Wattle-Bird	x	x	x	x	x			Yes
Emblema guttata	Diamond Firetail		x	x		x			Yes
Peophila cincta	Zebra Finch			x	x	x			Yes
Aegintha temporalis	Red-browed Finch	x	x			x			Yes
Passer domesticus	House Sparrow					x			Yes
Passer montanus	Tree Sparrow					x			Yes
Carduelis carduelis	Goldfinch					x			Yes
Chloris chloris	Greenfinch					x			Yes
Sturnus vulgaris	Starling				x	x			Yes
Acridotheres tristis	Indian Myna					x			Uncertain

Scientific name	Common name	Habitat							Breeding in study area
		1	2	3	4	5	6	7	
Oriolus sagittatus	Olive-backed Oriole	x	x						Yes
Grallina cyanoleuca	Magpie-Lark			x		x	x		Yes
Corcorax melanorhamphus	White-winged Cough		x	x	x	x			Yes
Artamus leucorhynchus	White-breasted Wood-swallow					x	x		Yes
Artamus personatus	Masked Wood-swallow		x	x	x	x			Yes
Artamus superciliosus	White-browed Wood-swallow		x	x	x	x			Yes
Artamus cyanopterus	Dusky Wood-swallow		x	x		x			Yes
Strepera graculina	Pied Currawong		x			x			Uncertain
Strepera versicolor	Grey Currawong		x	x	x	x			Yes
Cracticus torquatus	Grey Butcher-bird		x	x	x	x			Yes
Gymnorhina hypoleuca	White-backed Magpie					x			Yes
Gymnorhina tibicen	Black-backed Magpie		x	x	x	x			Yes
Corvus coronoides	Australian Raven		x	x	x	x			Yes
Corvus mellori	Little Raven					x			Uncertain

Appendix 2B

MAMMALS OF THE NORTH CENTRAL AREA

This appendix contains a list of mammals recently recorded in the study area, with an indication of their occurrence, abundance, and the habitats in which they are most likely to be observed. Horizontal lines indicate separate families. Abbreviations for habitats are the same as those for the birds (Appendix 2A).

Occurrence

w = widespread

res = restricted

Abundance

R = rare
U = uncommon
C = common
V = vagrant

Scientific name	Common name	Habitat							Occurrence	Abundance
		1	2	3	4	5	6	7		
Tachyglossus aculeatus	Echidna	x	x	x	x	x			*w*	C
Ornithorhynchus anatinus	Platypus						x		*res*	U
Phascogale tapoatafa	Tuan	x	x	x					*w*	U
Antechinus flavipes	Yellow-footed Antechinus	x	x	x					*w*	C
Antechinus stuartii	Brown Antechinus	x	x						Pyrenee Range	C
Sminthopsis murina	Mouse Dunnart		x	x	x				*res*	R
Sminthopsis crassicaudata	Fat-tailed Dunnart			x		x			*w*	U
Phascolarctos cinereus	Koala	x	x	x					*w*	U
Trichosurus vulpecula	Brush-tailed Possum	x	x	x		x			*w*	C
Pseudocheirus peregrinus	Ring-tailed Possum	x	x	x		x			*w*	U
Petaurus breviceps	Sugar Glider	x	x	x					*w*	U
Petaurus norfolcensis	Squirrel Glider			x					*res*	R
Acrobates pygmaeus	Feather-tailed Glider	x	x	x					*w*	U
Cercartetus nanus	Eastern Pygmy Possum	x	x	x					*w*	U
Macropus giganteus	Eastern Grey Kangaroo	x	x	x	x	x			*w*	C
Wallabia bicolor	Black Wallaby	x	x	x	x				*w*	C
Pteopus scapulatus	Red Fruit Bat							x	*w*	V
Pteropus poliocephalus	Grey-headed Fruit Bat							x	*w*	V
Pipistrellus tasmaniensis	Tasmanian Pipistrelle							x	*w*	C
Eptesicus pumilus	Little Bat							x	*w*	C
Nycticeius greyi	Little Broad-nosed Bat							x		U
Chalinolobus gouldii	Gould's Wattled Bat							x	*w*	C
Chalinolobus morio	Chocolate Bat							x	*w*	C
Nyctophilus geoffroyi	Lesser Long-eared Bat							x	*w*	C
Tadarida australis	White-striped Bat							x	*w*	C
Tadarida planiceps	Little Flat Bat							x	*w*	U

Scientific name	Common name	Habitat							Occurrence	Abundance
		1	2	3	4	5	6	7		
Lepus europaeus	Hare		x	x		x			ω	U
Oryctolagus cuniculus	Rabbit	x	x	x	x	x			ω	C
Rattus rattus	Black Rat	x	x	x		x			ω	C
Rattus lutreolus	Swamp Rat	x							Pyrenee Range	U
Mus musculus	House Mouse	x	x	x	x	x			ω	C
Hydromys chrysogaster	Eastern Water Rat						x		ω	C
Vulpes vulpes	Fox	x	x	x	x	x			ω	C
Felis catus	Cat	x	x	x	x	x			ω	C
Carvus unicolor	Sambar Deer	x	x						Pyrenee Range	R

Appendix 2C

REPTILES OF THE NORTH CENTRAL AREA

This appendix contains a list of reptiles recently recorded in the study area, with an indication of their occurrence, abundance, and the habitats in which they are most likely to be observed. Horizontal lines indicate separate families. Abbreviations for habitats are the same as those for the birds (Appendix 2A).

Occurrence

w = widespread

res = restricted

Abundance

R = rare
U = uncommon
C = common

Scientific name	Common name	Habitat							Occurrence	Abundance
		1	2	3	4	5	6	7		
Chelodina longicollis	Snake-necked Tortoise						x		*w*	C
Emydura macquarrii	Murray River Short-necked Tortoise						x		*res*	R
Amphibolurus barbatus	Eastern Bearded Dragon		x	x		x			*w*	U
Amphibolurus muricatus	Tree Dragon		x		x				*w*	C
Diplodactylus vittatus	Stone Gecko			x	x				*w*	R
Underwoodisaurus milii	Thick-tailed Gecko		x	x					*w*	U
Phyllodactylus marmoratus	Marbled Gecko		x	x					*w*	C
Delma impar	Spinifex Lizard					x			*w*	R
Delma inornata	Mimicking Snake Lizard		x						*w*	R
Pygopus lepidopodus	Common Scaly-foot								-	R
Cryptoblepharus boutoni	Wall Lizard			x					*res*	U
Ctenotus robustus	Large Striped Skink		x	x		x			*w*	C
Ctenotus uber	Eastern Copper-tailed Striped Skink			x		x			*res*	R
Hemiergis decresiensis	Three Toed Skink			x					*w*	U
Leiolopisma guichenoti	Garden Skink	x	x						*w*	C
Leiolopisma entrecasteauxii	Grass Skink	x							*res*	C
Lerista bougainvillii	Bougainville's Skink		x	x	x				*w*	C
Menetia greyi	Grey's Skink			x					*res*	U
Morethia boulengeri	Boulenger's Skink		x	x	x				*w*	C
Sphenomorphus tympanum	Water Skink	x							*res*	C
Egernia cunninghami	Cunningham's Skink					x			*res*	U
Egernia saxatilis	Black Rock Skink		R	C C	K	S			*res*	R
Egernia striolata	Tree Skink			x					*res*	U
Egernia whitii	White's Skink		x	x					*w*	C
Tiliqua scincoides	Common Blue Tongue		x	x		x			*w*	U
Trachydosaurus rugosus	Stumpy-tail Lizard		x	x	x	x			*w*	U
Varanus gouldii	Sand Goanna		x						*w*	R
Varanus varius	Tree Goanna		x	x					*w*	R

Scientific name	Common name	Habitat							Occurrence	Abundance
		1	2	3	4	5	6	7		
Notechis scutatus	Tiger Snake			x		x			*w*	U
Pseudechis porphyriacus	Red-bellied Black Snake		x						*res*	C
Pseudonaja textilis	Brown Snake		x	x	x	x			*w*	C
Suta brevicauda	Mitchell's Short-tailed snake				x	x			*res*	R
Suta dwyeri	Dwyer's Snake		x	x					*res*	R
Suta flagellum	Little Whip Snake			x					*w*	U
Vermicella annulata	Bandy Bandy			x					*w*	R
Typhlina broomi	Blind Snake				x				*res*	R
Typhlina nigrescens	Blind Snake								*res*	-
Typhlina proxima	Blind Snake								*w*	-

Appendix 2D

AMPHIBIANS OF THE NORTH CENTRAL AREA

This appendix contains a list of amphibians recently recorded in the study area, with an indication of their occurrence, abundance, and the habitats in which they are most likely to be observed. Horizontal lines indicate separate families. Abbreviations for habitats are the same as for the birds (Appendix 2A).

Occurrence

w = widespread

res = restricted

Abundance

R = rare
U = uncommon
C = common

Scientific name	Common name	Habitat							Occurrence	Abundance
		1	2	3	4	5	6	7		
Litoria raniformis				x		x			*w*	C
Litoria ewingii	Brown Tree Frog		x	x					*w*	C
Litoria paraewingii			x	x					*res*	C
Litoria peronii	Peron's Tree Frog			x		x			*w*	R
Geocrinia victoriana	Smooth Froglet	x	x						*res*	U
Limnodynastes dumerilii	Eastern Banjo Frog	x	x	x		x			*w*	C
Limnodynastes fletcheri	Long-thumbed Frog		x	x		x			*w*	R
Limnodynastes interioris	Giant Banjo Frog	x	x	x		x			*res*	R
Limnodynastes tasmaniensis	Spotted Grass Frog		x	x		x			*w*	C
Neobatrachus pictus	Meeowing Frog			x		x			*w*	U
Pseudophryne bibronii	Brown Toadlet		x						*w*	U
Ranidella parinsignifera			x	x		x			*w*	C
Ranidella signifera	Common Eastern Froglet		x	x		x			*w*	C

Appendix 2E

LARGER FISH SPECIES

Information derived from "A Guide to the Inland Angling Water of Victoria - Second Edition" by B.R. Tunbridge and P.L. Rogan. (Fisheries and Wildlife Division: Melbourne 1977.)

Numbers provide a rough guide to relative abundance, ranging from 1 (least abundant) to 3 (most abundant).

Drainage basin	Wimmera River					Avoca River									Loddon River												Campaspe River					Goulburn River				
Stream/Lake	Wimmera River	Avon River	Franks Gully Reservoir	Lake Batyo Catyo	Malahkoff Dam Volcano Lake	Avoca River above Bealiba	Avoca River below Bealiba	Avoca Shire Dam	Avoca Town Supply	Bealiba Reservoir	Old Town Lake	Railway Reservoir	Red Bank Reservoir	Skinners Flat Reservoir	Teddington Reservoir (Top)	Teddington Reservoir (Bottom)	Barkers Creek Reservoir	Bet Bet Creek	Cairn Curran Reservoir	Dunolly Old Town Water Supply	Expedition Pass Reservoir	Goldfield Reservoir	Jim Crow Creek	Kennington Reservoir	Laanecoorie Reservoir	Lake Neanger	Lake Weeroona	Loddon River	Spring Gully Reservoir	Talbot Reservoir	Tullaroop Creek	Tullaroop Reservoir	Waranga West Channel	Campaspe River above Lake Eppalock	Campaspe River below Lake Eppalock	Coliban	Lake Eppalock	Myrtle Creek	Goulburn River above Goulburn Weir	Goulburn River below Goulburn Weir	Greens Lake	Lake Nagambie
Scientific and Common name																																								
Maccullochella macquariensis (Murray Cod)	1					1																					2					2					1	2		1
Plectroplites ambiguus (Golden Perch)																											2							2		3	3	3	2
Bidyanus bidyanus (Silver Perch)																															2						2		1
Gadopsis marmoratus (River Blackfish)																														1	2		2		3				
Tandanus tandanus (Freshwater Catfish)																											2						3						2
Fluvialosa richardsoni (Bony Bream)																																				3			2
Euastacus armatus (Freshwater Crayfish)																																					2		2
Salmo trutta (Brown Trout)	1		1		2	2	1	2	1				2	2	3	2	3	1	2			3	2	1			2	2		2	2	3	2	2		1	3	2	2			1
Salmo gairdneri (Rainbow Trout)	1		2					1	1		2	2			2		3		1	2		3	1		2	1	2	1		1			2			3	1	1					
Perca fluviatilis (Redfin)	2	1	2	2	2	2	2		2	2	2	2		2		2	2	2	3	2	3		2	2		1	3	2	2	2		3	2		2		3	2	3	3	2	3	2
Tinca tinca (Tench)	2					2	2		2									2				2			2		2		2	1		2	1		2		3		2	2		
Cyprinus carpio (European Carp)							2																	2		1					2		1					3	3		
Carassius carassius (Crucian Carp)						2	2		2									2	2							2	2		2	1					3	2	2					

Appendix 2F

MOLLUSCS OF THE NORTH CENTRAL AREA

An asterisk indicates an introduced species. Many of these introduced species are widely distributed, and greatly outnumber the native molluscs.

Family	Scientific name	Comments
Hydrobiidae		Freshwater snail
Thiaridae	*Plotiopsis balonnensis*	Freshwater snail
Lymnaeidae	*Lymnaea tomentosa* *Lymnaea lessoni*	Freshwater snail Freshwater snail
Planorbidae	*Glyptophysa cosmeta* *Glyptophysa aliciae* *Bulinus (Isidorella)* sp.	Freshwater snail Freshwater snail Freshwater snail
Ancylidae	*Ferrissia (Pettancylus)* sp.	Freshwater limpet
Succineidae	*Succinea (Austrosuccinea) australis*	Terrestrial snail
Charopidae		Terrestrial snail
Punctidae		Terrestrial snail
Limacidae	**Deroceras reticulatum* **Deroceras caruanae* **Lehmannia (Lehmannia) nyctelia* **Lehmannia (Limacus) flavus*	Slug Slug Slug "Yellow slug"
Milacidae	**Milax gagates*	Slug
Cystopeltidae	*Cystopelta petterdi*	Victoria's only native slug
Helicidae	**Helix aspersa* **Cochlicella ventrosa*	"Common garden snail" Terrestrial snail
Hyriidae	*Velesunio ambiguus*	Freshwater bivalve
Corbiculidae	*Corbiculina angasi*	Freshwater bivalve
Sphaeriidae	*Sphaerium* sp.	Freshwater pea mussel

Appendix 3

STREAM FLOW AND SALINITY - DATA FOR STATIONS NOT LISTED IN TABLES 12 AND 13

Stream	Guaging Station	Stream Flow						Salinity		
		Years of record	Annual discharge (10^3Ml)			Daily flow (Ml)		No. of recordings	Salinity (mg TDS per l)		
			Maximum	Minimum	Mean	Maximum	Minimum		Minimum	Maximum	Mean
Pranjip Ck.	Moorilim	12 1958--69	129	1.7	55	7788	Nil (b)	49	30	280	121
Cornella Ck.	Colbinabbin	10 1960--70	25	0.53	9	1940	Nil (c)	50	40	2900	870
Wanalta Ck.	Wanalta	10 1960--70	8.9	0.14	3	135	Nil (c)	27	55	1450	300
Campaspe R.	Redesdale	12 1958--70	158	4.8	75	9287	Nil (c)	68	76	3586	970
Loddon R.	Vaughan	22 1947--70	106	2.2	41	6819	Nil (b)	38	115	1100	366
Tullaroop Ck.	Clunes	14 1955--70	172	3.1	60	6826	1	30	100	1800	680
McCallum Ck.	Carisbrook	22 1944--70	67	0.09	19	4453	Nil (b)	21	140	1620	740
Bet Bet Ck.	Bet Bet	11 1944--55	35	0.10	21	8710	Nil (b)	Nil			
Avoca R.	Amphitheatre	3 1966--70	6.9	0.76	3.4	450	Nil	65	110	4104	1624
Wimmera R.	Glynwylln	24 1946--70	224	3.4	62	12000	Nil (c)	57	220	3050	1423
Richardson R.	Warranooke	7 1963--70	22	Nil (c)	7	2672	Nil (a)	12	80	135	106

(a) Nil yearly (b) Nil in most years (c) Nil in dry years

Appendix 4

WEEDS IN THE NORTH CENTRAL AREA

The study area contains a number of plant species considered to be noxious weeds or pests. Species discussed below that are currently declared noxious weeds are indicated by an asterisk (*).

Most of these plants are introduced species, but severe infestations of the following native species also occur in the study area.

Chinese scrub or drooping cassinia *(Cassinia arcuata*)* - vast sections of old mining areas and overgrazed land are heavily infested with this scrub. It is common to most forested areas as an understorey species and can become quite dense when the forest canopy is opened by thinning operations. The part of Victoria where severe infestations occur corresponds closely to the study area, and most is considered to be beyond economic control. This weed can, however, be curbed on agricultural land by grazing and fertilizer application.

Dodder-laurel *(Cassytha melantha)* - this parasitic creeper is widespread in the study area. Eucalypt regeneration is particularly susceptible to its attack, but it can also kill mature trees. The infestation of the Wellsford Forest started in the 1930s and is now especially severe. The weed is also common around Eaglehawk and in mallee eucalypts at Rushworth and Tarnagulla. Its eradication is extremely difficult, but grazing appears to exert some control.

Mistletoe (Family Loranthacea) is an aggressive parasite of native flora, particularly eucalypts. It causes growth reduction, and heavy infestations lead to tree mortality. The sticky seeds are spread mainly by birds, and infestation is common along roadways, in shelter trees, and at the forest fringe. Forest control is usually by manual removal where growth is obviously restricted. Hormonal chemical control is feasible and has been used where ornamental or park trees have been infected.

Burgan scrub *(Leptospermum phylicoides)* - infestations are well established in the central highlands and along the Goulburn River. It can form a dense impregnable mass that restricts any agricultural use.

Introduced species in the study area that are now declared noxious weeds include the following:

Furze *(Ulex europaeus*)* - this is common on disturbed land and derelict mining areas, especially in the southern and western parts of the study area. Its dense growth habit creates a natural haven for vermin, particularly rabbits, and presents a high fire hazard.

Like furze, boxthorn *(Lycium ferocissimum*)*, sweet briar *(Rosa rubignosa*)*, and blackberry *(Rubus fruticosus*)* have spines or prickles, and all occur in the study area. Infestations can restrict access to recreation sites such as streams or tracks. Blackberries are a particular problem in the Shire of Newstead, but in the drier areas are confined to moist situations, such as streams, irrigation channels, and townships.

Whitehorse nettle *(Solanum elaeagnifolium*)* - this weed covers more than 120 ha in the East Loddon Shire (particularly the Parish of Calivil). New infestations of this toxic weed are continually being located.

Golden thistle *(Scolymus hispanicus*)* - very heavy infestations of this weed exist in the Shire of Newstead, and in the Parish of Axedale. It restricts agricultural use of an area, provides an excellent harbor for vermin, and remains a potential source of infestation to agricultural lands downstream. Another perennial weed is the artichoke thistle *(Cynara cardunculus*)*, with small infestations at Bendigo, Dunolly, Stanhope, and the Heathcote district. Annual thistles include slender thistle *(Carduus tenuiflorus*)*, bad infestations near Dunolly, and the Illyrian thistle *(Onorpodum illyricum*)*, infestations at Castlemaine, Maryborough, and Campbelltown.

Bathurst burr *(Xanthium spinosum*)* is a persistent annual burr common to most shires in the area, but particularly the East Loddon and Goulburn Shires. The small burrs contaminate wool fleeces, damage shears, and cause injury to stock.

St. John's wort *(Hypericum perforatum*)* infests both agricultural and forested land, particularly in the Goulburn Shire but also at Bendigo, Clunes, Newstead, and in the Parish of Campbelltown. In one of the few instances of biological control in Victoria, the Chrysomela beetle has been moderately successful in reducing infestations of this weed.

Wild garlic *(Allium vineale*)* taints agricultural produce and is known from Bendigo and Castlemaine.

Paterson's curse *(Echium plantagineum*)* is widespread in the study area, competing with pasture species.

Wheel cactus *(Opuntia rubusta*)* is spreading in the study area, particularly near Castlemaine and Maryborough.

Boneseed *(Chrysanthemoides moniliferum*)*

- scattered in the study area - establishes readily on disturbed sites.

Stinkwort *(Inula graveolens*)*, a strong-smelling weed, widespread in the area.

Hoary cress *(Cardaria drabra*)* - affects large areas around Bendigo and Dunolly; it has a serious effect on crops.

Tangled hypericum *(Hypericum triquetrifolium*)* - only one patch known in Australia, at Tarnagulla, where 0.2 ha on public land and freehold is infested.

One-leaf cape tulip *(Homeria breyniana*)* - heavy infestations occur at Swanwater; it is also scattered throughout the study area.

Two-leaf cape tulip *(Homeria miniata*)* - firmly established at Swanwater and Carisbrook.

Topped lavender *(Lavendula stoechas*)* - infestations near Castlemaine compete with other species.

Spiny broom *(Calycotome spinosa*)* is common in the Maryborough--St. Arnaud area, providing a harbour for vermin, particularly rabbits.

Prarie ground cherry *(Physalis viscosa*)* - well established along the Goulburn valley, particularly around Rushworth.

Soursob *(Oxalis pes-caprae*)* - widespread as a garden weed in most parts of the study area, it is also a strong competitor in crops and pastures.

Appendix 5

PARISHES IN NORTH CENTRAL STUDY AREA

Parish	Block								
	1	2	3	4	5	6	7	8	9
Amherst				+					
Ararat	P								
Archdale					+				
Avenel									P
Avoca			P	P					
Axedale							P	P	P
Bagshot							+		
Bailieston									+
Banyena	P								
Baringhup				+					
Barkly		P	P						
Barp					+				
Barrakee						+			
Bealiba					+				
Beckworth				+					
Berrimal		P			P	P			
Bet Bet				+					
Bolangum	+								
Bolerch				+					
Bonn									P
Boola Boloke		+							
Borung						+			
Bradford				P			P		
Brenanah						+			
Bridgewater							+		
Buckrabanyule						P			
Bulgana	P								
Bunganail									P
Bung Bong				+					
Burnewang									+
Burramboot									+
Burramboot East									+
Burrum Burrum	P								
Calivil						+			
Callawadda	+								

Parish	Block								
	1	2	3	4	5	6	7	8	9
Campaspe									+
Campbelltown				P					
Carag Carag									P
Carapooee		P			P				
Carapooee West	P	P							
Carisbrook				+					
Castlemaine								+	
Cherrington									+
Chewton								+	
Clunes				+					
Colbinabbin									+
Concongella	P								
Concongella Sth	P								
Coonooer East						P			
Coonooer West	P	P							
Cornella									+
Corop									P
Costerfield								P	P
Craigie				+					
Crosbie									+
Crowlands	P		P						
Dalyenong		P			P				
Dargalong									+
Dargile									+
Darkbonee	P	P							
Derby							+		
Diggorra							P		P
Dingee							P		
Drummond								P	
Dunolly					+				
Eddington				P	P				
Edgecombe								P	
Egerton							+		
Eglinton				+					
Ellesmere							P		P

Parish	Block								
	1	2	3	4	5	6	7	8	9
Elmore							P		P
Elphinstone								+	
Emberton								+	
Eppalock								+	
Eversley			P						
Faraday								+	
Fryers								+	
Gampola	P								
Girgarre									P
Glenalbyn						+			
Glendhu			+						
Glengower				P					
Glenhope								+	
Glenlogie			P						
Glenmona				+					
Glenorchy	+								
Glenpatrick			P						
Glynwylln	+								
Gobarup									+
Goornong							P		P
Gowar		P							
Gre Gre	+								
Guildford								+	
Harcourt								+	
Hawkestone								+	
Hayanmi						P	P		
Heathcote								P	
Huntly							+		
Illawarra	P								
Inglewood						P	P		
Janiember East						P	P		
Jamiember West						+			
Jarklan						+			
Joel Joel	P		P						
Kamarooka							P		
Kangerrar					P	P			

Parish	Block								
	1	2	3	4	5	6	7	8	9
Kimbolton								+	
Kingower					P	P			
Kinypanial						+			
Kirkella	+								
Knowsley								P	P
Knowsley East								P	P
Kooreh		P			P				
Kooroc					+				
Korong						+			
Kurraca					P	P			
Kurting						+			
Laanecoorie				P	P		P		
Landsborough	P	P	P						
Langley								P	
Langwornor								+	
Leichardt							+		
Lillicur				P					
Lockwood							+		
Lyell								+	
Malakoff	+								
Maldon				+					
Mandurang							P	P	
Marnoo	+								
Marong							+		
Maryborough				+					
Metcalfe								+	
Minto							+		
Mitchell								P	P
Mitiamo						P	P		
Mokepilly	P								
Moliagul					+				
Monea North									P
Moolerr		+							
Moolort				+					
Moora									+
Moormbool East								P	P
Moormbool West								P	P
Morrl Morrl	+								
Moyreisk		P		P	P				
Muckleford				P				P	

Parish	Block								
	1	2	3	4	5	6	7	8	9
Murchison									+
Murchison North									P
Muskerry						P			P
Mysia							P		
Natteyallock					P				
Navarre	P	P	P						
Neereman				P					
Neilborough							+		
Nerring							+		
Nolan							P		P
Noorilim									+
Northwood								P	
Painswick					+				
Panyule								P	
Pompapiel						P	P		
Powlett						P	P		
Pranjip									P
Puckapunyal								P	
Rathscar				P	P				
Ravenswood				P			P	P	
Redbank		+							
Redcastle									+
Redesdale								+	
Riachella	+								
Rich Avon East	P								
Rodborough				+					
Runnymede									+
St. Arnaud		P							
Salisbury							+		
Salisbury West						P	P		
Sandhurst							+		
Sandon				+					
Sedgwick								+	
Shelbourne				P			P		
Smeaton				P					
Spring Plains								+	
Stawell	P								

Parish	Block								
	1	2	3	4	5	6	7	8	9
Strangways				P					
Strathfieldsaye							P	P	
Sutton Grange								+	
Swanwater	P	P							
Tabilk									+
Talambe						P	P		
Tandarra							+		
Tarnagulla					P	P	P		
Tarrengower				+					
Tchirree			P						
Tchuterr					+				
Terrappee						P			
Tooborac								P	
Toolleen									+
Tottington	+								
Tourello				P					
Waanyarra					+				
Wahring									+
Wallaloo	P							P	
Walmer				P					
Wanalta									+
Waranga									+
Wareek				+					
Warngar	P								
Warragamba							P		
Warranook	P								
Warra Warra	P								
Warrenmang		P	P	P					
Warrowitue								+	
Watta Wella	+								
Wedderburne						+			
Wehla					P	P			
Wellsford							+		
Weston								P	P
Whirrakee							+		
Whroo									+
Winjallok	P	P							
Wirchilleba	P								

Parish	Block								
	1	2	3	4	5	6	7	8	9
Wirrate									+
Woodstock							+		
Woosang						P			
Wormangal									+
Wychitella						P			

Note: + = wholly within block

Parish	Block								
	1	2	3	4	5	6	7	8	9
Yallook							+		
Yalong				P					
Yarraberb							+		
Yarrayne							+		
Yehrip			+						

P = partly within block

Appendix 6

METRIC CONVERSION FACTORS

Quantity	Metric unit	Imperial unit	Metric to Imperial	Imperial to metric
Length	millimetre (mm) centimetre (cm) metre (m) kilometre (km)	inch (in) foot (ft) mile	1 mm = 0.0394 inch 1 cm = 0.3937 inch 1 m = 3.281 feet 1 km = 0.6214 mile	1 inch = 25.4 mm 1 inch = 2.54 cm 1 foot = 0.305 m (30.5 cm) 1 mile = 1.61 km
Area	hectare (ha) square kilometre (sq km)(= 100 ha)	acre (ac) square mile (sq mile)	1 ha = 2.47 acre 1 sq km = 0.3861 sq mile (247 ac)	1 acre = 0.405 ha 1 sq mile = 2.592 sq km
Mass	kilogram (kg) tonne (t) (= 1,000 kg)	pound (lb) ton	1 kg = 2.20 lb 1 t = 0.984 ton	1 lb = 0.454 kg 1 ton = 1.02 t
Volume	cubic metre (m^3) megalitre (Ml) (= 1,000,000 litres)	cubic foot (ft^3) super foot (timber) acre feet (ac ft)	1 m^3 = 35.31 ft^3 = 423.7 super feet true = 332.6 super feet (Hoppus log volume) 1 Ml = 0.8098 ac ft	1 ft^3 = 0.0283 m^3 1 super foot true = 0.00283 m^3 1 super foot HLV = 0.003 m^3 1 ac ft = 1.235 Ml
Temperature	degree Celsius (^oC)	degree Fahrenheit (^oF)	$1^oC = 5/9 (^oF - 32)$	$1^oF = 9/5 (^oC + 32)$
Compound units	tonnes per hectare (t/ha) milligrams per litre (mg/l) litres per second (l/s)	bushels/acre parts per million (ppm) gallons per hour (gph)	1 t/ha = 14.9 bushels/ac (wheat) = 17.9 bushels/ac (barley) = 22.2 bushels/ac (oats) 1 mg/l = 1.000 ppm 1 l/s = 791.7 gph	1 bushel/ac = 0.087 t/ha = 0.056 t/ha = 0.045 t/ha 1 ppm = 1.000 mg/l 1 gph = 0.00126 l/s

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