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GOVERNMENT OF VICTORIA

LAND CONSERVATION COUNCIL

464 ST. KILDA ROAD. MELBOURNE VICTORIA. 3004

REPORT

WIMMERA 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. A limited number of Public Land and Descriptive Blocks maps are available from the Council's offices for those who wish to use them in making their submissions.

All such submissions must reach the Secretary no later than Monday 15 April, 1985.

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

Blackman

for I. KUNARATNAM
Secretary
Land Conservation Council

REPORT

on the

WIMMERA AREA

Land Conservation Council, Victoria

Melbourne: February 1985

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* These maps are inside the back cover.

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 Wimmera 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 land should be used. It is hoped that, in making submissions, members of the community will use as a basis the information provided by this report. The Council will make its proposed recommendations only after due consideration of those submissions. This will then be followed by a period for further submissions, which will again be considered by the Council before its final recommendations are presented to the government.

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 the 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*.

Submissions received by the Council will be available for inspection at the Council's offices 10 days after the closure of the submission period.

Land Conservation Council
464 St. Kilda Road
MELBOURNE, 3004

David Scott
DAVID SCOTT
Chairman

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 4 of the *Crown Land (Reserves) Act* 1978, State forest and parks within the meaning of the *National Parks Act* 1975;

(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 for national parks;

(e) the creation and preservation of areas for leisure and recreation, and in particular of areas close to cities and towns for bushland recreation reserves;

(f) the creation and preservation of reserves for the conservation of fish and wildlife;

(g) the preservation of species of native plants; and

(h) land required by government departments and public authorities in order to carry out their functions.

(3) Where the Council recommends the alienation of any land the recommendation shall include the Council's opinion as to the best method of alienating the land to ensure the most satisfactory use and management of the land in the public interest.

(4) Any person or body may make submissions to the Council as to how any public land can be better used to meet the needs of the people of Victoria and the Council shall consider any such submissions before making any recommendation under paragraph (a) of sub-section (1)

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 an investigation under pargraph (a) of sub-section (1) of section 5 the Council shall publish 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 areas 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) public 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 of sub-section (1) of this section.

Government departments and authorities to give effect to recommendations.

(3) Where the Council has made a recommendation to the Minister under paragraph (a) of sub-section (1) of section 5 the Minister may, after he has given not less than fourteen days notice of his intention so to do to the Minister administering a government department or responsible for a public authority recommend to the Governor in Council that notice of the recommendation or that part of the recommendation that affects the government department or public authority be given to the government department of public authority concerned and where notice of that recommendation or part is so given by the Governor in Council it shall be the duty of the government department or public authority to use all diligence and dispatch to give effect to such recommendation so far as it affects any land vested in or controlled by it.

Copy of every recommendation and of proposals to be tabled in Parliament.

Section 11.

A copy of every recommendation of the Council made under sub-section (1) of section 5 and of the proposals of the Council submitted to the Minister pursuant to section 7 shall be laid before both Houses of Parliament within fourteen days of the making thereof if Parliament is then sitting and if Parliament is not then sitting within fourteen days after the meeting of Parliament.

A copy of the *Land Conservation Act* 1970 can be obtained from the Government Printer Sales Office, 41 St. Andrews Place, East 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.

Information for maps and chapters was supplied by: the Departments of Conservation, Forests and Lands, Agriculture, and Minerals and Energy; the Rural Water Commission; the Victoria Archaeological Survey; La Trobe University Prehistory Division; the Museum of Victoria, and the Victorian College of Agriculture and Horticulture (Longerenong). Several of these bodies supplied photographs.

The following staff members from these organizations were closely involved in the preparation of chapters and maps for the report: C. Ashe, W. Bloodworth, J. Donovan, P. Dyson, D. Hooley, R. King, D. Luke, F. McClelland, P. Menkhorst, W. Middleton, R. Nott, R. Paul, D. Rawet, P. Robertson, F. Roseby, J. Sanders, N. Schoknecht, J. Taylor, A. Windust, and A. Yen.

Special studies were carried out by the following consultants: Aboriginal associations, C. Bird (assisted by R. Marks); vegetation - G. Carr; fauna, survey team from Arthur Rylah Institute for Environmental Research.

Many others also readily gave information, checked drafts, or contributed valuable discussion and advice. They include other Victorian and Australian government bodies, local government agencies, representatives of various industries, apiarists, outdoor recreation and sporting organisations, and individuals with expert knowledge of specific disciplines or localities. Their assistance is gratefully acknowledged.

This Council is indebted to the many government departments mentioned above that made photographs available for the report, and to the following organizations and individuals for the use of their photographs: La Trobe Library; Wimmera Tourism Ltd; C. Bird; G. Carr.

PART I

INTRODUCTION

1. AIMS AND METHODS

This report brings together information that is relevant to making decisions on 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 the 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, the Aborigines' association with it, and the history of European settlement.

Part II describes the main features of the environment for the whole of the study area. Climate, geology, geomorphology, soils, vegetation, fauna, water resources, and land zones are described. Maps show the geology, geomorphology, topography, vegetation on public land, water resources, and land zones.

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. Maps in this section indicate the areas used for the various forms of primary production, mineral and stone extraction, and recreation.

Part IV provides more detailed information and, for convenience, the study area has been divided into six descriptive blocks. Information for each block is set out in a consistent format of headings, so that specific information can be readily found and compared with its counterparts 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 'wisdom' 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 the preservation and protection of species and 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 decrease 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. Also one form of resource usage may increase opportunities for another form of use or make possible new uses. They may also be competitive, as is the case when an increase in one leads to a decrease in another.

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 unsuitable as a 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.

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.

Recently the need and opportunities for outdoor recreation have grown, and an appreciation of nature has become more apparent. The intangible values of recreation, aesthetics, and preservation associated with natural areas need to be recognized and the impact of other land uses upon them 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 aims and to assess levels above which secondary uses are unacceptable.

Where land has been committed to a particular use, it should be managed in such a way that its capability for that use is not impaired. Land serving a multiplicity of uses should be managed to ensure that no single use predominates, and should be maintained in a condition that will allow the widest possible choice of future uses.

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

3. THE STUDY AREA

The Wimmera area contains about 16,700 sq. km of land adjoining the South Australian border, between 36°00' and 36°46' South and 140°58' and 143°34' East (see Maps 1 and 2). Covering some 7.3% of the State, it includes the Shires of Donald, Dunmunkle, and Warracknabeal, and parts of the Shires of Arapiles, Birchip, Charlton, Dimboola, Kaniva, Kowree, Lowan, Wimmera, and Wycheproof. However, it excludes the City of Horsham, the region's main urban centre, which covers some 24 sq. km. Map 3 shows municipal, county, and parish boundaries.

Description

Most of the study area comprises the extensive Wimmera plains, which are mainly of aeolian origin. Two large fields of sand dunes extend into it from the west, forming the Little Desert and the southern part of the Big Desert. The only country with substantial relief occurs in the far east of the study area.

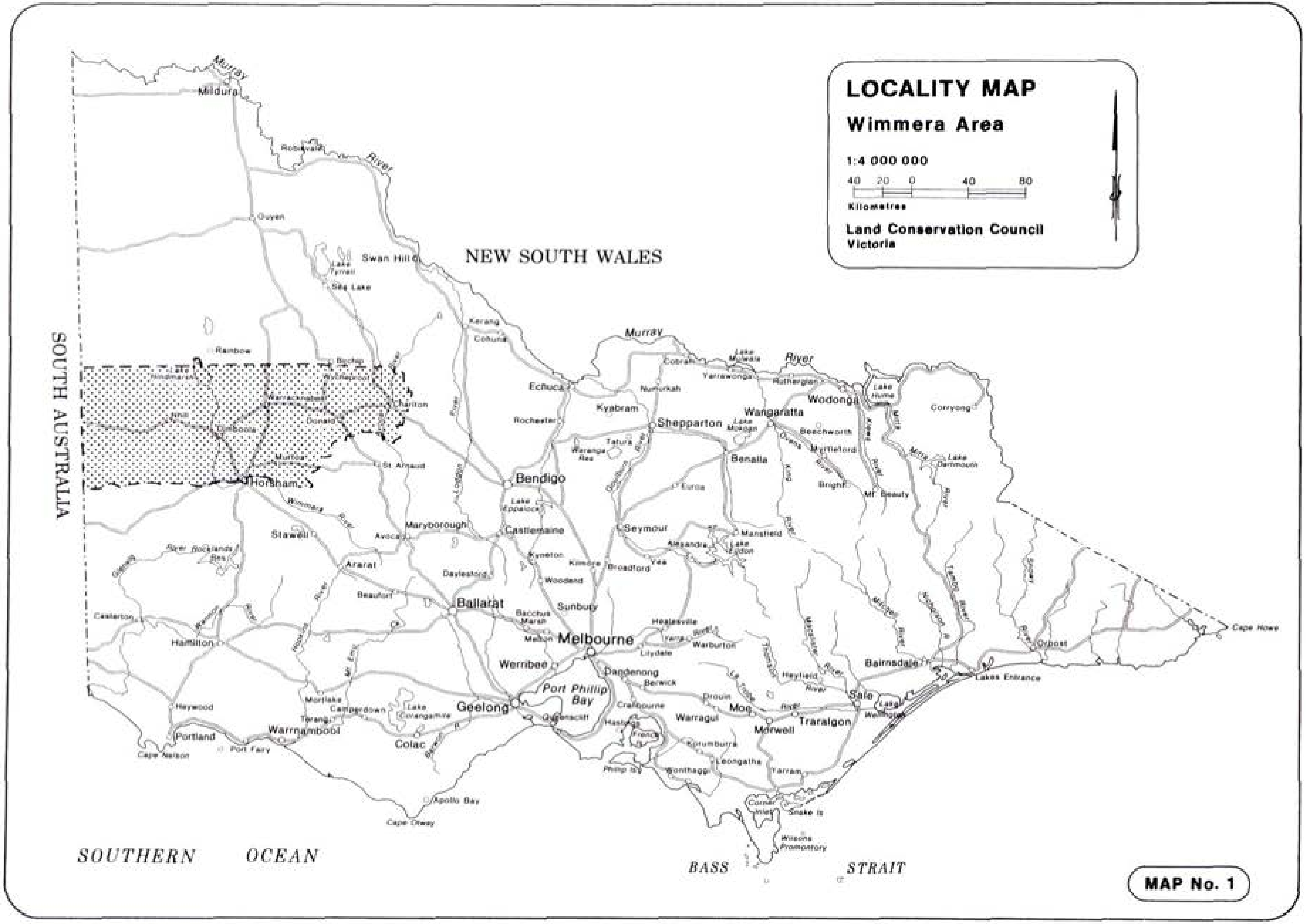
Several rivers, originating in the highlands south of the study area and flowing north, drain the eastern half of the Wimmera. A great number of anabranches and effluents ending in lakes are characteristic features of the drainage. The main river system, the Wimmera River, gives off two important effluents - the Yarriambiack and Dunmunkle Creeks. The country west of this river has no major streams.

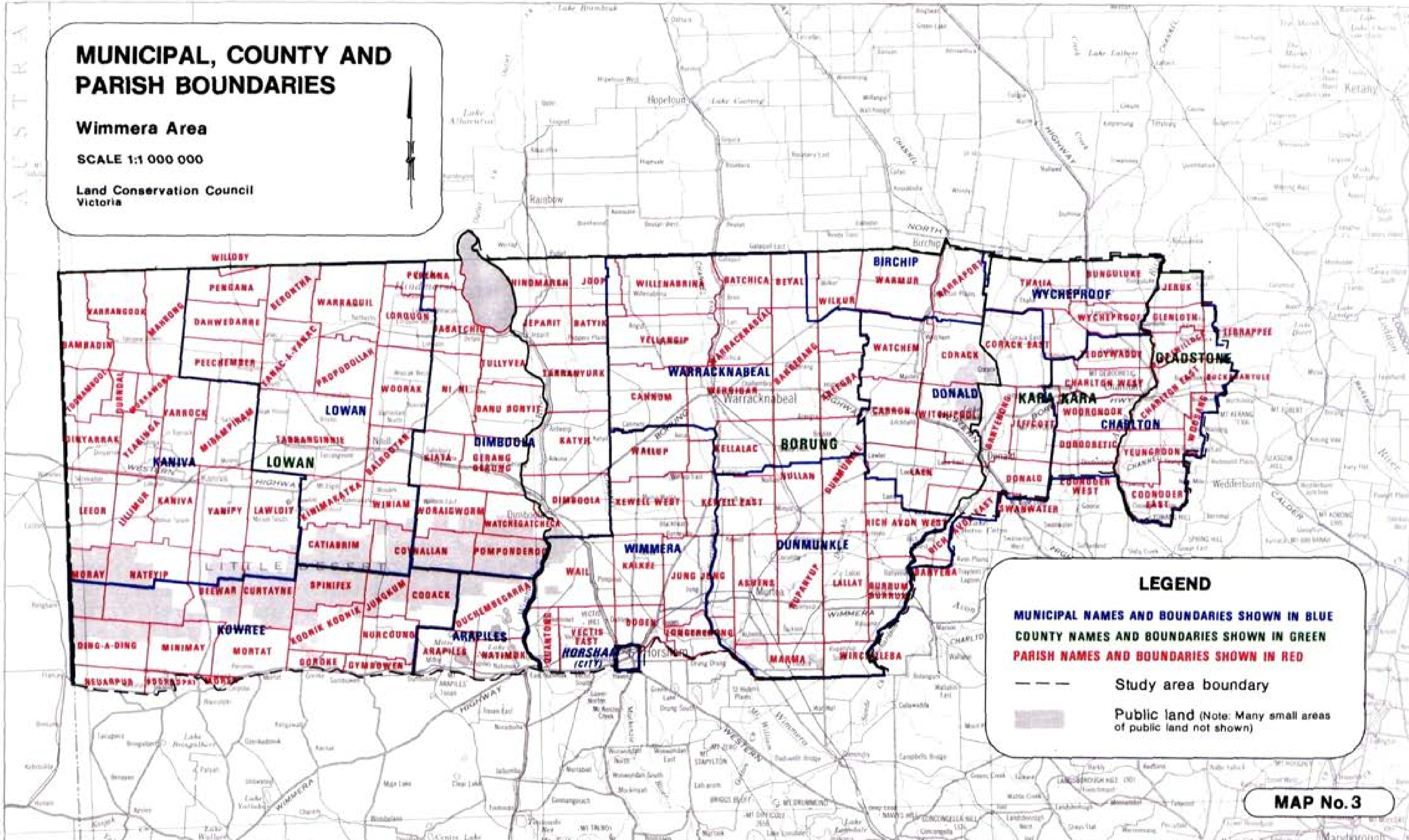
In the Wimmera, the flat to gently undulating topography generally ranges in elevation from 100 to 180 m, the major exception being the region of sedimentary outcrop in the far east of the study area (180--320 m). This part also includes the granitic Yowang Hill (340 m), which rises about 190 m above the nearby Avoca River. In addition, a number of isolated peaks (Palaeozoic outcrops) such as Mount Jeffcott, Mitre Rock, and Mount Wycheproof rise above the surrounding Wimmera plains.

The low average annual rainfall, varying from 550 down to 350 mm, decreases from south-west to north-east across the study area. Most rain falls during winter and spring.

Public Land

Public land occupies approximately 1,930 sq. km (about 11% of the study area).


LOCALITY MAP
Wimmera Area
1:4 000 000
40 20 0 40 80
Kilometres
Land Conservation Council
Victoria
NEW SOUTH WALES
SOUTH AUSTRALIA
SOUTHERN OCEAN
BASS STRAIT
Murray
River
Mildura
Ouyen
Swan Hill
Sea Lake
Rainbow
Kerang
Cohuna
Charlton
Horsham
Stawell
St Arnaud
Maryborough
Ararat
Bendigo
Castlemaine
Echuca
Rochester
Kyabram
Shepparton
Wangaratta
Wodonga
Benalla
Seymour
Ballarat
Melbourne
Werribee
Dandenong
Geelong
Port Phillip Bay
Colac
Warrnambool
Portland
Hamilton
Moe
Morwell
Traralgon
Sale
Bairnsdale
Lakes Entrance
Orbost
Corryong
Cape Howe
Apollo Bay
Cape Otway
Wilsons Promontory
MAP No. 1


MUNICIPAL, COUNTY AND PARISH BOUNDARIES
Wimmera Area
SCALE 1:1 000 000
Land Conservation Council Victoria
LEGEND
MUNICIPAL NAMES AND BOUNDARIES SHOWN IN BLUE
COUNTY NAMES AND BOUNDARIES SHOWN IN GREEN
PARISH NAMES AND BOUNDARIES SHOWN IN RED
Study area boundary
Public land (Note: Many small areas of public land not shown)
MAP No. 3
KANIVA
LOWAN
DIMBOOLA
WARRACKNABEAL
BIRCHIP
WYCHEPROOF
DONALD
CHARLTON
WIMMERA
DUNMUNKLE
KOWREE
ARAPILES
HORSHAM (CITY)
BORUNG
KARA KARA
GLADSTONE
141°00'
142°00'
143°00'
36°00'
37°00'

Most of this lies in the Little Desert, with the remainder comprising lakes, scattered small blocks, and roadside and streamside reserves.

Of that public land, the Little Desert National Park covers about 18% with various areas of reserved forest totalling a further 4%. Most of it, however, consists of unreserved Crown land and various Crown land reserves. A number of small areas are controlled by the Rural Water Commission for water supply and drainage purposes, and an area of nearly 1,000 ha east of Horsham carries the Longerenong campus of the Victorian College of Agriculture and Horticulture.

Most of the public land supports stands of native vegetation, which consists mainly of brown stringybark woodlands and scrub, mallee--broombush scrub, and heaths in the 'desert' areas, river red gum and black box woodlands along the rivers and streams, and gum--box--bulloak woodlands on the scattered blocks in the remainder of the study area. Extensive development for agriculture has left little native vegetation on freehold land.

Land use

The public lands in the area are used for recreation, conservation, water distribution, farm timber production, agricultural education, and apiculture, and they produce posts, firewood, gravel, forage, game, and honey.

Farmlands in the Wimmera produce wheat, barley, oats, wool, and some fat lambs and beef. Mixed farming is conducted on two small irrigation areas in the south. Water supply to the dryland farms comes through a vast system of open earthen channels from storages in the Grampians. West of the Wimmera River, supplies are drawn from groundwater resources.

Population

At the time of the 1981 census, the Wimmera area had a population of approximately 38,000 persons, representing 1.0% of Victoria's total. This figure includes the population of the City of Horsham (12,000)- although technically this is not part of the study area - and approximately 32% is concentrated here in the region's main urban centre. Outside Horsham the population density is very low. Large towns include Warracknabeal, Nhill, Dimboola, Donald, and Charlton.

Demographic patterns also reflect the availability of water for domestic and agricultural use; the west of the study area has a lower population density than the rest, which is served by the Wimmera --Mallee Domestic and Stock Water Supply System (see Table 1).

The population of the Wimmera has been declining since the mid 1960s and all of this decline has occurred in the rural areas. Over the period 1971--1981 the rural population fell by 2,342 (8.3%),

Table 1

DEMOGRAPHY

Local government area	Area (sq.km)	Population			Average annual increase or decrease 1971--81 (%)	Approximate population density (per sq.km)
		1971[A]	1976[B]	1981[C]		
Donald (Shire)	1,448	2,639	2,724	2,597	-0.2	1.8
Dunmunkle (Shire)	1,546	3,544	3,370	3,071	-1.3	2.0
Warracknabeal (Shire)	1,839	4,218	4,029	3,932	-0.7	2.1
Part of Arapiles (Shire)[D]	346	712	696	704	-0.1	2.0
Part of Birchip (Shire)[D]	458	1,041	945	895	-1.4	2.0
Part of Charlton (Shire)[D]	1,131	2,226	2,120	2,063	-0.7	1.8
Part of Dimboola (Shire)[D]	2,217	3,921	3,761	3,590	-0.8	1.6
Part of Kaniva (Shire)[D]	2,296	2,104	1,949	1,935	-0.8	0.8
Part of Kowree (Shire)[D]	1,455	957	863	827	-1.4	0.6
Part of Lowan (Shire)[D]	2,163	3,487	3,388	3,250	-0.7	1.5
Part of Wimmera (Shire)[D]	1,276	2,124	1,934	1,866	-1.2	1.5
Part of Wycheproof (Shire)[D]	485	1,342	1,311	1,245	-0.7	2.6
Total (actual study area)	16,660	28,317	27,090	25,975	-0.8	1.6
Horsham (City)[E]	24	11,045	11,647	12,034	+0.9	501.4
Total (including Horsham)	16,684	39,362	38,737	38,009	-0.3	2.3

Notes: A Census 1971 B Census 1976 C Census 1981
D Compiled from Collector District data. The populations include the townships of Natimuk (Shire of Arapiles), Birchip (Shire of Birchip), and Goroke (Shire of Kowree), each of which is bisected by the study area boundary. E Not part of the study area

Source: Australian Bureau of Statistics

Table 2

EMPLOYMENT BY INDUSTRY
(as at June 30, 1981)

Industry	Total	Percentage of total
Agriculture: agriculture, agricultural services, other	4,975	29.7
Forestry, fishing, hunting	40	0.2
Mining	24	0.1
Manufacturing: food, drink, textiles, clothing, metal products, machinery, other	795	4.8
Manufacturing: wood, furniture	42	0.3
Electricity, gas, water	281	1.7
Construction	899	5.4
Wholesale and retail trade	2,773	16.6
Transport (road, rail, water, and air) storage	785	4.7
Communications	283	1.7
Finance, property, business services	617	3.7
Public administration	612	3.7
Community services: health, education, other	2,453	14.7
Recreation, personal services: entertainment, restaurants, hotels, clubs, recreation services	724	4.3
Other (undefined)	1,425	8.5

Source: Australian Bureau of Statistics, compiled from 1981 Census.

with every rural municipality declining in population. This compares with an increase of 989 (9.0%) for Horsham. The Wimmera has a relatively low population density of 2.3 persons per square kilometre, even with Horsham included.

Economic activity

Since settlement, the major form of economic activity in the area has been agriculture, especially cropping and sheep. Other pursuits include beef, dairying, pigs, and poultry. The value of this agricultural production has national significance, especially that of the cereal cropping industry - the Wimmera produces about one-quarter of Victoria's wheat crop.

The retailing and service industries, mainly located in Horsham and the larger towns, are also economically important for the area (see Table 2).

In common with trends elsewhere in the State, a significant reduction in primary-sector employment has occurred here over the last 20 years, which has been only partly offset by growth in the tertiary sector. Much of this tertiary-sector growth has come from expansion of the tourist industry and the upgrading of community services. This has not been enough, however, to match the decline in traditional employment opportunities in the agricultural sector.

4. ABORIGINAL ASSOCIATIONS

This chapter summarizes a report commissioned and prepared for the Land Conservation Council describing the Aborigines' association with the Wimmera area. Ms Caroline Bird, a tutor in archaeology at La Trobe University, prepared the report, which drew on archaeological and historical sources as well as incorporating information from the present Aboriginal community, in particular from Mr Ronald Marks of Horsham (a descendant of the Wergaia tribe).

Aboriginal people have been associated with the south-east of Australia for at least 40,000 years. Because so little archaeological research has been done in the Wimmera, it is impossible to be sure when the region was first occupied. However, scientific dating of a burial site at Nhill implies that this occurred at least 10,000 years ago and probably longer.

Present-day Aboriginal descendants in the area claim that elements of their Aboriginality have survived from the period before European contact to the present. Aboriginality refers to their origins, philosophy, and culture, and to the views that they have of their cultural heritage - whether it be tangible (such as burial site) or intangible (a religious belief, say). An expression of their Aboriginality is the special relationship or affinity that exists between them and their ancestral lands.

There is now a consistent Aboriginal and academic view that sees the Aboriginal perception of the land in terms of a special relationship with the country. In this context, land use may not have the same meaning for Aborigines as it does for Europeans.

Traditional Aboriginal Perspective

Social organization

It is important to understand that social organization in Aboriginal Australia is inextricably linked to the economic and spiritual ties that exist between people and land. It is therefore useful to distinguish between land-owning and land-using groups.

There are two kinds of land-owning groups. One was the local-descent group - that is, a group of people bound to a particular locality by ties of kinship and with a religious affiliation to a given site or set of sites. In the Aboriginal world view, ancestral mythical beings created the natural features of the landscape in the course of their activities in the period known as the 'Dreaming'; or the features may even be the physical remains of these beings.

Human beings and other species also acquired their own physical characteristics, as well as the rules of behaviour they ought to follow, from the ancestral beings. Knowledge of these rules was handed down through myths and rituals associated with specific sites. It was the responsibility of the local-descent groups to perform the appropriate rituals and act as custodians of the land in order to maintain the natural and social order.

The second kind of collective land-ownership involved division of all the people of the Wimmera into two classes or moieties - known as Gamutch (black cockatoo) and Krokitch (white cockatoo). Each of these was further divided into a number of clans. Members of these clans were linked together by descent through the mother and marriage had to be outside the clan.

However, the Aborigines classified not only people in this way but the whole of the natural world. Each clan therefore had a number of totems, which could be animal, vegetable, or mineral, attached to it. Each clan had a spirit-home or 'mi-yur' and the dead were buried pointing in the direction of their spirit home. This apparently applied even to dead animals, which were cooked with their heads pointing to the appropriate 'mi-yur'. It had a further practical implication - that particular animals should be hunted with weapons made of a material belonging to the opposite class.

As this system indicates, specific localities were significant to members of particular totemic clans. Moreover, totemism had deep significance for the Aboriginal people of the Wimmera, establishing bonds between people and land, living and dead, and the social and natural environments.

The basic land-using unit in Aboriginal society, and other hunter-gatherer societies, is known as the band. It often, although not always, comprised a group of related men with their wives and children. The band was nomadic, and its members hunted and foraged across a defined territory. Normally a division of labour occurred on the basis of sex - men hunted large game while women gathered vegetable foods and collected small game - although some activities might have involved co-operation. The band varied in size and composition according to seasonal changes in the supply of food and water. People normally took advantage of times when food was abundant to gather together in larger groups for such purposes as holding ceremonies, arranging marriages, and settling disputes.

Tribal boundaries and population levels

Bands were grouped into larger units, usually called tribes. The main tribes who occupied territory within the area - using the boundaries given by Tindale in 1974 - were the Wotjobaluk, Jaadwa, Marditjali, Warka Warka, Jupagalk, and Jaara. All these tribes seem to have been more or less related.

The principal tribe of the Wimmera, the Wotjobaluk, occupied the territory between the Wimmera and Richardson Rivers and extended up into the Mallee as far as Pine Plains. It included a number of named bands or local groups, such as the Gromiluk at Lake Hindmarsh, Kretch-baluk at Dimboola, Witch-wundaiuk at Warracknabeal, Yakkil-baluk at Lake Albacutya, and Yarikiluk at Lake Coorong - the two last-named being outside the study area.

It has been suggested that the tribal boundaries delineated by Tindale for north-western Victoria have little basis in fact and some authorities prefer to concentrate on linguistic data to establish group identity. The language spoken over virtually the entire study area is known as Wergaia, and the people who speak it prefer this name. Thus either Wergaia or Wotjobaluk would be a suitable name for the tribe that occupied most of the Wimmera.

Estimates of Aboriginal population levels made by the earlier explorers and squatters are usually treated with caution. Indications are that introduced diseases and frontier conflict had already severely reduced local population levels prior to large-scale European settlement of the area.

Surface scatter of stone artefacts - such sites are evidence of Aboriginal camping places.

In 1852 the Commissioner of Crown Lands estimated the pre-contact population of the Wimmera at 1,200, but the true figure may be somwhat higher, perhaps as much as 2,000.

Intertribal relations

Trade played a very important part in maintaining both the tries within the tribe and relations with other tribes. Stone axes from a quarry at Charlotte Plains on the headwaters of the Loddon in the territory of the Jaara were traded with the Lake Hindmarsh people.

Wirrengren Plain in the Mallee and Lake Buloke in the Wimmera were important meeting places where large gatherings were held and trade took place. Most of the axes found in the Wimmera and Mallee come from the well-known Mount William quarry near Lancefield, suggesting that the people of the Wimmera and Mallee acquired axes through exchange with tribes either to the east or to the north along the Murray Valley, rather than with the people of the Western District. The wide variety of other items traded included wooden and reed spears, possum-skin rugs, fur armlets, and wooden bowls.

Economy

Traditional economy in the Wimmera undoubtedly followed the usual hunter-gatherer pattern. Resources varied in distribution and abundance according to the season, and groups would move around the countryside to exploit them as they became available. Seasonal local abundance of particular species enabled large groups of people to gather together. These movements were by no means random, but formed part of a carefully designed strategy that varied little from year to year.

In the Wimmera the greatest diversity and abundance of resources probably occurred in summer. It was in summer and autumn that large gatherings occurred in the Mallee to exploit lerp, an insect secretion on the leaves of mallee eucalypts. Autumn was probably the most difficult period, because water would have been scarce.

Generally speaking, food-getting activities were divided between men and women

Permanent sources of water were often important Aboriginal camp sites.

(although many would have been carried out in co-operation). Food was shared and larger game animals, which were highly prized, were divided according to strict rules based on kinship ties. Various food taboos also operated: dingoes, for example, were greatly relished and could only be eaten by adult men.

Water

Water was crucial to maintaining life in the Wimmera, particularly at certain seasons. Swamps and watercourses are often very rich in food resources as well as providing water. It would be expected therefore that settlement was concentrated near freshwater lakes (Lake Hindmarsh and Lake Buloke), and the many small fresh lakes and swamps.

In the east, where outcrops of bedrock occur, water may be available in rock wells. In the drier area of the Little Desert, the Aborigines could obtain water from soaks in sandhill country or from the roots of certain species of mallee and hakea. They maintained soaks carefully and covered these with sticks to prevent fouling and reduce evaporation. When crossing dry country, they carried water in bags made of wallaby or possum skin with the fur inside to catch impurities.

Aborigines made a sweet drink by soaking flowers in water, using hakea, desert banksia, and grass-trees for this purpose.

Scarred tree near Antwerp - the bark was probably used for making a canoe.

Animal foods

The wide range of animal species hunted and eaten in the Wimmera included kangaroos, wallabies, possums, echidnas, and a variety of native rats and mice. The

Grinding stones were used for processing plant foods and are often found on former Aboriginal camp sites.

people took many species of birds, sometimes catching them in snares, and also ate the eggs.

For fishing - an important activity in rivers and lakes - they used various methods such as spears, nets, weirs, and poison. Other aquatic resources included yabbies, fresh-water mussels, tortoises, and frogs, as well as ducks and other water birds. Canoes commonly provided access to these resources.

Several species of lizard and snake were eaten, as were some insects, with lerp being particularly important.

Vegetable foods

Wimmera Aborigines ate a wide range of plant foods, including various species of seeds, roots, fruit, and greens. They ground seeds into flour, which they made into cakes with water and baked. Native millets and grasses had particular value for this, and they probably used species of wattle as well. Of the important plants with underground storage organs (tubers and bulbs), they ate some raw and roasted others.

The murrnong or yam-daisy had a special importance for them, as did species of orchids and lilies. Swamps provided rushes and sedges, of which they ate the roots. Fruits eaten included native cherries and currants, pig-face, sweet quandong, and kangaroo apples. Various species of fungi were also eaten.

Aboriginal People in the Wimmera since European Contact

First contact

The first European to enter the Wimmera was Major Mitchell, who crossed the plains of the Loddon, Avoca, and Wimmera Rivers in 1836. He had little contact with Aborigines there, but did describe an encampment close to White Lake, south-west of Mount Arapiles. The presence of an iron bolt in one of the huts suggests that goods of European make were already reaching Aborigines in this area through their trading networks. Two years later E.J. Eyre, following the course of the Wimmera River, discovered and named Lake Hindmarsh. European settlement in the Wimmera followed quite slowly at first.

Pastoral settlement inevitably had a destructive effect on Aboriginal society because it required the exclusive use of large tracts of land and involved the destruction of the natural environment through grazing. Traditional Aboriginal camp sites attracted the settlers because of the availability of water.

The Aborigines were thus displaced from their traditional territories and denied access to the resources on which they depended. Conflict was inevitable. E.S. Parker, writing in 1854, stated that settlement of western Victoria was accompanied by 'a fearful sacrifice of human life'.

At first the Aboriginal people of the Wimmera put up an active and spirited resistance to the invasion of their land. Their resistance was reinforced by people from the Western District and the Grampians, forced north by pastoral expansion. They not only attacked shepherds, but drove off thousands of sheep in the early 1840s, killing and eating some and maiming others. The area around Mount Arapiles and Mitre Rock seems to have been especially troubled.

Resistance was short-lived, however, and was largely over by 1846. The superior weapons of the settlers, the activities of the Native Police Force, and the decline in the Aboriginal population through disease and violent clashes were probably the most important reasons for the end of the conflict.

The Protectorate

As a result of an inquiry into the condition of Aboriginal peoples in British colonies, G.A. Robinson was appointed Chief Protector of Aborigines in the Port Phillip district. Four assistants were also appointed. Their function was to promote the well-being of the Aborigines, represent their interests, and ultimately 'civilize' them.

North-western district, including the Wimmera, came under the responsibility of Edward Stone Parker. Parker established a station at Jackson's Creek in 1839, moving to Franklinford on the

Loddon in 1841. He had little influence in the Wimmera and more remote districts, however, since he concentrated his efforts on the Jajowrong or Jaara people of the Loddon Valley.

The Port Phillip Protectorate was not a success. It was opposed by settlers and received inadequate backing from the government. A Select Committee recommended its abolition in 1849, but little further action was taken until 1858, when a Select Committee of Inquiry into the condition of Aborigines was held.

This Committee's report (1859) included evidence from settlers about the decline of Aboriginal population throughout Victoria and the condition of the people.

Wimmera Aborigines were receiving no assistance from the government at this time, and lived partly by catching possums and other game and partly on handouts from the stations. Some occasionally obtained employment on stations, and were 'paid in clothing, rations and sometimes in cash at the rate of 7 to 10 shillings per week'. In the late 1850s, wages for Victorian farm labourers averaged 22 to 25 shillings per week. The Select Committee recommended that funds be provided for the distribution of food and clothing and that adequate land be reserved in each tribal territory for the Aborigines to settle down and farm.

In 1860, a Central Board for the Protection of Aborigines (B.P.A.) was established, to oversee the distribution of rations through depots maintained by Local Guardians, and to supervise the proposed Aboriginal reserves. The Board's policy was to encourage missionary activity rather than establish government stations and, since Moravian missionaries were already active near Lake Hindmarsh, their Ebenezer Mission became the main reserve for the Wimmera region.

The number of Local Guardians varied slightly over the years, but at times depots seem to have been established at Mount Jeffcott, Rich Avon, Carrs Plains, Longerenong, Walmer, Vectis, and Benyeo stations.

Ebenezer Mission

In 1858, the Rev. F.W. Spieseke and the Rev. F.A. Hagenauer, of the Moravian Church, arrived in the Wimmera to look for a site for a mission and eventually chose a site on H.C. Ellerman's Antwerp station. The one chosen was a limestone ridge on a bend of the Wimmera River called Bunyo Budnutt, a favourite camping place and corroboree ground of the Aborigines. After some initial trouble, some 50 Aborigines were persuaded to settle at the station - largely through the efforts of two young men, Pepper and Bony. Pepper was later to be the missionaries' first convert to Christianity.

Problems still arose, but Hagenauer eventually succeeded in winning the

Ebenezer Mission, about 1892.

trust of the Aborigines, in May 1860, by reading a pamphlet telling the story of 'Willie Wimmera' to the children. Ellerman had originally been very hostile to the Aborigines and in 1846 had organized a punitive expedition against them, during which Willie's mother was killed. Ellerman took the boy home and his attitude to Aboriginal people seems to have changed about that time.

Willie subsequently went to Melbourne, where he was found wandering the streets and taken in by the Rev. Samuel Chase. Chase became fond of the boy and took him back to England. He was baptized there and given the name William Wimmera, but died in 1852. Chase later published the story as a pamphlet.

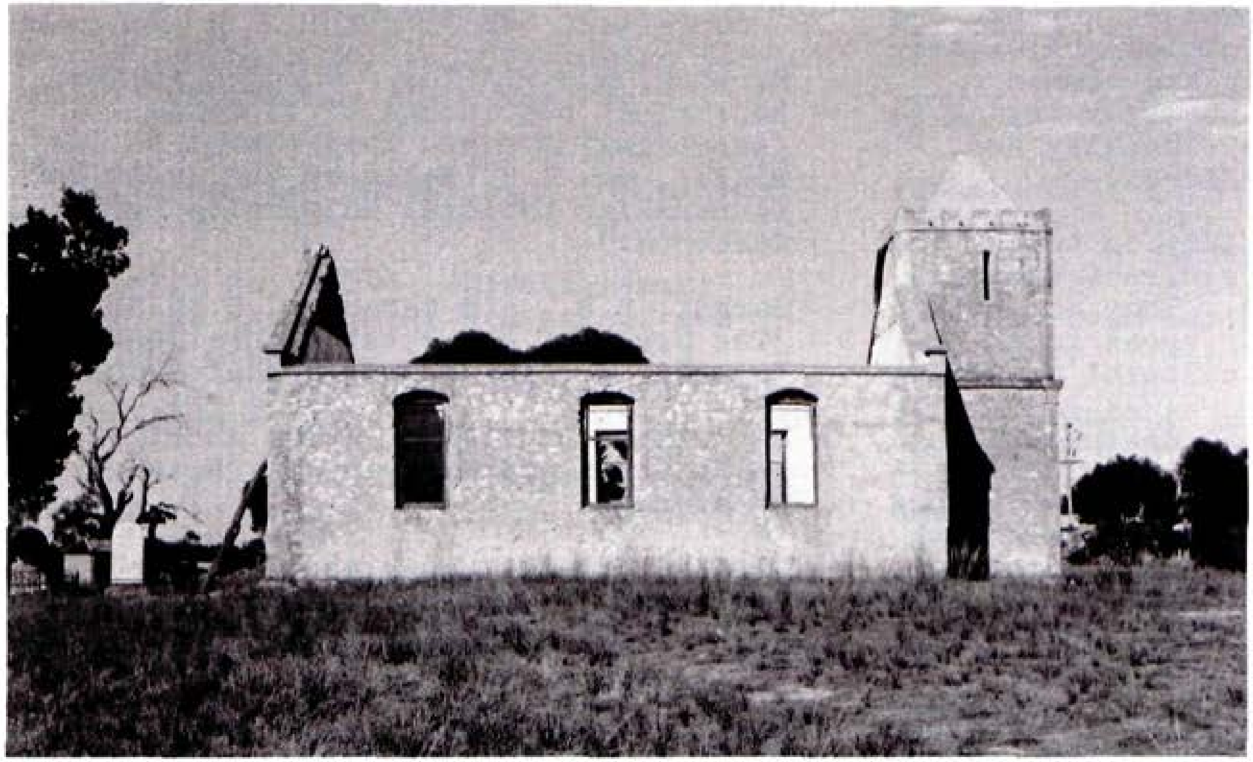
When Hagenauer read it to the children, they immediately identified Willie Wimmera, and pointed out his relatives and his mother's grave. This event seems to have fully established the missionaries and they were no longer opposed.

Meanwhile the B.P.A. had been established, and Ebenezer came under its jurisdiction. The first report of the Board commented favourably on the conduct of the Mission and 1,897 acres were gazetted there for Aboriginal purposes. The number then living at the station averaged 22, and 140 visited occasionally to receive food and clothing. Over the next few years Ebenezer grew and improved, and its apparent success seems to have encouraged the Board in its policy of gathering the surviving Victorian Aborigines together on the reserves.

The B.P.A. annual reports give accounts of expenditure and improvements to the station as well as its activities. The emphasis was on encouraging self-sufficiency. In 1886, for example, the report recommended that 'the natives should be encouraged to hunt and make rugs, for which it appears they find a ready market at high prices'. Reports in 1869, 1873, and 1875 recommended that Ebenezer be enlarged to make it self-supporting.

In 1877 the numbers at Ebenezer rose to more than 100 when Lower Murray people were resettled there, and in 1881 the remnants of the Wimmera tribes were finally brought in. The population as a whole was declining in numbers, however. The size of the community was further reduced by the 1886 amendment to the *Aborigines Act*, which forced Aborigines of mixed ancestry under the age of 34 to leave the station in accordance with the Board's policy of 'merging them with the European population'. One effect of this was a drastic reduction in the number of able-bodied men, and it became difficult to maintain agriculture.

Ebenezer Mission was now ending its life. In 1904 it was finally closed, the reserve was revoked, and the land made available for selection. The claims of the people of part-Aboriginal descent



The church and the cemetry at Ebenezer Mission near Antwerp as they are today.

camped in the district were ignored. The land on which the cemetery, church, and some of the buildings stand was made a Temporary Reserve in 1905. The rest of the surviving buildings were acquired in 1968 by the National Trust of Australia, which then took over management of the entire complex. The Trust has classified the group of buildings as 'highly significant'.

Wimmera Aborigines after 1900

By 1924, many families had been forcibly removed to Lake Tyers in Gippsland. A large number resisted, however, and remained in the district. (The Moravian missionaries had also been active in Gippsland, and family ties between the two areas already existed. These have persisted to the present day).

Rabbitting provided an important source of food and income during this period. Other sources of employment were the railways, salt-harvesting, wood-cutting, and farm labouring.

Today the Aboriginal population of the Wimmera numbers 150 to 175 people, most of whom live in the towns of Horsham and Dimboola. These communities are closely knit by ties of kinship and common experience. They are actively trying to maintain their cultural identity and pass it on to their children.

Since they now live mainly in towns, the people no longer have a direct economic relation with the land. They do, however, recognize certain areas as an important part of their cultural heritage.

Goolum-Goolum Aboriginal Co-operative runs educational programs, including cultural camps and excursions to culturally significant areas, to educate both Aboriginal and non-Aboriginal people about their heritage and increase awareness of Aboriginal culture among the wider Australian community.

The Grampians, while outside the study area, have great significance to Aboriginal communities in the Wimmera, mainly because of the important art sites there. The Wimmera River (especially the stretch rich in scarred trees between Dimboola and Antwerp) and the site of the Ebenezer Mission are also seen as areas of cultural significance. At camps held at Lake Hindmarsh, elders pass on bush skills of camping, hunting, and fishing to young people.

In the future, the Wimmera Aborigines plan to develop these programs, as well as attempting to re-establish permanent links with the areas mentioned above.

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5. EUROPEAN SETTLEMENT

Exploration

Major Mitchell

In the latter part of 1836, Major Thomas Mitchell and his large party became the first Europeans to pass through the Wimmera (see Map 4). Mitchell, Surveyor-General of New South Wales, took bullock drays, boats, and 25 people including an Aborigine named Piper, in an attempt to follow the inland rivers that Sturt had discovered on his expedition of 1829/30. During their expedition they journeyed from Sydney to western New South Wales, and then through western Victoria (which Mitchell called 'Australia Felix') before returning to Sydney via north-eastern Victoria.

They crossed the Richardson River and entered the study area on July 13, 1836. Mitchell named the stream after his botanical collector John Richardson, who came off his horse and was thoroughly soaked during the crossing. On this day Mitchell gazed across the Wimmera plains and wrote, 'We had at length discovered a country ready for the immediate reception of civilized man; and destined perhaps to become a portion of a great empire. Unencumbered by too much wood, it yet possessed enough for all purposes; its soil was exuberant, and its climate temperate...'

Mitchell's party continued westwards and camped near the Wimmera River. Piper ascertained the latter name from the local Aborigines - Mitchell tried to record the existing names of the topographic features he encountered.

The flat plains impressed him. He noted their rich black clay soils, and the useful timbers that grew in the open woodlands. He imagined a settled and prosperous countryside developing quickly in the wake of his explorations.

The expedition continued westwards to Mount Arapiles, which he named after a mountain near the Plains of Salamanca in Spain. He was particularly interested in the large number of circular saline and fresh-water lakes, and their bordering dunes, which were visible from the mountain.

On July 23, Mitchell's second-in-command, G.S. Stapylton, rode north into the Little Desert on a futile search for the course of the Wimmera River. He noted how the vegetation of the fertile plains gave way to heaths and 'Demiosa Scrub' (presumably dumosa mallee) on the barren white sands. He had 'never had a more dismal ride'. At the end of his 12-mile ride he saw a line of trees to the north-east, which he thought might have marked the line of the Wimmera River, but the intervening swamps prevented him reaching them.

On Stapylton's return to the camp at Mount Arapiles, Mitchell decided to abandon the search for the Wimmera River and turned south-westwards then south to the Glenelg River.

This left unresolved the destinations of the Richardson and Wimmera Rivers. Mitchell remained unaware that these streams flowed north to inland lakes. He imagined instead that the Wimmera would either discharge into the Murray, ultimately reaching an inland sea, or swing around to the south-west and enter the ocean near Discovery Bay.

Other explorers

Two years later, believing the Wimmera River flowed into the southern ocean, Edward Eyre set out from Port Phillip to overland stock to Adelaide via the Wimmera. Generally, he took Mitchell's route past the Grampians to the Wimmera River (see Map 4), which he followed north to 'a large fresh-water lake about 40 miles in circumference'. This he named Lake Hindmarsh, after the Governor of South Australia.

Prevailing drought conditions prevented Eyre from realizing that the river occasionally overflowed from the lake northward to Lake Albacutya and beyond. He explored to the north and west of Lake Hindmarsh, but considered the country virtually worthless for grazing. He turned back, retracing his steps before heading north to the Murray River and on to Adelaide.

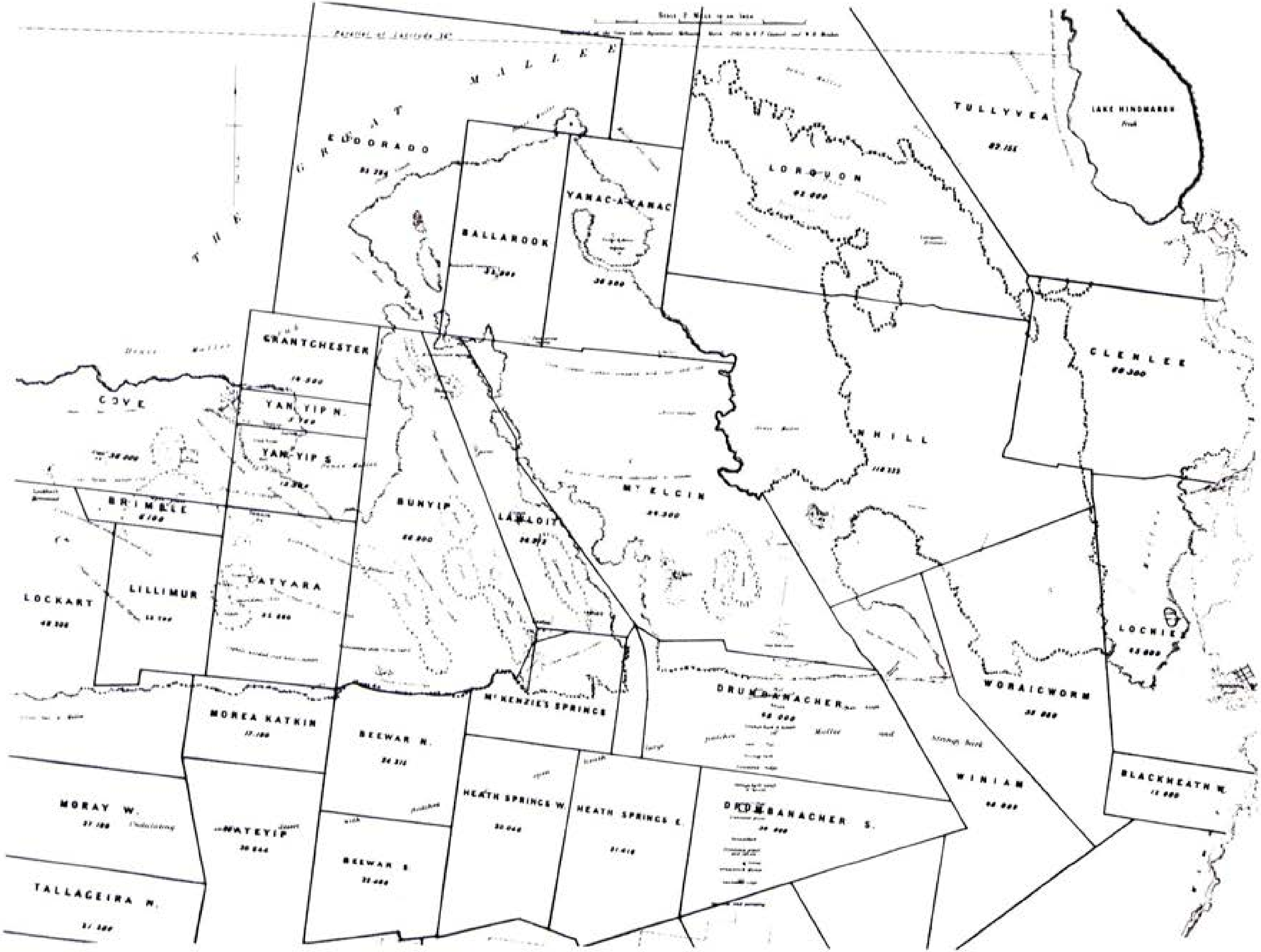
Much of the remaining exploration of the vast Wimmera region was carried out by squatters in search of runs - for example, McPherson and Belcher, who found the Nhill area and explored part of the Little Desert in 1844.

Captain Henry Dana, in charge of a native police force, investigated the area from near present-day Glenorchy to Lake Hindmarsh in 1845, but his report added little to existing knowledge of the Wimmera.

Surveyor Henry Wade began marking the border between Victoria and South Australia in 1847. From the coast at the Glenelg River estuary, he moved northwards about 200 km to a point in the vicinity of the Little Desert, which he described as 'the first belt of Marlee scrub' (see Map 4).

The Squatters

Squatters began moving into the Wimmera within a few years of Mitchell's report of its fertility and suitability for


THE GREAT MALLEE
TULLYVEA
LAKE HINDMARSH
LORQUON
YANAC-A-YANAC
BALLAROOK
GRANTCHESTER
COVE
YAN YIP N.
YAN YIP S.
BRIMBLE
BUNYIP
LAWLOIT
Mt ELGIN
NHILL
GLENLEE
LOCKART
LILLIMUR
TATYARA
LOCHIEL
WORAIGWORM
DRUMBANACHER
Mc KENZIE'S SPRINGS
MOREA KATKIN
BEEWAR N.
BEEWAR S.
WINIAM
BLACKHEATH W.
MORAY W.
NATEYIP
HEATH SPRINGS W.
HEATH SPRINGS E.
DRUMBANACHER S.
TALLAGEIRA N.

settlement. James Monckton Darlot took up Brighton, the first run in the study area, in 1841. During the early years of the decade graziers came from the east and from the south to occupy the plains around the Richardson River and the south-western Wimmera plains. By 1851, pastoral holdings occupied all but the poorest land in the Wimmera.

The boundaries of the squatters' runs were defined by gentlemen's agreement that squatters' homes were to be 6 miles apart. The Commissioner of Crown lands later adopted this practice to settle disputes and grant licences. Squatters' runs, at their peak, measured up to 180,000 acres (70,000 ha) with as many as 100,000 sheep on the largest. Licences changed hands frequently.

Orders in Council of 1847 provided that squatters in the Wimmera could take out leases for up to 14 years and, at the same time, secure pre-emptive rights for homestead blocks when the leases expired. Since subdivision provided a straightforward means of obtaining additional pre-emptive rights, many of the large runs were subdivided several times during the 1850s. This practice also had economic motives - it was more advantageous for a run-holder to exercise his right to purchase a minimum of 160 acres (63 ha) at £1 per acre than to pay licence fees for the land and stock it carried.

The perennial grasslands of the Wimmera provided excellent winter fodder for fattening livestock, which was unavailable in southern Victoria. Sheep flocks remained relatively disease-free in the drier Wimmera climate. However, the same climatic factors saw the failure of early attempts to introduce cattle in the area.

Stock water was only available from the major streams and rivers, so grazing was concentrated in their vicinity and early attempts were made to improve distribution, both geographically and seasonally, of the limited water resource.

During the squatting era exotic pest species were introduced in the Wimmera, most importantly rabbits and the wild dog, which interbred with the dingo. Both were to cause major problems in the years to follow. Combined with drought, they had almost defeated the squatters by 1870 when selection began.

The pastoral holdings were large - averaging 20,000 to 50,000 ha - and carried sheep (and occasionally cattle) at a low average stocking rate of between 0.5 and 1.0 sheep per hectare. Holdings were unfenced and shepherds tended the sheep in small flocks, returning to a secure holding area and water each night. The sheep were mustered annually, washed in a nearby creek, and hand-shorn. The wool went by bullock wagon to railheads at

Opposite: *Reproduction of 1868 map of the western Wimmera showing squatters' runs.*

Ballarat or Geelong. Sheep population figures in the sketchy records suggest a level of reproductive performance similar to that experienced today.

Passive introduction of annual species more resistant to grazing than the native perennial species, together with the uneven distribution of grazing pressure, quickly led to a replacement of the perennial grasslands by predominantly annual grasses and herbs. These annuals had higher dry matter production and higher digestibility, and so allowed a higher stocking rate.

Husbandry methods used were very labour-intensive, requiring about one man per 200 sheep throughout the year and double that at shearing time. The gold rush of the early 1850s placed a drain on farm labour as shepherds left to make their fortune at the diggings, and so forced a change to less labour-intensive methods.

Some attempts at genetic improvement of the sheep (which were mainly Merinos) were made, particularly during the gold-rush period, when the high demand for meat in the mining areas and low labour availability meant that culling was at its heaviest. However, the lack of fencing made controlled mating extremely difficult.

A major communal boundary fencing effort (accomplished in the early sixties) was followed by a greater emphasis on internal subdivisional fencing for passive stock control with a much smaller labour requirement.

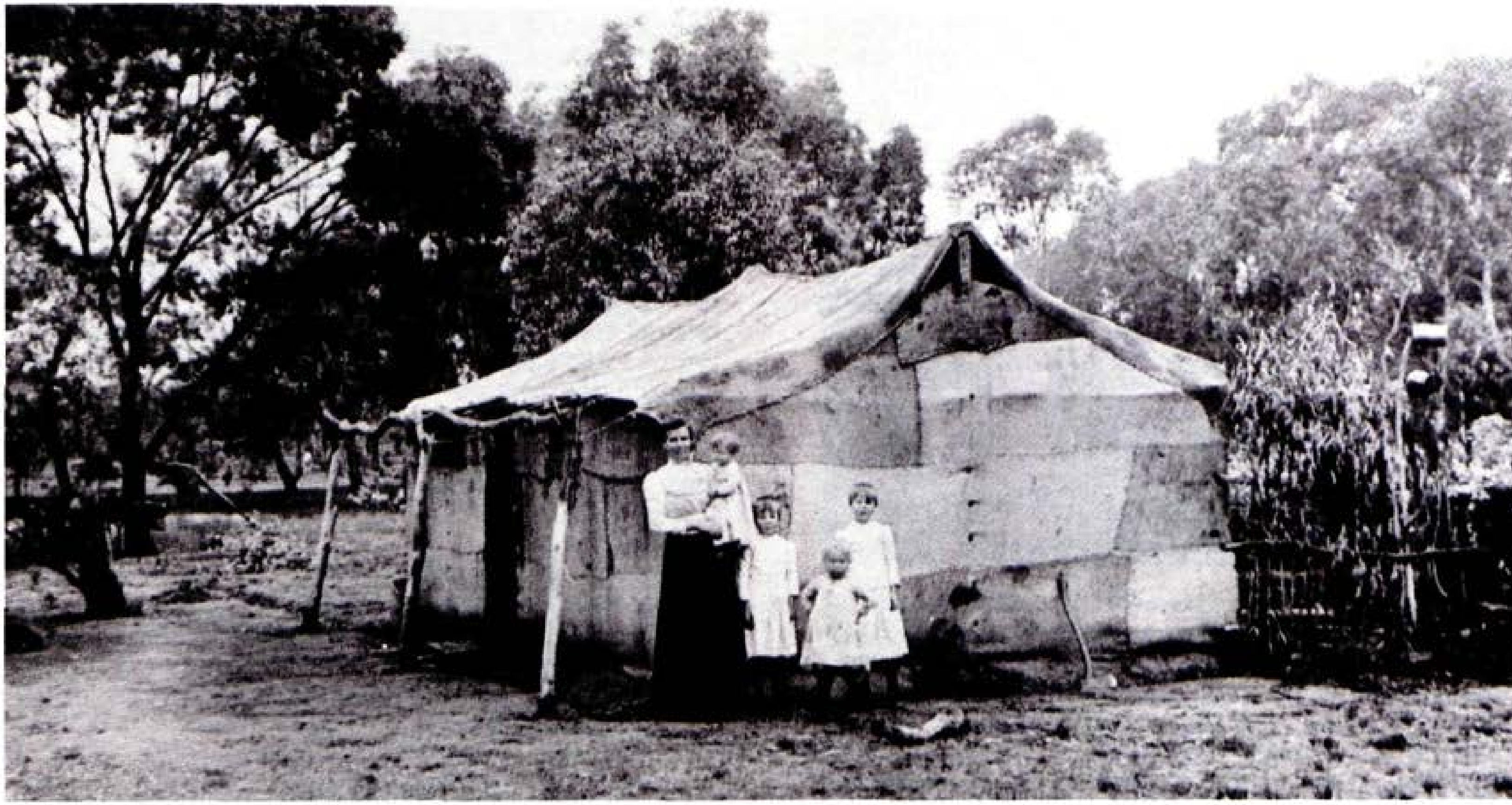
Benefiting from the sound economic and labour situation of the sixties, a few individual pastoral operations improved rapidly in size and efficiency. By 1873 the Warracknabeal run was selling 2,000 bales of wool from a flock of 100,000 sheep at a grazing intensity of 1.4 sheep per hectare. However, this run was unusual - it had water and a good creek frontage. Most squatters struggled against the droughts, rabbits, and wild dogs.

The poor demand for meat following the end of the gold rushes meant that most culled stock were slaughtered on-farm, and only the skins and tallow were sent south.

Lost in the bush

Life for the early settlers in the Wimmera was very lonely and at times frightening, particularly for the women, who not only worked long hours on the farms but also frequently had to stay at home alone or with their children while their husbands were away with the flocks.

A story familiar to generations of Victorian primary school students is that of the three lost Duff children, their eight nights in the bush, and their discovery by a search party led by the black-tracker, King Richard.



The pride of the pioneers is evident here, dressed for the occasion in front of their new home.

In August 1864 the Duff family lived on an isolated part of Spring Hill station, near the present Nurcoung, on the southern boundary of the study area and 20 km west of Natimuk. The father was a shepherd. While collecting broombush for their mother, the children strayed. The searchers had virtually given up hope when they were finally found, very near death. Seven-year-old Jane had wrapped her dress around Frank, four, to protect him. They all recovered; Jane and Isaac both died in the Wimmera in the 1930s.

The story was widely related and it inspired people in Australia and abroad. Monuments to the rescue were erected at Horsham and Duffholme, paid for by public subscription, as was Jane Duff's headstone in the Horsham cemetery. An area of native woodland adjacent to the cairn at Duffholme is managed as the Jane Duff Highway Park.

The Gold Escort

Discoveries of gold in Victoria throughout the 1850s brought vast changes as the colony grew rapidly in population and prosperity.

However, the Victorian finds drained neighbouring South Australia. During the first months, 16,000 men - more than half the work force - left their jobs and rushed eastwards.

In deserted Adelaide, Police Commissioner Alexander Tolmer conceived a plan to assist his colony. In 1852, with the Governor's approval, he surveyed a route approximately 550 km long between the central Victorian gold-fields and Adelaide. He paid higher prices than the Victorian authorities for gold from Bendigo and Castlemaine, then transported it under heavily armed escort across north-central Victoria through Navarre, Longerenong, Polkemmet (where the parties forded the Wimmera River), Duchembegarra, and further west through the Little Desert, crossing the South Australian border near present-day Serviceton (see Map 4).

The venture proved very successful. The escort made 18 journeys during 1852/53 and carried a total of more than 328,000 oz. of gold, worth more than £1 million in the currency of the time. The weight of the precious cargo varied between trips, exceeding a tonne on three occasions, but averaging about half a tonne.

Although the troopers had to contend with severe problems, such as shortages of water in the Little Desert and, in sharp contrast, flooded streams, they were sufficiently formidable to deter bushrangers. Stories of bushrangers watching from the rocks as the escort passed to the north of Mount Arapiles are probably true, but the existence of a buried billy of gold there remains unverified.

Using detailed records kept by the original survey party under Alexander Tolmer, it is possible to locate and follow parts of the route with reasonable accuracy, even today.

Selectors

As gold diminished in the 1860s, the ex-diggers turned their eyes to the land. Pressure grew to settle the land held under licence by squatters. This led to a period of extended and at times violent conflict that soon moved into the political arena - where at first the squatters, who held political supremacy through the 'Pastoral Protection Society', prevailed. But as time went by the selectors were able to achieve fair legislation and 'unlock the land'.

The Victorian *Land Act* 1860 (the Nicholson Act, passed in Victoria's first parliament under manhood suffrage) and the *Land Act* 1862 (the Duffy Act) both failed because of 'dummying' employed by large land-holders. This was a subterfuge involving the illegal use of nominees - it favoured the wealthy, whether speculators or existing farmers. However, some important principles were established, including that of selection after survey.

Most of the best land in the Western District was alienated under these Acts, and this put additional pressure on the Wimmera land.

The *Land Act* 1865 did little to remove much of the 'dummying' and was not particularly successful for selectors in Victoria. Selection was limited to no more than 640 acres (250 ha), but the *Land Act* 1869 (the Grant Act) reduced this to 320 acres (126 ha). Choice of land was made 'subject to survey' so that a rational land-ownership pattern could be retained.

Under the 1869 Act, all remaining Crown land in Victoria became available for settlement, even if unsurveyed. It was under this Act that closer settlement of the Wimmera began in earnest. Starting with smaller holdings around Horsham, selection gradually moved northward. By the summer of 1872, selectors with a great desire for land ownership and experienced in more-intensive agricultural systems were securing freehold title to 126-ha blocks throughout the study area.

Early settlers' home.

The pastoralists raised an outcry as the better-watered areas were taken up by the first selectors. Although they could retain their freehold, the squatters were ultimately powerless to prevent settlers becoming established on their leased runs.

Selectors came from many areas of Victoria, especially the Western District, and from South Australia, including many settlers of German extraction. By 1881, more than half a million acres (200,000 ha) of Wimmera land was occupied, if not fully freeholded. During and following the selection era, farm sales, abandonment, and amalgamation by *bona fide* selectors determined the pattern of land-holdings. These transactions were often influenced by drought, rabbits, isolation, and limited knowledge of farm practices.

The 'Dingo Fence'

By the 1880s both sheep and wheat farmers were suffering from the depredations of rabbits, wild dogs, and foxes. In 1885 the government began constructing a vermin-proof fence to prevent rabbits moving south from the ravaged Mallee into the Wimmera. Constructed chiefly of white-ant-resistant cypress pine, the 6-foot-high fence had small mesh netting close to the ground to block rabbits, broader mesh higher to stop wild dogs, and a barbed wire top strand.

As late as 1949, the 'Wimmera Shires Association' for the suppression of wild dogs and foxes was maintaining the vermin-proof fence. However, continued burning off had ruined the fence in a number of places, and it was allowed to lapse into disrepair. Relics of the fence, which follows the northern boundary of the study area, still stand. A quite sturdy section may be seen north of Perenna.

Cereal-growing

Limited cereal cropping for hay during the pastoralist era had demonstrated the potential of the Wimmera. The selectors brought with them the tools and the skills needed to develop this potential - many of the settlers of German descent were experienced practical farmers who had moved from South Australia to continue wheat-growing. Those with money to invest equipped their farms with a horse team, ploughs, harrows, stripper, and winnower, allowing the fast and timely sowing and harvesting that were necessary to exploit the short growing season of the study area effectively.

Settlers quickly recognized the suitability of the grey self-mulching soils for cropping: these commonly produced wheat yields from 1.3 to 2.0 tonnes per hectare, whereas yields on the poorly structured red soils often fell below 0.3 tonnes per hectare.

Selected blocks were progressively developed (about 8 ha per year) and then continuously cropped until yields no longer justified the effort and expense required. On the better soils, this apparently occurred after some 10 years, but progressive expansion of the cropped area on a selection, enabling grain production of 40--50 tonnes a year, ensured whole-farm viability for longer periods.

Crop yields until the 1890s were relatively low considering the fine quality of Wimmera soils. This could be put down to a number of contributing factors, including unsuitable wheat varieties, poor cropping practices, inadequate water supply, rabbits, crop disease, and transport distances and costs. Droughts - particularly in the late seventies - made matters worse, as did the economic depression of the 1890s.

By the early '90s, declining yields were threatening the long-term viability of the industry and farmers were keen to adopt new technology that would arrest the decline. Adoption of 'Salter's method' - incorporation of damp superphosphate with grain just prior to hand sowing - improved establishment, winter growth, and yield of crops and laid the foundation for the more advanced sowing technology introduced by the Department of Agriculture in the late '90s. By the end of the century, most farmers in the study area were sowing cereals, with superphosphate, through a seed drill and the yield decline was reversed.

A survey of 144 farmers in the County of Borung, conducted in 1907, clearly demonstrated the advantages of the new technology. Yields with superphosphate averaged 0.7 tonnes per ha, compared with less than 0.5 tonnes per ha without.

Some farmers had practised the technique of fallowing - to eliminate green plant material and thus soil moisture loss by transpiration through the spring, summer, and autumn prior to sowing - since selection. As larger cultivation equipment became available, allowing one man to cope with a greater area, this practice (now known to provide an extra 60 mm of available soil moisture) became almost universal on the heavy soils, reinforcing the benefits of superphosphate use.

At about this time, H.V. McKay developed the combine harvester, which combined the previously separate operations of stripping, threshing, and winnowing and hence increased the rate of harvesting and reduced the labour requirement enormously. The return of prosperity following the severe drought in 1901/02, which depopulated parts of the area by 60%, saw rapid adoption of the new harvesters throughout the study area.

Further shrinkage in labour availability during World War I stimulated further development of labour-saving equipment including the 'combine' for sowing, which allowed simultaneous final cultivation, fertilizing, and seeding. By the 1920s tractors were readily available and found to be ideally suited to the flat wheat paddocks of the Wimmera; and, although they could not compete with the draught horse during the financial depression of the 1930s, the economic and labour situation during and after World War II rendered them indispensible. The drought of 1944 finally spelt the end of the horse era.

Low wheat prices in the thirties meant financial difficulties for the farmers, and these were exacerbated by the steady decline in crop yield as the inherent supplies of available soil nitrogen were exploited and not replaced.

In the forties, recognition of the benefits of a rotational cropping system, incorporating a legume (medic or sub clover) phase to allow soil nitrogen accumulation, led to rapid and widespread adoption of the three-course rotation (fallow, wheat, legume). This rotation became the basis for a stable cereal industry, which has become the economic mainstay of the Wimmera.

Ploughing by tractor near Murtoa, in the early 1920s; a large wheat storage shed can be seen in the background.

Table 3

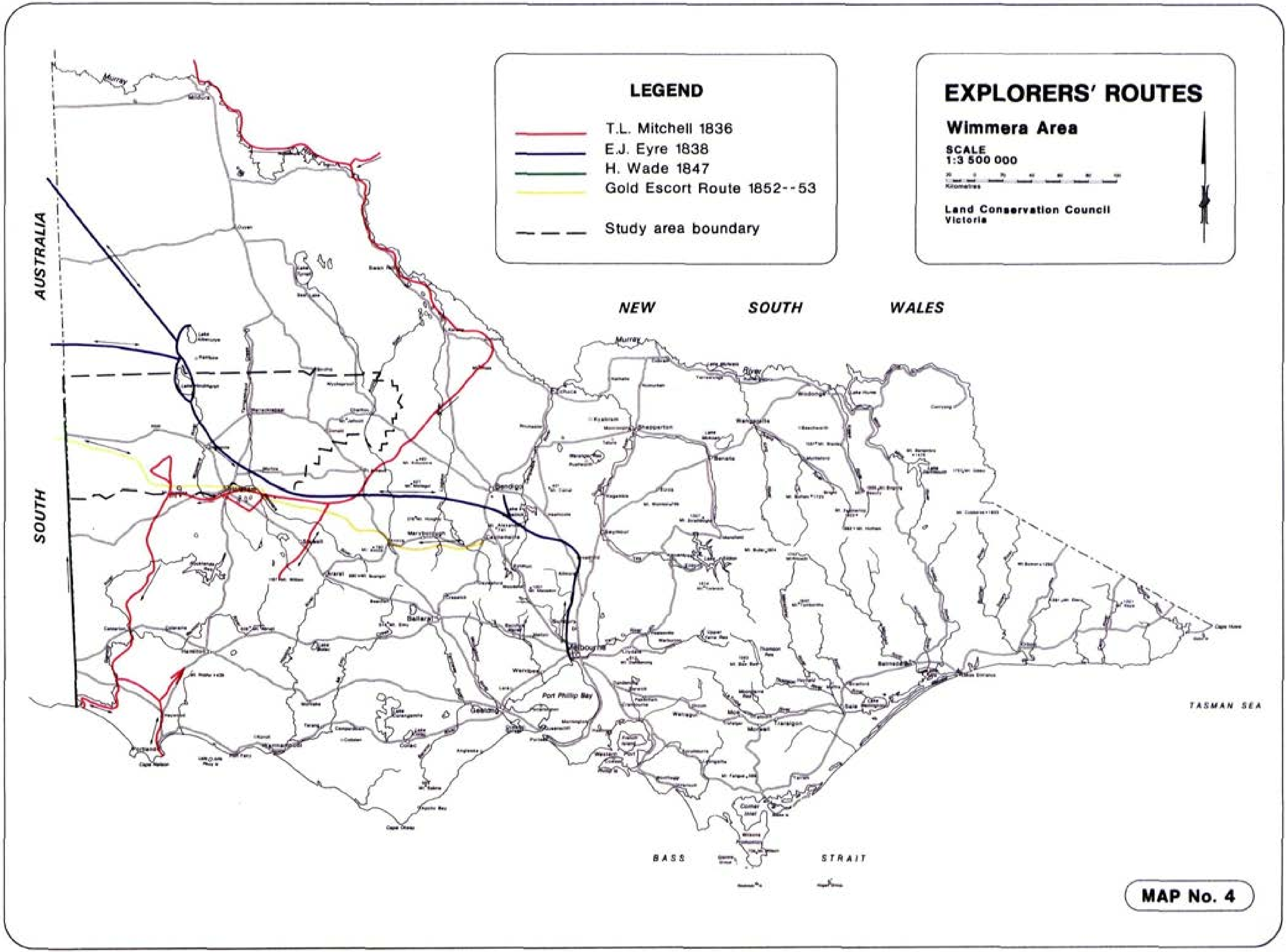
WHEAT YIELDS FROM ROTATION TRIAL AT DOOEN, 1918--53

System	Yield (tonnes per ha)
Wheat every year	0.60
Fallow--wheat	2.15
Fallow--wheat--legume	2.44

Other agricultural developments

The livestock industries have had a chequered history since the demise of the pastoral era. With closer settlement the great flocks were dispersed and few livestock remained in the study area. The smallness of the selections - and poor access to water on most - rendered them unsuitable for other than small subsistence herds and flocks for milk and meat.

In response to a buoyant export market for butter in the 1890s, many farmers contributed to the establishment of a milk production and processing industry in the Wimmera. Nutritional problems caused by the short growing season were partially ameliorated through fodder conservation (as hay and silage), and in the next century with irrigation to provide summer fodder. Marketing problems, however, proved less amenable to solut-



LEGEND
T.L. Mitchell 1836
E.J. Eyre 1838
H. Wade 1847
Gold Escort Route 1852--53
Study area boundary
EXPLORERS' ROUTES
Wimmera Area
SCALE
1:3 500 000
Kilometres
Land Conservation Council
Victoria
NEW SOUTH WALES
SOUTH AUSTRALIA
Murray
Bendigo
Maryborough
Ballarat
Melbourne
Port Phillip Bay
Geelong
TASMAN SEA
BASS STRAIT
MAP No. 4

ion and the industry, with all its local infrastructure, failed.

Throughout this century, lamb breeding has been an important, if economically variable, sideline. Initially it met a strong demand for frozen export lamb, with local slaughtering and freezing facilities; more recently it supplied the domestic trade through centralized processing facilities. Introduction of a legume into the rotation allowed winter and spring grazing over about one-third of each farm and provided, from the '40s on, a stable fodder base for sheep production that remained unchallenged until the recent trend towards grain legumes.

In the early 1880s a few farmers had started to irrigate orchards, vineyards, and market gardens from streams around Horsham, especially the Wimmera River. During the next 10 years various irrigation colonies, such as that at Quantong, were established using water from Lake Wartook in the Grampians. Chinese market gardeners at Nhill irrigated their gardens using groundwater.

Production of eucalyptus oil for local consumption was a relatively small-scale industry in the region, but one that had a significant impact on the landscape - notably in the Dimboola--Kiata--Antwerp area. Several factories operated between 1880 and 1910.

Secondary industries developed, particularly to serve agriculture. They included blacksmiths, engineering workshops, quarries, sawmills, tanneries, flour-mills, and butter factories. Many were later to close, especially during the early 20th century, unable to compete with the large-scale manufacturing industries in the coastal cities. Present-day Natimuk shows little evidence of its diverse commerce in the decade 1890--1900. Then the town had a coach-builder, two saddleries, at least one foundry making agricultural implements (Beard and Sissons employed 105 men in 1895), a large flour-mill, a smithy fabricating windmills, a creamery, and a cordial factory.

Disputed Territory

The disputed territory was the area of land lying between the current Victorian --South Australian border and the 141°E meridian of longitude. The position of the border was not finalized until 1914.

The 1836 Imperial Act that first defined the boundary between South Australia and New South Wales stated that it was to be the 141st meridian of longitude.

In 1839 Charles James Tyers made three separate determinations for the longitude of a sand hill to the east of the mouth of the Glenelg River. The results of his observations were independently checked by Captain Owen Stanley. A further determination of longitude was made by Captain Stokes of Her Majesty's surveying ship 'Beagle'. Unfortunately, all of these attempts to determine the longitude of the same point gave different answers (due primarily to the lack of accurate time pieces, which are essential for longitude determinations).

Between March and August 1847, Surveyor Henry Wade from New South Wales and Assistant Surveyor Edward Riggs White from South Australia marked the boundary for 123 miles (198 km), but they were forced to abandon the survey due to lack of provisions. Between mid 1849 and December 1850 White continued the survey to the Murray.

In 1849 the Secretary of State for the Colonies gave formal approval to proclamations declaring that the boundary as defined by Wade should be deemed and construed to be the eastern boundary of the Province of South Australia.

In December 1868 Mr Smalley, the Government Astronomer for New South Wales, and Mr Todd, the Superintendent of Telegraphs for South Australia, made longitude determinations using accurate time via the telegraph at Chowilla, and found that this 'correct' location of the 141st meridian lay some 3.6 km to the east of the line surveyed by White. South Australia then decided to claim the whole of the territory between the two lines - a claim that Victoria rejected.

The dispute between the two States over this strip of land some 3.6 km wide and 500 km long continued until 1914, when the Privy Council settled the argument in favour of Victoria - deciding that the line as surveyed by Wade and White should be adopted as the boundary irrespective of its relation to the 141st meridian.

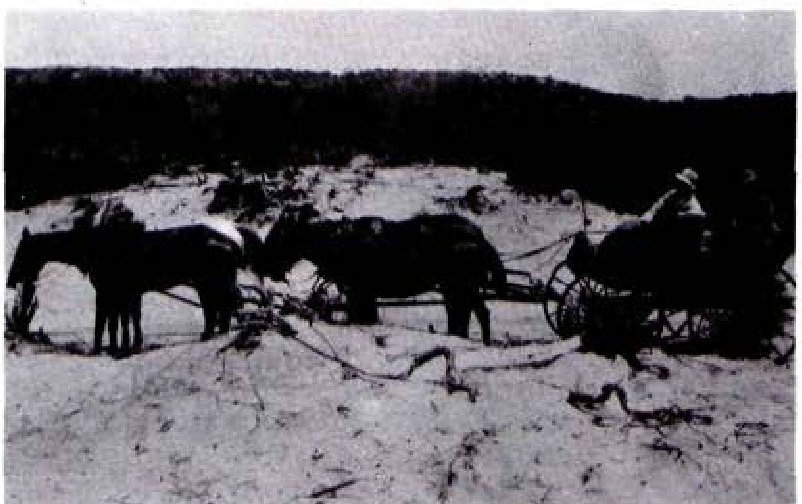
Murtoa Post Master's residence in 1883.

The lengthy problem of the disputed territory was important for several reasons - it confused the problems of paying customs duties when transporting goods from one colony to another in pre-Federation days, it provided a haven for 'evaders of the law' including the notorious bushranger 'Mad Dog' Morgan, and it contained the important railway centre of Serviceton, originally thought to be in South Australia, but now in Victoria.

Currently, work is being carried out by Victorian and South Australian Surveyors to re-establish the boundary as surveyed in 1847--50. Due to the low priority of the work it is not expected to finish for several years.

Transport and Communications

The road network evolved very slowly from the tracks that squatters and drovers followed from spring to spring, and from the access tracks to stations and homesteads. Major crossroads became recognized camping places from which grew several towns, notably Dimboola and Nhill. Horsham, Warracknabeal, and Donald grew from shanties at river crossings. Conditions on the roads were generally poor, especially in winter.

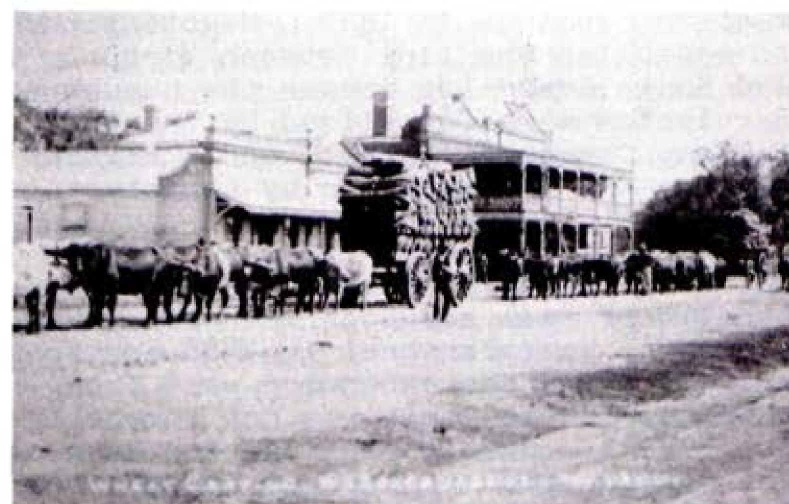


Transport through mallee scrub in horse and buggy days was most precarious.

In 1862, Captain Bowden introduced the first coach service in the Wimmera, between Horsham and Stawell. A decade later, Cobb and Co. began services to more remote areas. Attempts were made to improve the standard of main roads for the coaches by the formation of District Road Boards (the forerunners of Shire Councils) from the 1860s, but roads that were properly surveyed and built did not become common until well after 1900.

Late in 1881, the inland route for the overland telegraph between Melbourne and Adelaide was completed - via Dimboola, Nhill, and Lawloit to the border.

The railway brought about profound changes in the development of the Wimmera. The western line reached Horsham



Wheat-carting by bullock-teams through the main street, Warracknabeal, in 1906.

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An 1896 freight train.

in February 1879 and Dimboola became the western terminus in 1882. Negotiations to establish the link between Victoria and South Australia across the border at Serviceton were formalized by the 1884 *Railway Construction Act*, and a regular service was in operation by the start of 1887.

While the northern Wimmera gained the benefit of rail services when lines were opened to Warracknabeal in 1886 and Jeparit in 1894, the extension west from there as far as Yanac was not completed until 1916. Special legislation enabled the construction of another branch from Natimuk west to Goroke, under the auspices of a local Trust, in 1894. This was extended to Carpolac in 1927.

Water Supply

Water was a scarce commodity for the early Wimmera settlers, who had to rely on dams and wells, long before the times of water tanks.

The needs of an increasing population, the prevalence of disease caused by contaminated water, and two droughts in the late 1870s led to the production of an official report 'Supply of Water to the Northern Plains' by Messrs Gordon (former Chief Engineer of Water Supply) and Black (later Surveyor General), from which today's Wimmera--Mallee water scheme has developed. Its key features were storage of winter flood-waters by the construction of weirs on the Wimmera, Richardson, and Avon Rivers and the use of bores, wells, and dams in the country west of the Wimmera River.

To provide the substantial funds needed, the *Water Conservation Act* 1881 provided for the setting up of local water trusts. The Wimmera United Waterworks Trust was founded the following year, and as its first major project constructed Wartook Reservoir in the Grampians in 1886. Local trusts proliferated, and developed an extensive network of reservoirs, connecting channels, and storage tanks.

Following its creation in 1906, the State Rivers and Water Supply Commission took over responsibility for the Wimmera --Mallee waterworks system and considerably expanded its scope to supply many thousands of farms and numerous towns in the Wimmera region.

Tank-sinking near Birchip, using bullocks and horses.

Closer and Soldier Settlement

Closer settlement as such commenced under the *Land Act* of 1898, which contained provision for the acquisition of private land by the government for closer settlement purposes. Under this Act 30,000 acres (12,000 ha) of land was purchased at Wando Vale, Walmer near Horsham (13,800 acres), Brunswick, and Eurak.

Closer settlement was introduced into Victoria under a separate Act in 1904 (and soldier settlement in 1917). In 1905 a part-time Board was set up to administer the Act. In 1915 a Board of public servants was formed. This was followed by various Boards and Acts until World War II. Soldier settlement schemes in Victoria incurred a loss to the State of £21 million by 1938, but a relatively small share of this loss is attributable to the Wimmera. Nevertheless, such settlement does not appear to have been very successful in the Wimmera prior to World War II. By 1938 a scheme of adjustments had been completed whereby the remaining settlers were given new terms of repayment on adjusted liabilities. Following this, and the resolution of some of the other problems, especially inadequate farm size, the Wimmera continued as a significant and efficient area for primary production, particularly for wheat and other grain.

Under the Commonwealth--State War Service and Settlement Agreement some Wimmera land was compulsorily resumed, planned, and developed for and by returned servicemen from World War II.

Under this Soldier Settlement Scheme, 37 servicemen were settled on Wimmera cereal and grazing land and a further 36 dairy-farmers were established on two irrigation projects near Horsham and Murtoa.

These figures are low compared with the total number of servicemen settled under the Scheme in the rest of the State. They underline the fact that the Wimmera at this time had already been effectively settled, unlike parts of the Western District, which still contained a number of larger holdings capable of extensive subdivision.

In 1951, special legislation was enacted to enable the Australian Mutual Provident Society to be granted development leases within an area of 231,000 ha of Crown land in the Big Desert adjacent to the South Australian border.

Two separate development leases were actually granted, eventually totalling some 133,000 ha. The leases covered a term of 25 years and required the A.M.P. to carry out general improvement for primary production purposes on the land. The Society was empowered to allocate the land as farms for persons it thought fit and who were approved by the Minister for Lands. The Act did not include residence clauses, although many young farmers took up residence, especially in the early stages.

Development under this scheme ceased in 1968. Further development would be subject to the findings of investigations into aquifers for adequate water supply, and would be certain to raise conservation objections.

The Little Desert controversy

Plans to farm the Little Desert, which contains the largest remaining blocks of Crown land in the Wimmera, have been put forward from time to time since 1905 by local Councils and other interested parties. In 1964, the Wimmera Regional Committee of the Central Planning Authority recommended that 65,500 acres (26,500 ha) selected over a wide range of habitats should be withheld from land development. The Committee included both municipal and government representatives, and its recommendations met with popular approval at a public conference in Lowan Shire Office on 26 August 1964.

In October 1968 and April 1969, the then Minister for Lands Sir William McDonald announced plans to develop the Little Desert. These plans included reserving an area of 80,000 acres (32,000 ha) in the eastern section, which is mostly covered by treeless heaths growing on deep sands. The only other area to be reserved was 1,300 acres (500 ha) at The

Craters. The rest of the Little Desert was to be developed into 50 farms - each of about 4,000 acres - giving a total developed area of about 200,000 acres (81,000 ha).

Economists were quick to debate the issue. They pointed out that the farms would be at best only marginally economic and most likely very unprofitable and that the benefits to the State would be more than offset by the heavy costs of road construction.

Conservationists also questioned the scheme. The areas proposed for development included most of the areas recommended for reservation by the Wimmera Regional Committee, and development would entail the destruction of extensive areas of yellow gum woodland, mallee --broombush, and brown stringybark woodland, thus greatly reducing the diversity of vegetation in the Little Desert.

Under pressure from both economists and conservationists, the government reduced its plan in September 1969 to the development of only 12 farms - a total area of 50,000 acres (20,000 ha). The location chosen was adjacent to the South Australian border in the area of best soil and highest rainfall.

The issue continued to receive much attention from the press and public, and in December 1969 the government announced that it would shelve its plans for development of the Little Desert. The Little Desert controversy indicated the need for a different approach to deciding uses of public land in Victoria, and led to the proclamation of the *Land Conservation Act* 1970, which established the Land Conservation Council in February 1971.

The Land Conservation Council carries out investigations and makes recommendations to the government with respect to the use of public land in order to provide for balanced land use in Victoria.

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PART II

NATURE OF THE LAND

6. GEOLOGY

The surface of the study area is predominantly made up of wind-blown, alluvial, and marine sediments that range in age from about 7 million years old to present-day. These sediments are geologically quite young, belonging to the late Cainozoic era. The action of the wind and water has sculptured the surface into a number of features, which are referred to briefly in this chapter but discussed more fully in the chapter on geomorphology.

At Mitre, and in the far east of the study area, substantially older and different rocks occur - forming the only local hard-rock hills. These rocks come from the early Palaeozoic, and they range in age from 550 to 380 million years old.

Map 5 shows the surface geology of the study area, together with cross-sections representing its subsurface geology, while Table 4 and Figure 1 present it diagrammatically. The following description starts with the oldest rocks, progressing through to the youngest. A glossary at the end of this chapter explains the meanings of many of the technical terms used.

Palaeozoic Bedrock

Palaeozoic bedrock outcrops in the eastern part (see Map 5) and consists of a number of rock types. The oldest are marine sandstone and siltstone of Cambrian age, and the latter has in places been converted to slate. These rocks outcrop near Jeffcott and Cope Cope.

Granitic rocks outcrop near Wycheproof.

Table 4

STRATIGRAPHY

ERA	PERIOD	Million years	STRATIGRAPHY (SOUTH – NORTH)	MAJOR EVENT
CAINOZOIC	QUATERNARY		Dunes: *Lowan Sand, Woorinen Formations; lunettes* / *Alluvial and lacustrine deposits*	*Phases of global glaciation cause climatic variations: semi-arid land forms develop*
		0.05	*Erosion*	
		1.8		*Sea retreats in stages depositing sandstone*
	TERTIARY	5.0	Parilla Sand: *shallow marine sandstone and siltstone*	*Sea advances*
				Sea retreats
			Murray Group: *marine marl, limestone, and clay*	*Major marine trangression*
			Renmark Group *non-marine sand, silt, clay, coal*	*Continental deposition commences*
MESOZOIC		65	*Erosion*	*Extended period of erosion*
PALAEOZOIC	PERMIAN	247	*Tillite, sandstone*	*Major glaciation. Glacial sedimentation in north*
	CARBONIFEROUS	290	*Erosion*	*Uplift - extended erosion*
	DEVONIAN	367	*Intrusion of granite*	
	SILURIAN	416	Grampians Group: *marine and non-marine sediments*	*Downwarping and sedimentation in south*
	ORDOVICIAN	446	*Erosion*	*Uplift and erosion*
				Major earth movements fold sedimentary rock and destroy geosyncline: sedimentation ends
	CAMBRIAN	509	*Marine sedimentation and lava extrusion on sea floor*	*Major geosyncline sedimentary basin receiving marine sediment, lava*
		575		

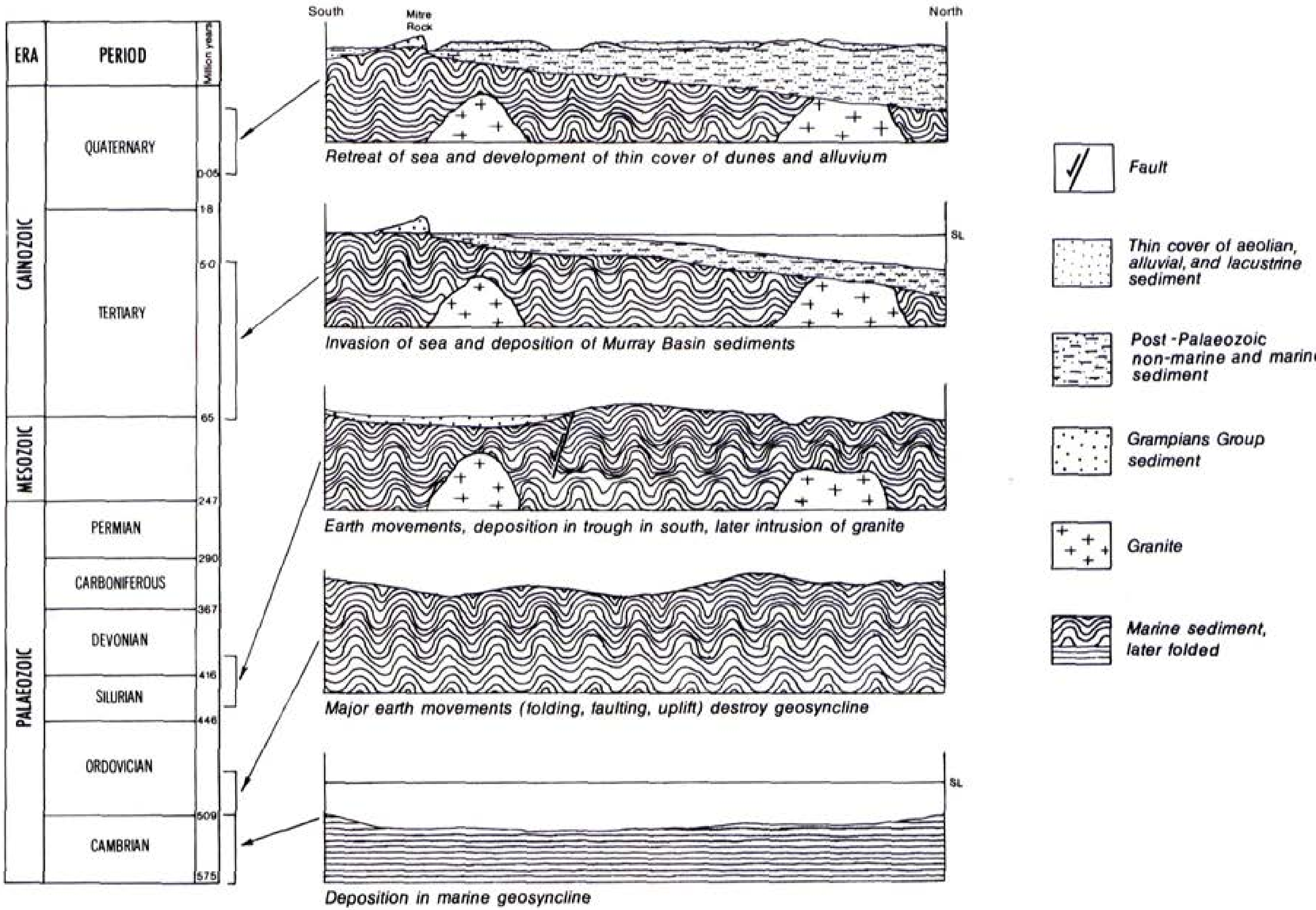


FIG. 1 SIMPLIFIED GEOLOGICAL HISTORY

Mitre Rock: this monadnock of Grampians Group sediment protrudes through younger Cainozoic sediments of the south-western Wimmera plains.

Elsewhere the sediment and slate have been metamorphosed to schistose hornfels, knotted schist, and spotted slate by granitic intrusions. These metamorphic rocks outcrop north-west and south-east of Charlton, and at Jeffcott. The granitic rocks - which intruded the sediment and slate during the early Devonian period causing the metamorphism - now outcrop at Buckrabanyule, Mount Gowar, Yowang Hill, north-west of Charlton, near Jeffcott, and at Wycheproof.

The only other area of Palaeozoic bedrock outcropping in the study area is Mitre Rock, west of Natimuk. Mitre Rock is made up of non-marine sandstone and mudstone of late Silurian--early Devonian age and, together with Mount Arapiles, forms an outlier of the rocks that make up the bulk of the Grampians to the south-east.

All of the study area overlies rocks of Palaeozoic age. In addition to the rocks just described, areas of glacial sediments of Permian age are deeply buried in the west. At Netherby, 420 m of tillite and other glacial sediments occur at a depth of 400 m.

Tertiary

The study area lies on the south-eastern edge of the large sedimentary basin known as the Murray Basin. The sediments filling this are of Tertiary and Quaternary age.

At the beginning of the Tertiary, the sea started to inundate the Wimmera from the north and west. By the mid Tertiary the bulk of the study area was under water, but towards the end of the mid Tertiary the sea began to retreat.

In the late Tertiary it again advanced, leaving only Mitre Rock and the higher areas of Palaeozoic rocks in the east free from inundation. At the end of the Tertiary, the sea finally retreated from the area.

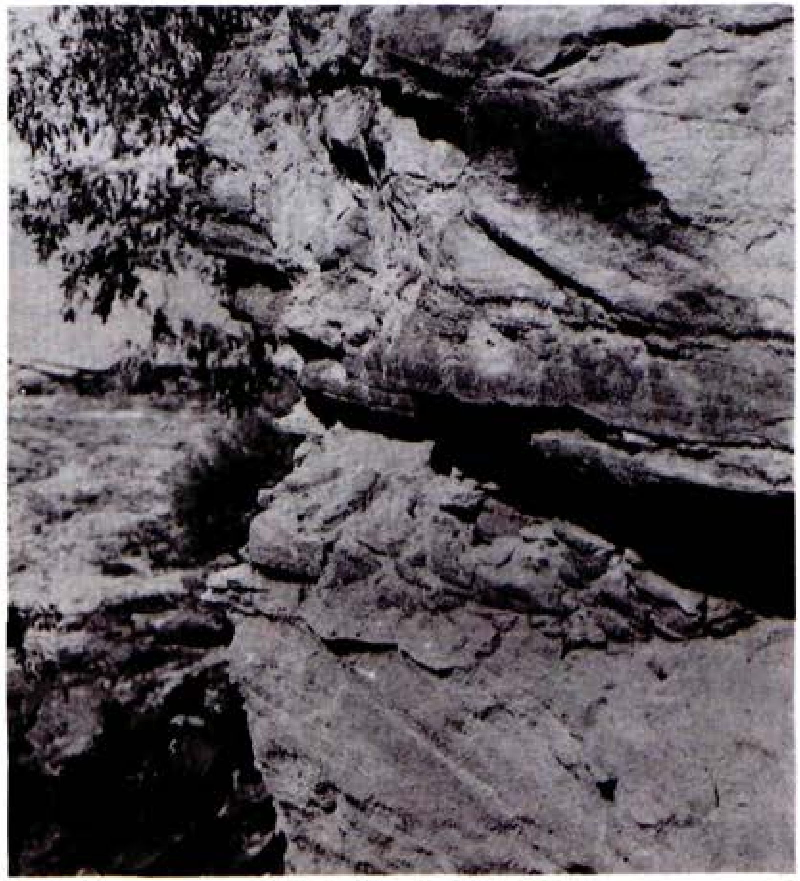
Associated with this marine transgression--regression was the cycle of sedimentation. (The sediments that were deposited are represented diagrammatically in the two cross-sections on Map 5.)

This cycle commenced with sediments laid down in alluvial to tidal flat environments, comprising up to 160 m of sand, silt, clay, and coal, known as the Renmark Group. At the highland front, streams laid down gravels that now outcrop along the eastern margin of the study area.

As the marine influence increased, marl (Ettrick Marl) and limestone (Duddo Limestone) were deposited in deeper water in the west, while clay (Geera Clay) and marl, marly limestone, and silt (the Winnambool Formation) were deposited in shallower water in the east. At the same time the river system draining the highlands to the south was depositing coarse gravel and sand (Calivil Sand) in valleys and out onto the coastal plain near Horsham.

In the mid Tertiary the sea returned, depositing clayey marl (Bookpurnong Beds), but in the late Tertiary as it again swept across it deposited sand, silt, and gravel (Parilla Sand) near the shore. The latter unit now outcrops widely in the study area.

In the late Tertiary, as the sea retreated from the Murray Basin, it continued to lay down Parilla Sand. The sea retreated in stages, and in doing so moulded the upper surface of the Parilla Sand into a series of ridges running NNW--SSE, reflecting standstills of the retreating shoreline. The most obvious of these ridges occur at Warmur, at Diapur, and just west of Lake Buloke.



Cross bedding in Parilla Sand indicating a high-energy shallow-water depositional environment: The Cliffs, Lake Hindmarsh.

Quarternary

As the sea retreated at the end of the Tertiary, a sandy coastal plain was left over much of the study area.

The different geological units that now cover much of this plain developed during the Quaternary period. The units comprise alluvial, aeolian, lacustrine, and chemical sediments that were laid down in response to climatic oscillations during the Quaternary. Often the different types of deposits are intimately associated in time and space, giving a complex interfingering in the stratigraphic column.

Climatic oscillations during the Quaternary were due primarily to phases of global glaciation. They had a significant impact on the world's weather, and in the study area the maximum global glacial phases were marked by a general drying of the climate and the development of arid or desert land forms.

All the major stratigraphic studies concentrating on this period have been conducted to the north of the study area but their results are generally applicable to the Quaternary fluvial, aeolian, and lacustrine sediments present in the Wimmera.

A major wet phase occurred between 50,000 and 30,000 years ago. Large lakes existed, bordered by sand lunettes to the east. By 28,000 years ago lake levels had fallen and a major arid phase had commenced, reaching a peak between 18,000 and 16,000 years ago. During this phase widespread dune development and extension occurred. Extensive clay lunettes developed adjacent to drying lake basins, west--east linear clay-rich dunes (Woorinen Formation) developed over much of the western and central parts of the area, and irregular subparabolic quartz-rich mobile dunes encroached into the study area from South Australia.

Lake levels again rose about 13,000 years ago and remained high for a further 8,000 years. The rises were much smaller than those recorded during the Pleistocene, however. During this period, extensive alluvial deposition also took place. In approximately the last 5,000 years, conditions have become drier, resulting in the lakes again contracting.

Lake deposits

Associated with the drainage system are broad areas of lake and swamp deposits, often bordered by one or more dunes (lunettes) to the east and north-east.

The development of these lake basins was initiated in the Pleistocene epoch, when the northward-flowing drainage system was dissipating in the Wimmera and riverine plains - either in a fine network of distributary channels or playettes, or in topographic lows such as the broad corridors between the Parilla Sand ridges.

Stream discharges had much higher levels in the past than today. So some of the lakes were much larger, as can be seen by the broad areas of lake-bed deposits of clay and silt bounded by multiple lunettes at Lake Buloke, Lake Hindmarsh, and south of the Little Desert. Most of the sediment had been laid down 30,000 years ago, with lesser amounts laid down between 13,000 and 5,000 years ago.

During the arid period from 28,000 to 16,000 years ago, gypsum was deposited in depressions where the water table lay close to the surface, and salt was deposited where lakes seasonally dried, particularly in the area running north--south from Lake Hindmarsh to Mitre.

Lunettes

Vegetated dunes known as lunettes occur adjacent to shallow lake basins in the Wimmera. The dune ridges range widely in composition - from well-sorted quartz sand, through clayey sand, to gypseous sandy clay. The sediments in the lunettes are closely related to the hydrologic conditions that formed them.

Those that occur close to major drainage lines, such as the lunettes of Lake Hindmarsh on the Wimmera River system, tend to have larger quantities of quartz sand, which was contributed to the

Sandy lunette to the east of Lake Hindmarsh.

shoreline dune by wave action and longshore drift. The only example of this type of lunette on public land occurs near Ellam, east of Lake Hindmarsh.

Most of the lunettes in the study area are clay-rich, however, because they formed during periods of low water level. In this situation seasonal exposure of saline mud flats permitted the efflorescence of salts, especially halite and gypsum, causing clays to form pelletal aggregates. These were then blown into dunes by high-velocity winds. With the onset of seasonally moist conditions, the dune was stabilized annually and as a result did not migrate but remained at the salt-flat margin.

At least two phases of clay-lunette building have taken place. An older, partly eroded red phase - such as the outer lunettes at Lake Buloke - developed between 28,000 and 22,000 years ago. A subsequent younger grey phase, closer to the present lakes or overlying the older red lunettes, developed from about 20,000 years ago, with maximum development (18,000--16,000 years ago) coinciding with the last glacial maximum.

As a fossil land form, the lunettes represent a legacy of Pleistocene environments and are particularly useful indicators of the variations in Quaternary climates.

Source-bordering dunes

Dunes occur adjacent to current and abandoned stream courses along the Avoca River at Teddywaddy and south of Glenloth East. These dunes developed by wind deflation of sandy stream-beds during the last major arid phase, which ended around 15,000 years ago. They formed under predominantly westerly winds and are found to the east of major streams or arranged in a more generally west--east outcrop. Minor development of source-bordering dunes has taken place since that time.

Woorinen Formation

Low elongate sand ridges or linear dunes and dune sheets comprise the most characteristic land form, extending across most of the study area, especially in the wheat-growing districts. The Formation consists of pale to dark reddish-brown calcareous sandy clay and clayey sands, usually less than 7 m thick. The dunes contain an average of 7--10% clay, reaching higher values in the swales. Carbonate content can be as high as 14%, but averages about 5%. Clay and carbonate contents reach maximum values in the swales and this variation is reflected in the vegetation distribution.

The dunes rest unconformably over the earlier phases of the alluvial Shepparton Formation and, where that is missing, the Parilla Sand. The various dune forms are discussed further in the chapter on geomorphology.

The last episode of linear dune mobilization coincides with the last major arid period between 25,000 and 16,000 years ago, when water tables and lakes were considerably lower than they had been previously. Dune formation is similar to that of the lunettes.

Reversal of the hydrologic budget during this dry time caused groundwater salts to accumulate in the swales, developing salt pans. The attendant efflorescence was responsible for breaking clays into pellets, which were then deflated into the flanks and crests of adjacent dunes. These dunes are relict features stabilized by vegetation. European settlement, clearing, and subsequent drought have led to reactivation of some dunes.

Lowan Sand

The Lowan Sand extends into the Wimmera as a lobe of irregular dunes forming the Little Desert. Part of the Big Desert occupies the noth-western corner of the study area. Outside the 'deserts', the Lowan Sand is found along the north--south ridges of Parilla Sand where that unit has been reworked into dunes.

It is a fine- to medium-grained grey-white, quartz-rich, windblown sand derived from the underlying Parilla Sand. It contains little carbonate or clay and therefore dunes differ quite markedly from the clay-bearing linear dunes of the Woorinen Formation.

Those in the Little Desert are often referred to as 'jumbled' dunes. On closer inspection, however, they possess a degree of order, reflecting the influence of the prevailing westerlies that formed them. The last active development of these irregular dunes coincided with the last major arid period, ending around 16,000 years ago.

Alluvial sediments

Associated with the major north-flowing drainage systems are alluvial sediments ranging in age from the Pleistocene to the present, with the bulk of them located in the east and south. These sediments consist of sand, gravel, and clay, and may be a mere film overlying the Parilla Sand, as on parts of the flat plain to the north of Lake Buloke, or up to 60 m thick as occurs east of Horsham and north of Charlton. On the geological map these alluvial sediments are separated into two groups - the older and more extensive sediments that make up the bulk of the alluvial outcrop (Shepparton Formation), and younger more restricted ones associated with current drainage lines (Coonambidgal Formation).

Colluvial deposits

These were deposited towards the base of slopes by the actions of gravity and water and are principally associated with the Palaeozoic outcrops in the east of the study area. Colluvial or scree slopes of granitic sand fan off the granitic outcrops in the area, whereas slopes of soil containing fragments of sandstone and siltstone surround the higher areas of contact metamorphosed Cambrian rocks at Jeffcott, Charlton, and elsewhere. Generally the colluvial deposits are unconsolidated.

Glossary

Aeolian - pertaining to the wind; in this study area refers to sand and silt laid down by the wind, and the resultant land form produced

Alluvial	- pertaining to or composed of alluvium, or deposited by a stream or running water
Calcareous	- containing calcium carbonate: when applied to a rock, implies up to 50%
Deflation	- removal of loose material by wind
Efflorescence	- one or several minerals, generally soluble salts, precipitated as a surface incrustation on a rock by evaporation of water
Gypsum	- hydrous calcium sulphate, $CaSo_4.2H_2O$
Hornfels	- a fine-grained rock formed by contact metamorphism
Lacustrine	- pertaining to, produced by, or formed in a lake
Longshore drift	- material that is moved along a shore by a current caused by the approach of waves to a coast at an angle
Lunette	- one of the broad, low, smooth, crescent mounds or ridges of clay loam or silty clay bordering the leeward (eastern) shore of almost every lake and swamp in the plains of northern Victoria.
Marl	- applies to a soft deposit consisting chiefly of a mixture of clay and calcium carbonate in varying proportions
Metamorphic rocks	- any rock derived from pre-existing rocks by mineralogical, chemical, and structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment at depth in the earth's crust
Schist	- strongly foliated crystalline rock formed by metamorphism
Scree	- a sheet of any loose, fragmented material lying on or mantling a mountain slope or hillside

Slate - a fine-grained metamorphic rock formed from rocks such as shale, which are fissile along planes independent of the original bedding (slaty cleavage)

Swale - in this study area the trough-like depression between dunes

Tillite - a consolidated sedimentary rock deposited directly by and underneath a glacier without subsequent reworking by water from the glacier, and consisting of a heterogeneous mixture of clay, sand, gravel, and boulders varying widely in size and shape

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7. GEOMORPHOLOGY

Like all areas in Victoria north of the Highlands, the landscape is either flat or undulating. In the Wimmera this general flatness reflects the geological processes of the Tertiary period. About 60 million years ago the seas started to inundate north-western Victoria, laying down sediment.

By the time the sea finally retreated, about 5 million years ago, a broad sandy plain had developed over the whole region, including the bulk of the study area. Wind and water started to slowly remould the surface of this plain, with the greatest impact registered during the last 50,000 years, when major phases of global glaciation began to profoundly influence the Quaternary climate.

Alternating periods of wet and dry led to the formation of the low-relief semi-arid land forms that now blanket much of north-western Victoria and extensive tracts of the rest of south-eastern Australia to the north and west.

The study area lies on the extreme south-western edge of this huge region, and hence the semi-arid land forms here are generally much more subdued than those to the north and north-west. It does contain siliceous dune fields, but these are vegetated, lower, and in places used for agriculture. It also has the great linear dune fields - so characteristic of large parts of central Australia - but in a greatly reduced form, finally petering out in patchy sheets and hummocks of dune in the east and south-east. On the other hand the lunettes and lake basins, although somewhat smaller than elsewhere in south-eastern Australia, are still highly impressive land forms, and are significant reminders of the climatic variations of the Quaternary period.

This chapter describes the topography and drainage, separates the landscape into geomorphic units, and describes the way these units were formed. As the geomorphic subdivisions are closely related to the stratigraphic units, the geology map (Map 5) can be consulted to show the detail of the various geomorphic units. Map 6 shows the more generalized geomorphic units, while topography is shown on Map 7. The glossary at the end of this chapter explains the meanings of many of the technical terms used.

Topography

The only area of substantial relief in the Wimmera is in the region of Palaeozoic sediment outcrop in the east of the study area. The granite at Yowang Hill and parts of its metamorphic aureole, at 340 m, rise about 190 m above the nearby Avoca River. Elsewhere the topography is gently undulating and of low relief. A number of monadnocks of Palaeozoic rock protrude through the Cainozoic cover at Jeffcott, Mitre Rock, Charlton, and Wycheproof, rising 140 m, 120 m, 60 m, and 40 m respectively above the surrounding plain.

Sandstone strandlines, representing successive stages in the retreat of the late Tertiary sea from the study area, trend NNW--SSE across much of the area. The most prominent of these ridges occur east of Kaniva and south of Kiata, where they rise about 70 m above the surrounding landscape.

Aeolian land forms dominate the remainder of the landscape. The lunettes at Lake Hindmarsh and Lake Buloke rise 60 m and 20 m respectively above the adjacent lake floors, while in the Little Desert the dune relief can be up to 30 m.

Drainage

While no substantial drainage system rises within the study area, a number of major streams, all rising to the south of it, either pass through or terminate in the Wimmera area. Numerous lakes of varying sizes are associated with this drainage system and dissipation of water. Some, such as Lake Buloke, are freshwater lakes situated on or at the end of major drainage lines. In the western Wimmera, which has no significant surface drainage, numerous small freshwater ephemeral lakes contribute to the groundwater system.

Elsewhere, near Mitre and adjacent to the Wimmera River, the small lakes and depressions are saline. Here they intersect the saline regional groundwater systems and hence are groundwater discharge lakes and points.

The Avoca and Wimmera Rivers are the principal streams passing northward through the study area. The smaller Yarriambiack Creek also passes through it while the Richardson River and Dunmunkle Creek terminate here.

Notable features of the drainage pattern are the effluents or anabranches from the main streams, the two most important being the Yarriambiack and Dunmunkle Creeks - effluents of the Wimmera River. North of Glenloth the Avoca River splits into a complex network of anabranches on its flood-plain. Similar anabranching also occurs in the drainage system feeding into Lake Marmal.

The Wimmera River flows along the southern boundary of the study area before swinging suddenly northward at Quantong.

This sudden course change probably occurred due to earth movements raising the land to the west and forcing the stream northward. With the exception of the Avoca River, the remainder of the drainage system in the Wimmera is greatly influenced by ridges of Tertiary marine sandstone running through the area.

South of the Little Desert strings of lakes occupy the inter-ridge corridors, with sluggish seasonal water movement from south to north.

In the east, sandstone ridges pass through Yellangip, Bangerang, Warmur, and Thalia. The Yarriambiack Creek is confined to the corridor west of Bangerang for much of its course through the area. Dunmunkle Creek follows, and then terminates in the corridor between the Bangerang and Warmur ridges.

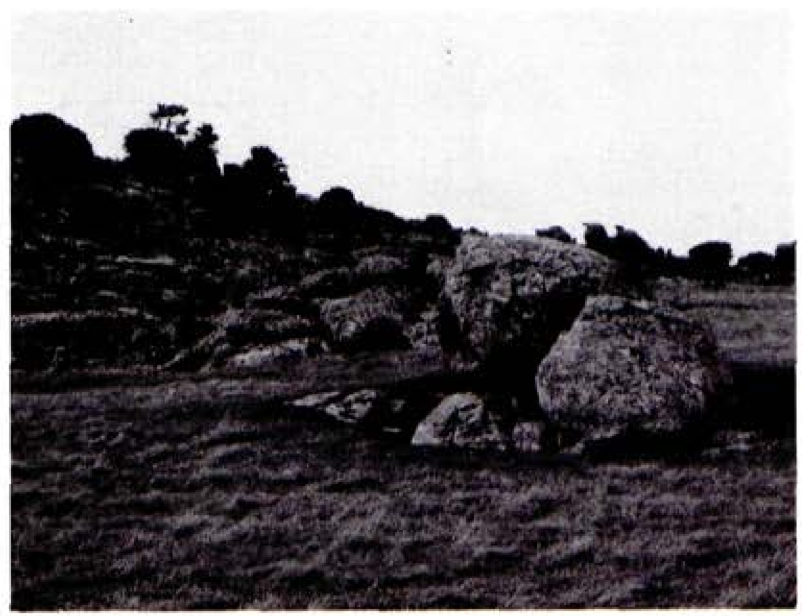
Richardson River skirts the highland front before swinging northward and emptying into the terminal basin at Lake Buloke between the Warmur and Thalia sandstone ridges. A number of small streams terminate in small lake basins close to the highland front at Lake Marmal and Wooroonook Lakes.

Geomorphic Subdivisions

The study area falls within two main physiographic divisions. Most of it lies in the Murray Basin plains, where a number of distinct geomorphic units are recognizable. The eastern portion lies within the Western Highlands.

Western Highlands

Palaeozoic hills of granite and contact metamorphosed sediment in the east of the study area form part of the Western Highlands. These Palaeozoic rocks are not uniformly resistant to erosion. Typical hilly granite landscapes with tors occur at Yowang Hill and Buckrabanyule. Elsewhere the granite is more deeply weathered than the enclosing contact metamorphic aureole of schist and hornfels, with the latter remaining as a resistant ridge. This occurs north



Hilly granite landscape with tors at Yowang Hill.

Strings of swamps aligned NNW--SSE on the south-western Wimmera plains between parallel ridges, showing the underlying influence of the Parilla Sand.

and north-east of Yowang Hill. The monadnocks of Palaeozoic rock at Charlton, Jeffcott, Wycheproof, and Mitre Rock are outliers of the Western Highlands.

Murray Basin Plains

Most of the study area falls within this physiographic division, comprising a number of distinct geomorphic forms, as discussed below. The chapter on geology discusses the origin of the various units more fully.

For the purposes of the remaining geomorphic description, the following brief comments will be of assistance. The land forms in this division are predominantly aeolian in nature and are relict features from the last major arid phase, which commenced about 30,000 years ago and culminated about 18,000 to 16,000 years ago. This phase coincided with the last major glacial maximum. Since that time the land forms have undergone little change, except where the activities of European man and drought have caused some reactivation of the dunes.

Ridged marine plains

A series of low sandstone ridges trend NNW--SSE across much of the study area. They represent successive coastline positions developed at the end of the Tertiary period, as the sea retreated in stages from the Murray Basin. They have a pervasive influence over the topography of the Wimmera. They have been the major controlling influence over the drainage systems passing through or terminating in the area, as well as the position of the major lake basins since late Tertiary times. Even where the ridges are not exposed, their presence often remains obvious, as the Quaternary cover generally mirrors the underlying form of the ridge.

Although large ones occur east of Kaniva and south of Kiata, elsewhere the ridges are more subdued. The upper surface of the sandstone is generally ferruginized and deep red-brown in colour. Often a thin cover of dune tops the sandstone ridges, having developed by wind erosion of the sandstone. In places the plain takes the form of a flat expanse of sandstone 'gibber plain'. This has occurred between Lake Buloke and Birchip in places where the action of water has scoured off the overlying cover.

Irregular sub-parabolic dunes

Two large fields of irregular siliceous sand dunes (Lowan Sand) extend into the study area from the west. The southern lobe takes in the Little Desert, while the northern one forms part of the Big Desert. Outside these two 'desert' areas, siliceous sands occur along the ridges of Parilla Sand where the sandstone has been reworked into dunes.

Within these areas a wide variety of forms are represented, with dune relief up to 30 m in places. Although generally irregular, the dunes do possess a degree of order reflecting the influence of the prevailing westerlies that formed them. In places the dune topography is flat and sheet-like.

Linear dunes

Low discontinuous dunes with a general west--east orientation (Woorinen Formation) cover much of the western and central parts of the study area. Further north, in the Mallee, the dunes have relatively straight regular forms, but in the Wimmera the dune form is subdued to sheet-like, and often indistinct or patchy.

West of Warracknabeal the dune field is relatively continuous, but east of the Yarriambiack Creek it begins to break up - varying between sheet-like areas such as around Nullan--Laen and Wilkur to patchy discrete dunes trending ENE--WSW, as at Banyena, south-west of Minyip, and at Rich Avon West, where the Richardson River has cut through the linear dune system. The dunes are typically less than 100 m wide, 200--2,000 m long and 3--10 m high.

In places the Woorinen Formation covers the Parilla Sand marine ridges. Where the form of the underlying Parilla Sand ridge is pronounced, the Woorinen Formation topography consists of closely spaced parallel west--east dune chains within a NNW--SSE trending dune ridge.

Lunettes

The occurrence of smooth crescent dunes, known as lunettes, on the eastern side of lake basins is well known in southern Australia, and this study area contains some excellent examples.

The lunettes record complex oscillations of hydrologic sequences varying through periods when deep and relatively fresh water concentrated clean quartz sands on the eastern beaches for contribution to the downwind dune, as has been the case for part of the history of lunette development at Lake Hindmarsh.

Later, during more saline conditions associated with drying, gypseous clay pellets were transported by saltation from exposed lake floors to provide the smooth surfaces most characteristic of the present form of most lunettes in the Wimmera.

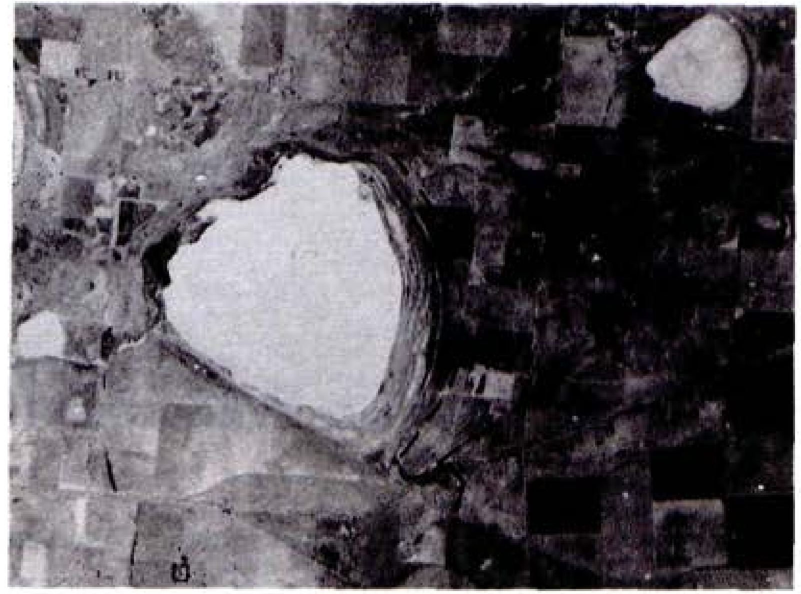
The size of the lunette generally bears a strong relation to the size of the basin from which its materials were derived. Thus, a small lake less than 1 km in diameter may have a lunette only a few metres high. Examples of this occur south of the Little Desert in corridors between Parilla sandstone ridges, between the Little and Big Deserts, north of Dimboola, and intermittently east of Warracknabeal. Elsewhere, on the larger basins at Lake Buloke and Lake Hindmarsh, the lunettes rise to 20 m and 60 m respectively above the lake floors.

The lunettes often consist of multiple units, reflecting successive stages of lake contractions from a period of extensive lakes and high stream discharges to a major arid period coinciding with the last glacial maximum. Multiple lunettes are well developed at both Lake Hindmarsh and Lake Buloke. The distance from the western boundary of Lake Buloke to its easternmost lunette is about 22 km, indicating the large extent of the former lakes.

To the north of the study area, stratigraphic analysis of lunettes has been particularly instructive in helping to demonstrate the complex palaeohydrologic history of south-eastern Australia during the Quaternary. Moreover, lunettes to the north of the study area have provided one of the richest sources of vertebrate remains and evidence of prehistoric man in southern Australia. To date the archaeological potential and the faunal content of the major lunettes in the Wimmera have not been assessed in any detail.

Alluvial plains

A number of broad areas of alluvium occur in the Wimmera and are referred to briefly in the section on drainage. Part of the riverine plain extends into the east of the area, east of Lake Buloke. The plain is channelled, particularly north of Glenloth, where the Avoca River splits into numerous small anabranches on its flood-plain. A



Lunette to the east of Mitre Lake.

similar anabranching situation exists along the drainage system feeding into Lake Marmal. A number of areas of thin sand sheet and individual source-bordering dunes also are located in this area adjacent to drainage lines.

Other major areas of alluvium are associated with the Richardson River, Wimmera River, and the drainage system south of the Little Desert. Between Yarriambiack Creek and Lake Buloke areas of alluvium and linear dune alternate rapidly with exposure of the underlying marine plain. This situation is simplified on the geomorphology map (Map 6), with the detail more fully displayed on the geology map (Map 5).

Typical saline depression in a narrow belt running south from Jeparit. This area is a zone of groundwater discharge with gypsum and salt precipitating in these depressions.

Lake floors

Lake basins have been represented on the geology and geomorphology maps where the presence of low-lying areas is defined by a relatively sharp break in slope on the western margin, representing an ancient or modern cliff line. At Lake Hindmarsh the cliff developed in sandstone on the western side is up to 4 m high, while the one at Lake Buloke is only 1--2 m high and less obvious. On their eastern sides such depressions are enclosed by the lunettes so characteristic of lake basins across southern Australia. The basins are typically smooth and elliptical, often kidney-shaped in outline, with the long axis oriented north--south or NNW--SSE.

All large basins are associated with drainage lines that contributed the waters so important in shaping their outlines. Lake Hindmarsh is part of the Wimmera River system, and Lake Buloke is the terminal point of the Richardson River.

As the Wimmera River flows into and out of Lake Hindmarsh the lake is fresh and permanent. A number of smaller lake basins in the Wimmera, such as Wooroonook Lakes, are permanently full, having been filled artificially and used as water storage basins.

Most of the small lakes in the area, however, are ephemeral, being filled seasonally by normal surface run-off or floods and then drying in the hotter months. The small lakes and depressions west of a line joining Duffholme and Netherby, for example provide groundwater recharge. By contrast, those running from Mitre northwards to Jeparit intersect the saline water table of the area. The latter are groundwater discharge lakes and points, and the saline conditions favour the precipitation of salt and gypsum.

Glossary

Anabranch	- a diverging branch flowing out of a main stream and later rejoining it further downstream
Aureole	- a zone surrounding an igneous intrusion in which the country rock shows the effects of contact metamorphism
Contact metamorphism	- alteration of existing rocks in contact with or near an igneous intrusion by heat
Effluent	- a surface stream that flows out of a lake, or a stream or branch that flows out of a larger stream
Ferruginous	- pertaining to or containing iron: said of a rock having a rusty colour due to the presence of ferric oxide; the quantity of iron does not have to be large, nor do all red rocks derive their colour from iron
Monadnock	- a hill of resistant rock rising conspicuously above the general level of a plain
Siliceous	- said of a rock containing abundant silica, especially free silica (SiO_2), the chemically resistant dioxide of silicon
Strandline	- in this study area a former shoreline now elevated above sea level

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8. CLIMATE

The general pattern of climate across the study area is one of gradation rather than fluctuation, as no major topographic variations occur that would cause marked climatic difference between nearby sites.

Temperatures are relatively uniform throughout the Wimmera, with a tendency for summers to be slightly warmer in the north and north-east. Average annual rainfall has a similar monthly distribution pattern throughout, but decreases from south-west to north-east across the study area.

An irregular succession of depressions ('lows') and anticyclones ('highs') brings the local weather, as is typical in most of southern Australia. These systems generally, although not always, move from west to east, but they can develop or degenerate within any area. Their speed varies and they can be almost stationary for a week or more.

The Wimmera typically has hot summers and mild winters with few frosts. The greater part of the annual precipitation occurs in winter and is of low intensity - most of the summer rainfall results from irregular thunderstorms with intense rain. Annual evaporation is high and greatly exceeds precipitation.

The Bureau of Meteorology undertakes measurement of the climatic elements at a network of stations throughout the area. It measures rainfall in a fairly intensive network, and temperature, wind, cloud, and visibility at five of the stations. Evaporation is measured at Birchip and Kaniva and at Longerenong Agricultural College, while pluviographs (chart-recording rain gauges) register rainfall amount and intensity at Charlton and Horsham. The study area does not contain any anemometers or sunshine recorders.

Data from the now-defunct Central Planning Authority's reports on the Wimmera and Loddon Regions have been used to tabulate the probabilities of receiving the 'effective' amount of rainfall. All other data come from the most recent records of the Bureau of Meteorology.

Rainfall

All of the effective precipitation in the area falls as rain and occasional hail. Altitudes are too low for snow to fall.

Table 5

RAINFALL

A = Mean rainfall in mm

B = Median rainfall in mm

C = Average number of raindays (a rainday is a day receiving 0.2 mm or more of precipitation other than frost, dew, or mist. It is taken as the 24 hours between 0900 hours on consecutive days.

Station & span of records		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Melbourne 1855--1983	A	48	48	53	58	58	50	48	50	59	68	59	58	657
	B	37	32	41	50	57	43	44	49	54	69	52	48	653
	C	8	7	9	12	14	14	15	16	15	14	12	10	146
Birchip 1898--1983	A	19	26	24	26	37	39	38	38	38	38	27	22	372
	B	12	13	13	19	34	37	35	36	31	30	21	14	371
	C	3	3	3	5	8	10	11	11	9	8	5	4	80
Charlton 1951--1983	A	32	27	28	37	44	39	42	50	45	44	31	20	439
	B	24	6	20	28	43	35	42	54	35	33	25	17	437
	C	5	3	5	6	10	10	12	12	10	9	6	5	93
Dimboola 1878--1983	A	22	25	23	31	42	46	43	44	42	41	31	24	414
	B	14	14	16	26	40	46	42	42	39	34	24	18	419
	C	3	3	4	6	9	11	13	12	10	9	6	5	91

Station & span of records		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Donald 1884--1983	A	22	27	26	30	41	42	39	43	41	41	29	24	406
	B	15	15	17	24	40	38	38	39	35	34	21	19	393
	C	3	3	4	6	8	10	12	11	9	8	5	4	85
Horsham 1873--1983	A	22	26	25	34	48	50	46	48	46	44	34	27	450
	B	14	16	18	27	45	46	47	47	43	36	28	20	440
	C	4	4	5	7	11	12	13	14	12	10	7	5	104
Jeparit 1898--1983	A	20	25	23	28	40	39	39	40	40	38	29	25	386
	B	14	13	16	22	40	39	39	37	36	34	22	16	401
	C	3	4	4	6	9	11	12	12	10	9	6	4	90
Kaniva 1883--1983	A	20	22	21	35	49	52	53	54	49	43	33	27	459
	B	14	13	13	28	42	51	49	54	47	41	32	21	465
	C	3	3	4	6	10	12	13	13	11	9	6	4	94
Longerenong Agricultural College 1860--1983	A	24	25	25	31	44	44	42	44	40	44	32	27	422
	B	16	13	21	22	40	42	40	44	36	38	24	21	414
	C	3	3	5	6	9	11	12	13	10	9	6	5	92
Nhill 1883--1983	A	22	23	23	31	41	47	46	47	43	41	31	27	422
	B	13	13	17	24	35	47	45	47	37	36	23	20	418
	C	4	4	4	7	10	12	13	14	12	10	7	5	102

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Station & span of records		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Warracknabeal 1883--1983	A	21	24	23	29	41	41	40	43	39	40	30	23	394
	B	12	13	17	20	40	41	40	39	36	35	26	17	391
	C	3	3	3	5	8	10	12	12	10	8	6	4	84

Source: Bureau of Meteorology

Note: Figures for Melbourne have been included for comparative purposes.

Annual average precipitation generally decreases from south-west to north-east across the study area, being lowest (350 mm) at Brim in the north and highest (>600 mm) in the far south-west adjacent to the South Australian border. As in many other parts of Australia, the precipitation varies considerably from year to year, with periodic droughts. Table 5 gives rainfall data for a number of stations, and Map 7 shows the regional isohyets.

Generally, more rain falls in winter than in summer, with the wetter months being May to October. Summer averages vary from 15 to 32 mm per month.

The low summer precipitation is not sufficient to maintain plant growth, because high summer temperatures result in high evapotranspiration and because much of the summer rain comes from occasional heavy showers of short duration. In addition, the rainfall tends to be more erratic in summer and autumn than in winter and spring.

Annual totals can vary markedly from year to year. In 1982, a drought year, the area received some 50--70% less than the annual average.

Temperature

Air temperature is measured in a Stevenson screen, which ensures unobstructed circulation of air and protection of the instruments from the direct rays of the sun. Mean daily temperature is calculated by averaging the daily minimum and maximum values. Temperature is an important factor in plant physiological processes and in influencing the evaporation rate.

Mean monthly long-term averages are remarkably even throughout the area. They range from 12°C minimum to 30°C maximum in summer and 4°C to 14°C in

Table 6

AVERAGE MAXIMUM AND MINIMUM DAILY TEMPERATURES

Station		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Melbourne	Max.	25.8	25.7	23.7	20.1	16.5	13.9	13.3	14.8	17.1	19.5	21.8	24.1	19.7
	Min.	14.0	14.3	12.9	10.5	8.4	6.7	5.7	6.4	7.7	9.3	10.9	12.7	10.0
Donald	Max.	29.9	30.1	26.0	21.6	16.9	13.8	13.2	14.7	16.8	20.6	24.4	27.6	21.3
	Min.	14.1	14.7	12.4	9.2	6.8	4.2	3.6	4.6	5.9	7.7	9.8	12.2	8.8
Horsham	Max.	29.8	29.8	26.4	21.4	17.1	13.9	13.3	15.0	17.7	20.9	24.8	27.8	21.5
	Min.	13.3	13.6	11.5	8.6	6.3	4.5	3.7	4.5	5.7	7.5	9.7	11.9	8.4
Longerenong Agricultural College	Max.	29.8	30.0	25.9	21.3	16.9	13.6	13.0	14.8	17.2	20.7	24.4	27.8	21.3
	Min.	12.8	13.2	10.6	8.0	5.8	3.9	3.1	4.0	5.0	6.8	8.8	11.3	7.8
Nhill	Max.	29.6	29.4	26.2	21.5	17.3	14.2	13.7	15.2	17.8	21.0	24.8	27.8	21.5
	Min.	12.9	13.2	11.0	8.3	6.1	4.2	3.4	4.1	5.5	7.2	9.4	11.6	8.1
Warracknabeal	Max.	30.5	30.8	26.7	22.0	17.6	14.3	14.0	15.6	17.7	21.4	25.3	28.8	22.1
	Min.	13.9	14.5	12.1	9.1	6.9	4.1	3.6	4.3	5.8	7.6	9.8	12.1	8.7

Source: Bureau of Meteorology

winter. In the two warmest months - January and February - the mean monthly maximum temperatures range from 29.4°C to 30.8°C, tending to be about 1°C higher in the north. By contrast, in the coolest month (July) they range between 13.0°C and 14.0°C.

All stations in the study area have, on occasions, experienced very hot days. All the Wimmera would have had summer temperatures greater than 45°C. The absolute record is Horsham's 49°C. Temperatures may exceed 38°C from October to the end of March. Generally these extremes correspond to a dry, turbulent, northerly or north-westerly wind.

Table 6 shows the average monthly and average annual maximum and minimum daily temperatures for the five meteorological stations recording temperatures in the study area, plus the figures for Melbourne to provide a comparison.

Frosts

The occurrence of frost depends not only on the temperature and the humidity of the air, wind speed, and cloud, but also on characteristics of the ground surface - the slope (and slopes of nearby surfaces), vegetative cover, and water content. Local topography can significantly influence its distribution. Hollows are particularly frost-prone, due to pooling of dense cold air, while slopes (where the flow of air is unimpeded) are much less susceptible to frost.

Frosts may be expected each year over most of the area, but their main occurrence is usually restricted to winter. Spring frosts may constitute a serious hazard to agriculture, and in some years a late frost may result in serious crop damage. Most of the Wimmera can expect to undergo 2--3 months of severe frosts and at least 6--7 frost-free months per year.

The first observed frosts (equivalent to a screen temperature of 2.2°C) occur on average in May throughout the study area, although variations occur from year to year. Most stations have experienced frosts as early as March.

Severe frosts (with screen temperatures of less than 0°C) start around June and may vary from none to 30 per year. In general the last severe frosts occur in August--September and the last light ones in October, but light frosts have been recorded as late as December at the Longerenong Agricultural College.

Table 7 lists the average number of occasions of screen temperatures of 0°C or less for the five meteorological recording stations. This clearly shows that, unlike average temperatures, frequency of frost is not determined mainly by latitude.

Sunshine

As no sunshine recorders have been installed in the study area, only the

Table 7

AVERAGE NUMBER OF SEVERE FROSTS
(Screen temperatures of 0°C or less)

Station	No. of years	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Donald	17	0	0	0	0	1	3	4	2	1	0	0	0	10.5
Horsham	27	0	0	0	0	0	3	3	1	0	0	0	0	7.7
Longerenong Agricultural College	19	0	0	0	0	0	4	3	2	1	0	0	0	10.2
Nhill	27	0	0	0	0	2	5	4	3	2	0	0	0	16.3
Warracknabeal	14	0	0	0	0	0	3	3	2	1	0	0	0	9.3

Source: **Bureau of Meteorology**

following estimates showing trends in monthly hours of sunshine can be given.

Jan.	Mar.	June	Oct.
315	265	145	235

Evaporation

The amount of evaporation from a standardized evaporimeter is determined by measuring the loss of water from an open-topped standardized tank and de-

Table 8

COMPARISON OF AVERAGE EVAPORATION AND AVERAGE RAINFALL

Month	Longerenong Agricultural College		Birchip	
	Evaporation (mm)	Rainfall (mm)	Evaporation (mm)	Rainfall (mm)
January	241	24	268	19
February	205	25	216	26
March	169	25	191	24
April	93	31	116	26
May	48	44	58	37
June	34	44	27	39
July	37	42	49	38
August	54	44	76	38
September	78	40	110	38
October	125	44	161	38
November	154	32	205	27
December	224	27	274	22
Annual totals	1,464	422	1,752	372

Source: Bureau of Meteorology

Note: Evaporation figures are unreliable and may be higher than indicated above.

pends on temperature, humidity, and wind speed.

Annual rates of evaporation greatly exceed rainfall on all open sites throughout the study area. These rates change from about 1,250 mm in the east and 1,400 mm in the south and west up to 1,800 mm in the north. The greatest monthly evaporation is in January - 240 mm in the south and 270 mm in the north.

Table 8 compares evaporation and rainfall for Longerenong Agricultural College in the south of the study area and for Birchip in the north, where rainfall is lower and summer temperatures are slightly higher.

Evaporation is an important factor in management of the Wimmera--Mallee Domestic and Stock Water Supply System. During summer, the evaporation is about ten times the average rainfall. During winter, however, the two totals approach equality. Average annual evaporation is usually three times the average rainfall in the south, but may be up to five times the rainfall in the north.

Wind

Wind data are available from five stations in the study area. However, these stations do not have anemometers for the accurate measurement of wind speeds. Wind speed is generally less than 20 km per hour, but in spring and summer a significant proportion of days have winds between 20 and 50 km per hour. Wind speeds greater than 50 km per hour have been recorded in the area. Wind direction tends to be from the south during spring and summer, but more westerly during autumn and winter.

Growing season

Plant growth depends collectively on soil conditions (drainage, aeration, nutrients, heat transference, depth, and texture) and climate (light, temperature, and rainfall). Variations in the length of the growing season are most often climatic in origin - with distribution of rainfall being a prime determinant. Indeed, 'effective rainfall' is often used as an indicator of the growing season.

Effective rainfall - based on both rainfall and evaporation - is defined as the amount necessary to start germination and to maintain growth above the wilting point of plants. The growing season is deemed to be the period during which rainfall has a better than 50% chance of exceeding the effective amount, plus a further period when water stored in the soil allows plant growth to continue. Irrigation and fallowing can also extend the length of the growing season - the former providing water in dry months, the latter conserving water in the soil.

Estimates of effective rainfall are useful for agricultural planning, but they do not necessarily indicate the effects

Table 9

PROBABILITY (%) OF RECEIVING RAINFALL EQUAL TO OR GREATER THAN THE 'EFFECTIVE' AMOUNT

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Birchip	2	12	17	26	57	85	85	77	54	34	18	9
Charlton	9	12	25	37	69	89	86	87	67	36	16	12
Dimboola	6	13	10	46	71	90	89	87	74	42	18	11
Donald	9	13	20	43	69	89	87	86	71	42	20	14
Goroke	7	16	12	58	85	94	100	94	93	67	27	20
Horsham	9	17	18	48	78	93	95	92	82	55	27	20
Jeparit	5	17	16	30	69	86	89	83	67	40	15	21
Kaniva	7	10	9	46	79	89	95	91	85	53	21	14
Nhill	7	16	13	43	71	88	93	91	80	46	17	14
Warracknabeal	7	14	13	33	72	88	87	88	67	39	16	12

Source: Central Planning Authority

of dry spells on deep-rooted perennial plants, and the reseeding ability of annual plants.

Table 9 lists the probabilities of the actual monthly rainfall equalling or exceeding the calculated effective rainfall at ten 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 the growing season in most of the study area usually lasts only 5 months, commencing in early May. The southern and western parts (such as Horsham and Kaniva) have an average growing season of 6 months, while Goroke in the far south-west - where rainfall is highest - has an average growing season of 7 months' duration.

Thus it is clear that throughout the study area lack of rain will severely restrict growth for substantial periods. Low winter temperatures may also affect it and interrupt the growing season.

Drought

Since climatic recording began, many dry spells have occurred throughout Victoria, and several have lasted long enough to be termed droughts.

In comparison with other areas of this State, the Wimmera has a very limited surface water resource. As would be expected, the probability of drought in the study area increases from south-west to north-east.

Over the years, droughts have had devastating effects on pastures, crops, soil stability, and water supply, but in this part of the State recurrent drought must be regarded as a normal feature of the environment.

Dust storms

Dust storms result from drought and widespread disturbance or removal of vegetation. The lack of plant cover and binding roots leaves the topsoil unprotected, so high winds blowing over dry country can lift dust at any time. This phenomenon is, however, most likely in summer, when turbulence (caused by strong surface heating) can pick up soil particles.

Once common in the Wimmera, dust storms now occur only rarely because of pasture

A dust storm in a Wimmera town in the 1930s.

improvement and better techniques of cultivation, fallowing, and soil conservation.

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9. WATER RESOURCES

The Wimmera is virtually devoid of any significant independent surface water supplies: the sources of rivers serving the area lie outside the study area boundaries. Rainfall in both the Pyrenees Ranges and the Grampians - which are the principal surface water sources - is much higher than on the plains that make up the Wimmera. All streams flow northward, finally discharging to inland lakes of varying salinity. Water reaching these lakes is eventually lost through evaporation.

Surface Water

Stream flow

The quantity of water that a catchment yields as stream flow is related firstly to the total annual precipitation, and secondly to the proportion of this precipitation that is lost as evaporation, transpiration (from plants growing in the catchment), and deep seepage.

Average annual rainfall in the Pyrenees and Grampians is as high as 900 mm, with a significant proportion available as run-off. In the study area itself, which predominantly comprises plains of aeolian or alluvial origin, run-off is slight and the bulk of water loss occurs through evaporation and deep seepage.

As a comparison, average annual run-off is 560 ML per sq. km from the Grampians (at Wartook Reservoir), but 34 ML and 44 ML per sq. km respectively for the Wimmera River at Horsham and the Richardson River at Carrs Plains.

The main streams in the study area are the Wimmera, Richardson, and Avoca Rivers. The Avoca drains the northern flank of the Pyrenees Ranges, and the Wimmera River drains the western flank of the Pyrenees and the eastern flank of the Grampians. While the main branch of the Richardson River drains an area north of Glenorchy in the foothills of the Pyrenees, its major tributary - the Avon River - carries off water from the north-western flank of the Ranges. Each of these streams discharges about 90% of its annual flow during the winter--spring period.

Effluent streams of the Wimmera River are the only others of any significance; the main ones, Dunmunkle and Yarriambiack Creeks, leave the Wimmera River at Glenorchy and east of Horsham respectively.

Table 10

STREAM CHARACTERISTICS

Stream	Gauging station	Catchment area (sq. km)	Mean annual discharge (ML)	Run-off (ML per sq. km)	Flow variability (ML per day)		Salinity (mg per L)	
					Max.	Min.	Max.	Min.
Wimmera River	Horsham	4,066	139,000	34	44,200	0	3,080	105
Richardson River	Carrs Plains	137	6,060	44	4,280	0	208	61
Avoca River	Coonooer Weir	2,668	84,000	31	39,500	0	7,970	112

Source: Rural Water Commission

Table 10 lists some of the characteristics of streams in the study area and Figure 2 shows graphically the seasonal stream-flow variations that occur.

Water quality

The quality of water is an essential criterion when deciding its suitability for various uses or as an environment for aquatic life.

The most important quality characteristic affecting local water suitability for domestic, stock, and irrigation use is salinity.

Salinity is measured as total dissolved solids (T.D.S.), with the upper limits per L being about 1,000 mg for domestic use, 1,000--1,500 mg for irrigation, and 7,000--16,000 mg for cattle and sheep. Table 11 indicates uses appropriate to various T.D.S. levels.

When streams are in flood, salinities fall because of dilution. Conversely, when stream flow is low, evaporation

Table 11

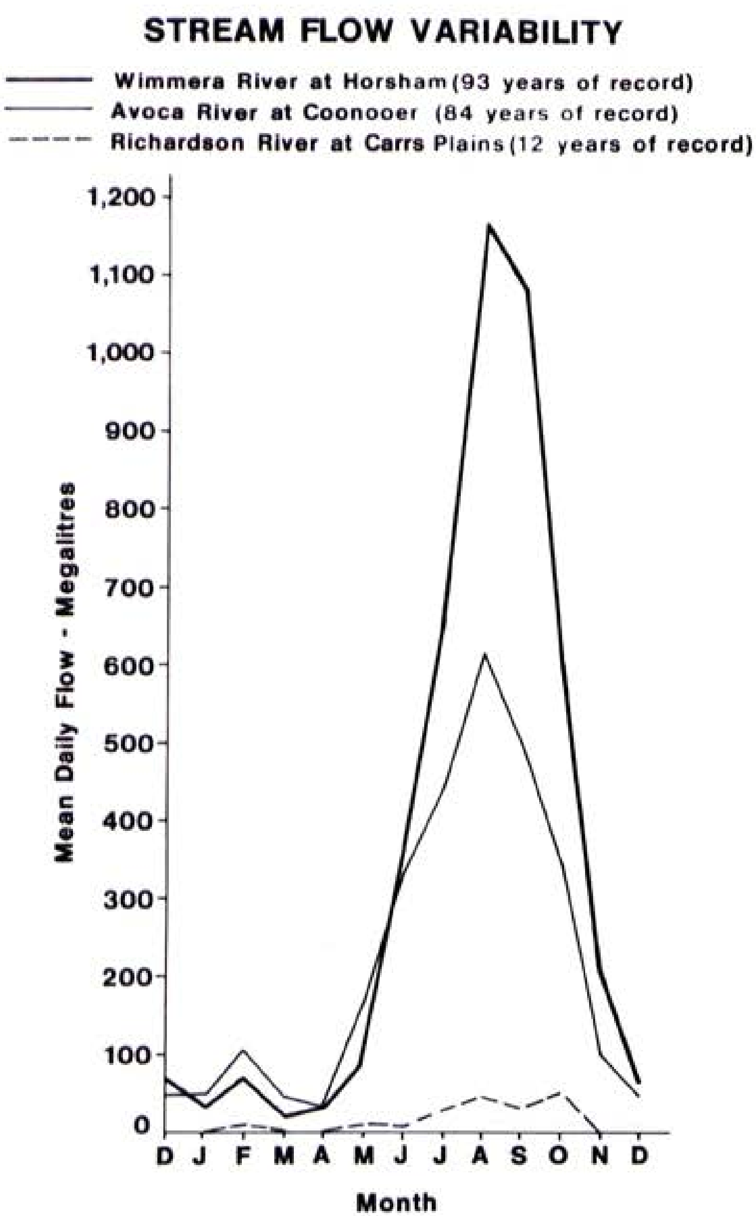
WATER SALINITY

Salinity (mg T.D.S. per L)	Usage
Less than 1,000	Commonly suitable for domestic and industrial use, and for livestock and irrigation. (The salinity of Melbourne's water is 100 mg per L; Adelaide's is 300 mg per L.)
1,000 -- 3,000	Brackish water. Maximum salinity humans can normally tolerate is around 2,000 mg per L. The threshold salinity for the growth of most plants is 3,000 mg per L. This water is suitable for all livestock, and some domestic and limited industrial uses. Use for irrigation is possible under favourable conditions.
3,000 -- 7,000	Increasingly brackish water. Suitable for most livestock (poultry - up to 3,500; pigs - up to 4,500; horses, ewes with lambs, and dairy cattle - up to 6,000 mg per L), but very limited for domestic and industrial purposes.
7,000 -- 16,000	Salty water. Beef cattle will tolerate up to 10,000 mg per L and sheep on saltbush can utilize water up to 14,000 mg per L - 16,000 mg per L is the maximum for sheep on green pastures.
More than 16,000	Unsuitable for livestock.
35,000	Sea water.

tends to increase the concentration of salt.

Water quality in the area varies between streams. The Wimmera River at Horsham has average T.D.S. levels of about 860 mg per L, while quality in the upper reaches of the Richardson River is very good, with levels between 60 mg and 210 mg per L.

Figure 2



Wimmera River

Approximately 2,000 sq. km of the Wimmera River's total catchment lies within the study area. It comprises the ancient coastal plains and the dune country adjacent to them. The river flows through these plains to Lake Hindmarsh and, in exceptionally wet periods, on to Lake Albacutya in the Mallee study area via Outlet Creek. Occasionally overflows from Lake Albacutya reach a series of lakes further north in the Wyperfeld National Park. Historical records indicate that last century these waters reached as far north as Wirrengren Plain about every 20 years, but they have not reached that far this century.

The Wimmera River near Antwerp.

Yarriambiack and Dunmunkle Creeks - the two major effluent streams of the Wimmera River - formerly discharged significant flows to the north during flood periods, but since regulation of the Wimmera River system these flows have also been reduced considerably.

The Wimmera River system is characterized by great variability and unreliability of stream flow. For example, annual discharge at Horsham has varied from a maximum of 570,000 ML in 1956 to a minimum of zero in 1944. This extreme natural variability makes it difficult to determine accurately what effects the construction of storages and diversions has had on the river system.

Reduction of natural stream flows in the Wimmera River system through consumptive water uses has also reduced the stream's capacity to assimilate waste inputs and so has added to the water quality problems. Water uses that suffer as a result of poor quality include domestic and stock consumption, swimming, boating, fishing, and passive enjoyment, and aquatic ecosystem protection.

Water-quality and related problems experienced in the catchment include high salinity, colour, and nutrient levels, depressed dissolved-oxygen levels, and nuisance aquatic weed growths. Factors contributing to these problems are mostly diffuse inputs such as leaching of saline soils, colour from the decay of plant matter, and nutrients in

Yarriambiack Creek is an effluent stream of the Wimmera River.

run-off from both dryland and irrigated agricultural areas.

The major point source of pollutants entering the river is the discharge from the City of Horsham's sewage-treatment works to the McKenzie River prior to its confluence with the Wimmera River 5 km downstream of Horsham. Components of this discharge causing most concern are the nutrients, in particular phosphorus, which contribute to the nuisance aquatic plant growths observed along the Wimmera River below Horsham.

While algal growths do not appear to be a major problem, macrophytes such as

Phragmites australis (common reed) have established extensive stands at a number of sites downstream as far as Lake Hindmarsh. Nuisance *Phragmites* stands occur to a lesser extent upstream of Horsham, as does the native fern azolla at less than nuisance levels.

Nuisance stands of Phragmites australis *along the Wimmera River upstream of Jeparit.*

Excessive aquatic plant production restricts access to the river and so interferes with recreational and other uses, while macrophyte stands can impede stream flow, resulting in siltation and flooding. Eventual decay of the plant matter results in depressed dissolved-oxygen levels, which degrade the river for aquatic ecosystems and many water supply and recreational uses.

A State Environment Protection Policy for the Wimmera River and its catchment is currently in preparation. It will address such issues as beneficial uses and factors affecting water quality. In particular, it will examine methods of reducing the impact of diffuse sources of pollution and the discharge of the City of Horsham's sewage-treatment works.

Avoca River

While the study area contains 1,300 sq. km of the Avoca River catchment, as with the Wimmera catchment it contributes very little run-off. It runs parallel to the eastern boundary of the area, and its flow varies similarly to that of the Wimmera as seen by the maximum annual flow of 408,000 ML in 1956, and a minimum of 428 ML in 1914. The T.D.S. level, however, averages 3,600 mg per L - considerably higher than that of the Wimmera. The Avoca River normally terminates in a series of marshes north-east of Quambatook near Kerang. Very high floods will, on filling the marshes, continue on to the Murray River via the Little Murray.

Richardson River

The Richardson River lies parallel to and almost mid way between the Wimmera and Avoca Rivers. Only part of its catchment lies within the study area. It rises in the alluvial plains north of Glenorchy and, like the other streams here, has a variable annual discharge, with water reaching its termination point in Lake Buloke only occasionally. Water quality in the upper reaches is very good, with a recorded variation in T.D.S. between 60 and 210 mg per L.

Natural lakes and swamps

Table 12 lists the major natural lakes and swamps here, and gives an indication of their water quality and approximate surface area. Many of them are located on the south-western Wimmera plains between Horsham and the South Australian border. The larger lakes only dry up during extremely severe droughts, while the smaller swamps are more often dry.

The Avoca River at Coonooer Bridge.

Table 12

NATURAL LAKES AND SWAMPS

Name	Salinity (F : fresh) (S : salty)	Location	Approx. area (ha)
Lake Hindmarsh	F	5 km NW of Jeparit	13,500
Lake Buloke	F	7 km N of Donald	5,500
Lake Wyn Wyn	S	8 km N of Natimuk	750
Mitre Lake	S	10 km NW of Natimuk	530
Unnamed lake	S	11 km N of Natimuk	380

Table 12 (continued)

Name	Salinity (F : fresh) (S : salty)	Location	Approx. area (ha)
Lake Natimuk	F	4 km N of Natimuk	270
Peechember Swamp	F	23 km NE of Kaniva	220
Wooroonook Lakes	F	13 km W of Charlton	210
Nhill Swamp	F	1 km S of Nhill	190
Minimay Swamp	F	27 km W of Goroke	160
Darlot Swamp	F	10 km W of Murtoa	160
Bunyip Swamp	F	16 km NE of Kaniva	140
Little Lake Buloke	F	6 km NW of Donald	120
Yanac Swamp	F	25 km NW of Nhill	110
Lock Iel (Pink Lake)	S	8 km NW of Dimboola	90
Merwyn Swamp	F	16 km E of Kanica	80
Yarrackigarra Swamp	F	21 km W of Goroke	80
Red Gum Swamp	F	27 km N of Kaniva	80
Mortat Swamp	F	8 km W of Goroke	70
Lake Perin	F	39 km W of Goroke	50
Lake Lawloit	F	20 km SW of Nhill	50
Reedy Swamp	F	9 km S of Dimboola	30
Boyeo Swamp	F	16 km NW of Nhill	30
Lake Marma	F	Murtoa	15
Lake Watchem	F	2 km W of Watchem	15

Groundwater

This section on groundwater contains a number of technical terms that are explained in the glossary at the end of this chapter. It should be read in conjunction with the groundwater resources map (Map 8) at the rear of the report.

Most of the water in any region occurs below the surface as groundwater. The water table in the Wimmera area lies at depths of 0--35 m beneath the land surface, and beneath the water table the rocks are saturated. Usefulness of this groundwater to man depends on its salinity and on the volumes that can be extracted, which in turn depend on the rocks in which it occurs. If a body of rock is porous (that is, it can hold a lot of water) and permeable (that is, water flows through it easily), then the rock body or formation can be utilized for its water if the salinity of the groundwater is satisfactory. Such a body of rock is called an aquifer.

In the Wimmera the aquifers that have value for groundwater are sediments of Cainozoic age, and are either confined or unconfined. The groundwater in these sediments has originated in two ways - from rain-water seeping down through the sediments, and from sea water trapped in them when they were deposited. The quality of groundwater in those aquifers varies - from water fit for drinking to waters with salinities similar to that of sea water.

Regional groundwater variations

The best-quality groundwater and the highest yields occur in the western part of the Wimmera, due to the favourable combination of a principal groundwater recharge area and underlying limestone at shallow depth. Generally poorer-quality groundwater occurs elsewhere in the Wimmera study area.

Western section

The most extensive area of good-quality groundwater is found west of a north--south line joining Lake Hindmarsh and Mitre Lake (see Map 8). Here, usable groundwater occurs within three aquifer systems: a deep confined aquifer system, which consists of the lower units of the Cainozoic sequence (Renmark Group); a semi-confined aquifer (Duddo Limestone); and an unconfined aquifer (Parilla Sand) comprising the Upper Cainozoic sediments.

Recharge of the unconfined and semi-confined aquifers takes place by vertical infiltration of a proportion of the rainfall, by lateral throughflow of groundwater within the aquifer, and by upward leakage from the confined aquifer in some parts. Recharge of the confined aquifer occurs mainly by lateral throughflow of groundwater within the aquifer and, in some areas, by downward leakage from the unconfined aquifer.

Groundwater in all aquifers moves to the north and west, and in the Mallee and in South Australia the groundwater in the unconfined aquifer, and to a lesser extent the confined, is extensively used.

Central and eastern section

East of a line joining Lake Hindmarsh with Mitre Lake, groundwater quality - with a number of minor exceptions - suddenly deteriorates. One of the reasons for this deterioration is a change in the subsurface geology. The Duddo Limestone in the west has good porosity and has been well flushed out by the infiltration of rain-water. To the east the limestone grades into marl and silt of the Winnambool Formation, which has low permeability and still contains saline water.

The high salinity of groundwater beneath the plains east of Gerang Gerung is due to the combination of low local rainfall, capillary rise of water during the summer, high evaporation rate, low permeability of the sediments, and finally the consequent slow sub-surface water movement that has given little chance for the connate salts to be flushed out. The composition of these groundwaters shows a similarity to sea water. The water table ranges in depth from 0 to 35 m and is related to the topography - being deepest beneath sandstone ridges and shallowest beneath depressions. The topography and under-lying geology can also result in perched water tables.

Running south from Lake Hindmarsh, saline groundwaters lie close to the surface. In depressions the groundwater is a metre or so beneath the surface and when it is drawn to the surface in hot weather by capillary action - fractional crystallization of gypsum ($CaSO_4$) occurs. North-east of Mitre, a number of groundwater discharge lakes occur and in dry period salt (NaCl) precipitates around the edges of the lakes as they contract due to evaporation.

Aquifer and groundwater characteristics

The characteristics of aquifers and groundwater in the Wimmera area are described below and summarized in Table 13. The potential uses of groundwater of various qualities can be determined from the legend on Map 8. The relatively low density of bores providing groundwater data in the study area permits only general comments to be made on the resource, particularly in the central and eastern part of the area. Where drilling has detected local variations in the regional groundwater quality, these will be discussed briefly.

Wunghnu Group

A substantial stretch of Wunghnu Group sediments occurs in the study area east of Lake Buloke and south of Murtoa. These Quaternary fluvial and lacustrine sediments consist of sand, gravel, and clay and are characterized by rapid changes in lithology.

Table 13

AQUIFER AND GROUNDWATER CHARACTERISTICS

Aquifer	Depth intersected (m)	Thickness (m)	Salinity (mg T.D.S. per L)	Yield (L per sec.)	Comments
Alluvial sediments (Wunghnu Group)	0	0--60	300--10,000	<20	Low salinities in shoestring sands in the far east
Parilla Sand	0--60	60--100	600--15,000	<1.5	In west salinities are low, reflecting that of the underlying limestone, but yields are also low
Calivil Sand	~70	25	~7,000	20--60	Restricted occurrence close to highlands
Winnambool Formation	60--70	20--40	5,000--30,000	<10	Occurs only in east of study area
Duddo Limestone	45--120	30--90	600--3,500	>10	Major aquifer occurring only in west of study area; it has high potential
Renmark Group	70--220	60--160	1,000--4,000	<20	Deep and rarely tapped; higher salinities in east
Palaeozoic bedrock	0--400	basement	up to 25,000	<0.5	Low salinities in granite springs

Source: Department of Minerals and Energy

The youngest unit within this Group, the Coonambidgal Formation, refers broadly to deposits of existing streams and is usually represented by less than 10 m of sediment.

The bulk of the Wunghnu Group consists of the older Shepparton Formation, which is up to 50 m thick in the study area. The available data suggests that groundwater salinity as total dissolved solids (T.D.S.) ranges from 300 to 10,000 milligrams per litre (mg per L) in this unit, increasing generally away from the highland front.

In places, shallow bores in the Shepparton Formation will yield good-quality groundwater. Close to the highland front narrow sinuous sand aquifers (shoestring sands) - representing defunct leveed stream courses - contain groundwaters with salinities down to 300 mg per L. At Teddywaddy a series of shallow bores ranging in depth from 3.3 to 5.8 m yield groundwater with salinities of 330 to 1,075 mg per L. These are associated with either a series of dunes in the area or a shoestring sand in the Shepparton Formation.

In a number of places in the study area the surface stream system appears to recharge the regional groundwater system and the flushing effect in limited areas produces lower-salinity groundwater. This phenomenon has been detected at Werrigar, adjacent to Yarriambiack Creek, where shallow groundwaters contain 700 mg T.D.S. per L. It also occurs in a belt running north of Teddywaddy where the Avoca River is losing water, and the resulting flushing effect is seen in groundwater salinities of 1,000--4,000 mg per L from both the Wunghnu Group and the Parilla Sand.

Parilla Sand

The Parilla Sand is an unconfined aquifer that outcrops or lies beneath a cover of Quaternary deposits throughout the study area. The unit is up to 100 m thick and is only deeply buried (up to 60 m) in the areas described above under the Wunghnu Group.

On average, groundwater salinity in the Parilla Sand increases from west ot east. In the west the salinity is generally less than 3,000 mg T.D.S. per L, and may be as low as 600 mg beneath the Little Desert. To the east, recorded groundwater salinities increase from 3,100 mg per L at Arapiles and 7,000 mg at Horsham to an average of around 15,000 mg per L further east. Influent seepage from streams may account for local quality improvement in the groundwater in this aquifer.

Particularly in the west of the study area, the Parilla Sand has provided valuable stock and domestic groundwater supplies in the past. However, the small yields available from this source - generally less than 1.2 L per sec. - make it of limited current and future value compared with the deeper aquifers in the west.

Duddo Limestone

This semi-confined aquifer of Bryozoan limestone forms a continuous unit throughout most of the western part of the study area.

Beneath a thin, continuous, semi-confining unit of marl and clay, the limestone is intersected at depths of 45--60 m beneath the Little Desert and at depths of up to 125 m to the north. The quality of the groundwater is generally good, with the total dissolved solids varying from 600 to 3,500 mg per L, and invariably less than 1,000 mg per L beneath most of the Little Desert.

The limestone varies in thickness from about 90 m in the western part of the Little Desert, with groundwater yields of about 50 L per sec., to less than 30 m in the eastern part, where yields fall to less than 6.5 L per sec. To the south of the Little Desert yields also decline to around 7.5 L per sec. as the unit thins.

The Duddo Limestone is the principal aquifer in the study area and does not require special methods of development. It can yield water in sufficient quantities for irrigation, except for an area to the east and north-east of Gymbowen, where smaller yields and greater draw-down would make irrigation unfeasible.

Winnambool Formation/Geera Clay

As noted previously, east of a line running from Lake Hindmarsh to Mitre Lake the Duddo Limestone changes laterally into marl and silt of the Winnambool Formation, which further east wedges out to reveal the underlying Geera Clay. A corresponding rapid deterioration in groundwater quality occurs to the east, with groundwater salinity ranging from 5,000 mg to 30,000 mg per L. Limited bore information suggests that yields are generally less than 10 L per sec.

Calivil Sand

Deeply buried ancient river-bed deposits known as the Calivil Sand contain good-quality groundwater close to the highlands, but salinities increase to the north. Where they pass into the study area near Horsham, Marma, and Narre-willock, high yields can be obtained, but salinities are also relatively high, ranging up to 7,000 mg T.D.S. per L.

Renmark Group

The Renmark Group consists of up to 160 m of brown coal, clay, silt, and sand, and occurs as the basal unit of the Cainozoic sequence. Only a few bores have penetrated the deep confined aquifer of the Renmark Group at depths ranging from 70 to 220 m. Development of this aquifer has been negligible, due to the high cost of drilling, and increased pumping costs to the greater depths.

In the west the groundwater salinity in the Renmark Group is usually less than 1,500 mg per L. Generally yields are of the order of 5 to 20 L per sec. However, south of the Little Desert at Gymbowen, yields from this unit are considerably less and may be as low as 1.5 L per sec.

To the east, where the Renmark Group underlies the Winnambool Formation/Geera Clay/Parilla Sand, available analyses suggest that poor-quality groundwater from these overlying aquifers is moving through into the Renmark Group aquifer system. In places the unit does hold some prospect as a source of fair-quality groundwater. At Jung, just west of Murtoa, these sediments occur at a depth of 75 to 130 m and contain groundwater with a salinity of about 4,000 mg per L.

Palaeozoic bedrock

The entire study area overlies Palaeozoic sedimentary, igneous, and metamorphic rocks that only outcrop in the east, with one very small exception south of Mitre Lake.

Elsewhere the Palaeozoic bedrock is buried beneath Cainozoic sediments up to 400 m thick (for example, at Netherby in the north-west). The Palaeozoic rocks are generally poor aquifers due to their low porosity and storage capacity and their high groundwater salinities.

Outcrops of Palaeozoic rocks in the east generally contain very saline groundwater with up to 25,000 mg T.D.S. per L, and yields are invariably low (~.5 L per sec). One exception occurs in undulating granite country at Yowang Hill, near Coonooer Bridge. Permanent springs emanating from joints in the granite supply high-quality groundwater with a salinity range of 90 to 700 mg per L. Yields are limited, and average 0.8--0.9 L per sec. The only other granite with any relief in the study area is at Buckrabanyule, but no information is available on groundwater in these rocks.

Glossary

Bryozoan	-	an invertebrate of the phylum Bryozoa and characterized chiefly by colonial growth and a calcareous skeleton, stratigraphic range is Ordovician to present
Confined aquifer	-	an aquifer bounded above and below by beds of distinctly lower permeability than that of the aquifer itself
Connate salt	-	salt dissolved in water entrapped in the interstices of sedimentary rocks at the time of deposition

Fluvial - the results of river action

Leveed stream course - the elevated strip of land upon which a river flows; produced by the building up of the stream bed and the natural levees on each side

Lithology - the physical character of a rock

Perched water table - the water table of a body of groundwater separated from an underlying main body of groundwater by an unsaturated zone

Screen - used in unconsolidated formations to stabilize bore holes: the screen allows water into the bore and keeps sand out

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10. SOILS

Soils are formed through the interaction of processes that weather the rock or unconsolidated material near the earth's surface. The chemical and physical nature of the parent material together with climate and topography influence the nutrient status, structure, and water relations of the soils as well as their susceptibility to erosion and other processes of soil deterioration.

The Department of Agriculture has carried out extensive soil surveys of the whole of the Wimmera study area, and has conducted detailed work on the Kalkee Plains. In addition, the Soil Conservation Authority has carried out detailed soil surveys in the Shire of Kowree and the catchment of the Avoca River. These surveys form the basis for the following descriptions of the predominant soil types.

Throughout this chapter, the general occurrence of each soil type is related to the appropriate land zone(s) and is indicated in the text by the land zone symbol, DS1, LL2, etc. (see Chapter 13 and Map 10). The glossary at the end of this chapter explains the meanings of many of the technical terms used.

In this report, soils are discussed in broad classifications using the system of Northcote (1979), which relies mainly on the morphology of the soil profile. Only the dominant soils known to occur within major land zones are discussed.

Three primary profile forms occur in the study area.

Uniform soils have profiles showing small, if any, texture differences throughout, such that no clearly defined texture boundaries are to be found within the solum.

Gradational soils have profiles showing increasingly finer (more clayey) texture grades with depth, such that the texture of each successive horizon passes gradually from the one above to the one below.

Duplex soils have profiles showing a sudden increase in the clay content of subsoils - that is, a marked texture change between the A and B horizons.

Additional features such as colour and structure are also considered in the classification (see Table 14).

Land use

Because land use is intimately associated with soils, the attributes and limitations of the soils in the study area will be discussed in this chapter.

Uniform-textured Soils

Bleached sands with a coloured B horizon

Dark grey surface sands with a strongly bleached A2 and a coloured sandy B horizon are common on the undulating sand plains of the Little Desert (DS2) and the Big Desert (DS1), on the ridges

A uniform sandy soil in the Big Desert (DS1).

near Lawloit (DS3), and on some lunettes near Lake Hindmarsh (LL2).

Coarser sands with a non-bleached A2 horizon occur on the steep granite outcrops (HG) to the east of the Avoca River.

All these soils are highly permeable and acidic throughout the profile. Inherent fertility is very low. The profiles are freely drained and have low salt contents and low water-holding capacities. Their non-coherent sandy nature and droughty condition make them very susceptible to wind erosion, particularly in exposed conditions where the protective vegetative cover has been removed by clearing, cultivation, fire, or overgrazing. Large areas remain under native vegetation.

Shallow stony loams

The shallow stony loam soils are restricted to the eastern portion of the study area on the metamorphosed Ordovician sediments (HS) near Charlton. Their low water-holding capacity and shallow depth make them highly susceptible to sheet erosion where permanent ground cover is not maintained.

Grey self-mulching cracking clays

Grey self-mulching light to medium clay topsoils overlie deep, cracking, medium or heavy clays. Topsoils are moderately hard when dry, friable when moist, but sticky when wet. The profile is usually calcareous throughout and becomes strongly alkaline with depth. Concentration of soluble salts increases down the profile.

These soils predominate on the extensive plains (Pa2) from Lake Buloke through Warracknabeal to Dimboola. However, they also occur in the low-lying areas such as swales, depressions, and river flats in many other parts of the study area (P1, P2, Pa1, Pa3, Pa4, Paa, LL1, and LL2).

Grey cracking clays are extensively cropped for cereals and support many legumes and oilseed crops. Sown pastures are usually successfully established on these soils. Their inherent fertility is moderate to high, although phosphorus is usually limiting and nitrogen becomes limiting with extensive cropping.

Table

MAIN SOIL GROUPS OF

Primary profile form	Soil type	Northcote class
I. Uniform-textured soils	Bleached sands with a coloured B horizon	Uc2.2, Uc4.3
	Shallow stony loams	Um5.41
	Grey self-mulching cracking clays (sometimes with brown and red-brown crack-clays (Ug5.3)	Ug5.2

Seasonal cracking is a characteristic of these clays as they shrink with declining moisture content. The deep cracks promote soil moisture evaporation, bury topsoil material, and protect pests such as crickets and mice. Swelling and shrinking cause problems in constructing power lines, pipelines, and foundations for roads, buildings, and other structures. When dry, these clay soils are well aerated and permeable to water. However, upon wetting, the clays expand, thereby reducing macro-porosity and permeability to minimum values.

Intermingled with the grey clays - and similar in many respects - are the brown and red-brown cracking clays on the slightly higher areas of the plain. Gilgai formations are usually absent, but the subsoils usually have a high soluble salt content. Topsoils are more dispersible and prone to forming a surface seal.

14

THE WIMMERA AREA

Equivalent names[1]	Parent material	Land zone[2]
Podzols, siliceous sands	Quaternary aeolian deposits	DS1,2,3; LL2
	Devonian granite and granodiorite	HG
	Quaternary aeolian deposits and Tertiary marine sandstone	Paa (minor)
Lithosols	Metamorphosed Ordovician sediments	HS
Grey and brown clays	Quaternary aeolian deposits and Tertiary marine sandstone	Pa1,2,3,4
	Quaternary alluvium	P1,2; Pa4; LL1,2
	Quaternary aeolian deposits and alluvium	Paa

Table 14 (continued)

Primary profile form	Soil type	Northcote class
II. Gradational soils	Calcareous earths	Gc 1.1
III. Duplex soils	Hard pedal red duplex soils	Dr2.13--Dr2.43
	Hard pedal mottled yellow duplex soils	Dy3.42, Dy3.43
	Sandy pedal mottled yellow duplex soils	Dy5.41, Dy5.42, Dy5.43

Notes: 1. According to the classification of Stace *et al.* (1960)

2. For explanation of land zone symbols, see Chapter 13 and Map 10.

Equivalent names[1]	Parent material	Land zone[2]
Solonized brown soils	Quaternary aeolian deposits	Pa 2,3,4; LL2
Red-brown earths, solodized solonetz, and solodic soils	Quaternary aeolian deposits	Pa1; LL1
	Metamorphosed Ordovician sediments	HS
	Outwash derived from sedimentary rocks	AS
	Outwash derived from granitic rocks	AG
	Quaternary aeolian deposits and alluvium	Paa
	Quaternary alluvium	Pl
Yellow podzolic soils, solodized solonetz, and solodic soils	Quaternary alluvium and aeolian deposits	Pa1,4; Paa
Yellow podzolic soils, solodized solonetz, and solodic soils	Quaternary aeolian deposits and Tertiary marine sandstone	DS2,3
	Quaternary aeolian deposits	DS1; Pa1,3; Paa

Gradational Soils

Calcareous earths

Grey-brown to red-brown loamy topsoils that are soft when dry and friable when moist overlie brown clays that are weakly structured and calcareous. These soils occur on the undulating plains north and south of Dimboola (Pa3, Pa4), in the Wilkur area north-east of Warracknabeal (Pa2), and on the lunettes (LL2) associated with Lake Hindmarsh.

Topsoils tend to be soft and permeable, with satisfactory available water capacity. Inherent fertility is low to moderate, but can be significantly improved with additions of phosphorus, nitrogen, and possibly zinc. These soils are widely used for grazing, mixed farming, and some irrigated crops. Salt contents are usually moderate to high in the subsoils and, where seepage occurs, soil salting may develop, particularly under irrigation. The fine loose topsoil is prone to wind erosion and prevention is based on maintaining ground cover, supplemented by preparing rough surfaces during cultivation.

Duplex Soils

Hard pedal red duplex soils

The grey-brown to reddish-brown sandy loam topsoils are weakly structured and hard-setting. A2 horizons commonly occur, and they may be bleached. The red-brown, medium--heavy clay subsoil has a coarse blocky structure; it is often very hard when dry and may contain mottles at depth. Soil permeability, however, is generally low - as reflected by the conspicuously bleached A2 horizon. Carbonate occurs in the subsoil, giving an alkaline soil-reaction trend.

These soils predominate on the gentle slopes and low crests of NNW--SSE ridges (Pa1) west of the Wimmera River, on the gentle slopes (HS, AS, AG) and alluvium (P1) to the north, south, and east of Charlton, and on the lunettes (LL1) associated with Lake Buloke. They assume a sub-dominant role in most other parts of the region.

They have low to moderate inherent fertility, and crops or pastures respond well to fertilizers. The subsoils have a high soluble salt content, which is related to the low permeability of the profile.

The weakly structured topsoils pose management problems, particularly when regularly cultivated. Rain on bare or sparsely vegetated surfaces promotes surface sealing and compaction, thereby reducing germination. Gypsum is an effective ameliorant.

Cultivated topsoils are extremely susceptible to sheet erosion by wind and water, while the sodic subsoils often develop tunnels and gullies when run-off is channelled into drainage depressions. These soils are used extensively for cereal cropping, but volunteer and improved pastures support large numbers of sheep.

Hard pedal mottled yellow duplex soils

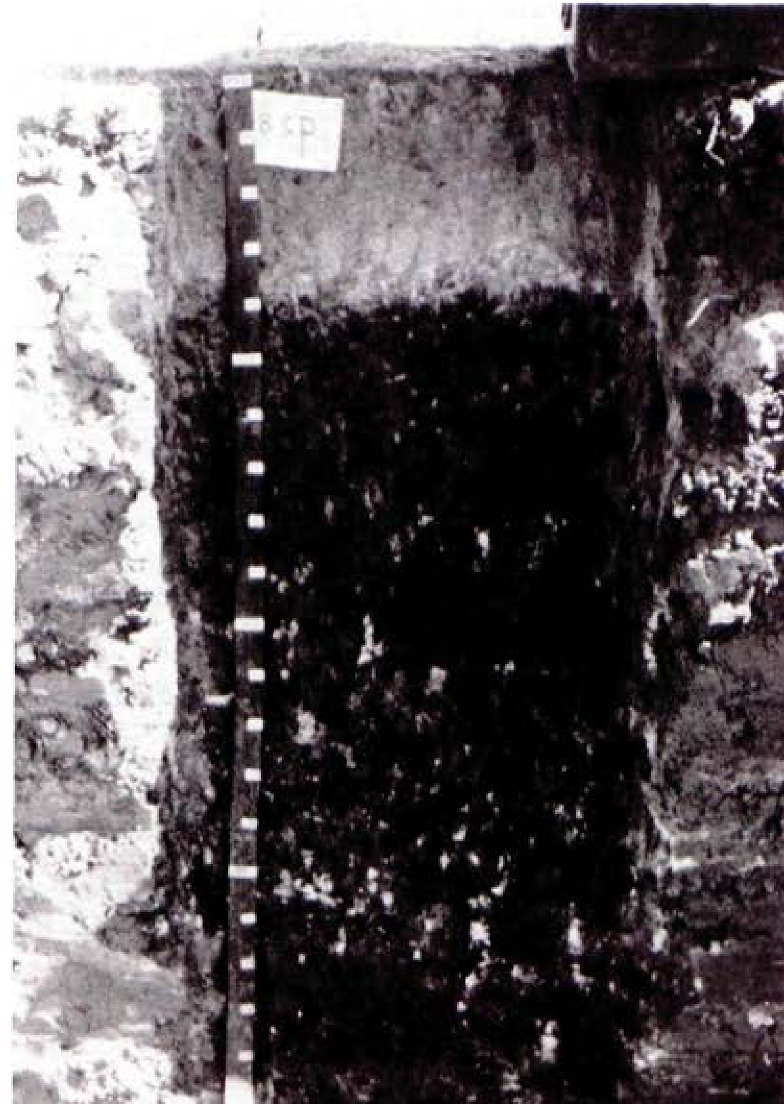
The grey-brown sandy loam topsoils are weakly structured and hard-setting. They overlie a structureless, conspicuously bleached A2 horizon containing varying amounts of ironstone and a B horizon of mottled sodic, heavy clay with a strong columnar structure. Shallower profiles may be acid throughout, but the more common deeper soils tend to have neutral to alkaline subsoils.

These soils occur in the poorer drained parts of the undulating plains (Pa1) north of the Little Desert and in the Horsham--Goroke area (Pa4, Paa). Specific features, such as hard-setting A horizons, dense sodic subsoils, low inherent fertility, low permeability, and seasonal waterlogging make them hard to manage and relatively unproductive.

Agriculture is generally confined to sheep grazing on native or sown pastures and some cropping in the drier areas. Sheet and gully erosion reflect the instability of topsoil and subsoil.

Sandy pedal yellow duplex soils

The topsoils are loamy sands that do not set hard, and the conspicuously bleached



A red calcareous sodic duplex soil - typical of the Avoca flood plain (P1), outwash aprons (AS and AG), and some gentle rises in the west (Pa1).

A2 horizons overlie strongly mottled sodic sandy clays. Subsoil structure is strongly blocky and large columns are common. Visible carbonate may occur in the deep subsoil and ironstone gravel is common at the interface between the A and B horizons.

These soils commonly occur in association with uniform sand soils in the Big Desert (DS1) and Little Desert (DS2), and on NNW--SSE ridges north and south of the Little Desert (DS3, Pa1, Paa). The low inherent fertility, the sodic dense nature of the subsoils, and the low water availability severely restrict agricultural use.

The loose topsoils are prone to both wind and water erosion, particularly on exposed ridges and lunettes, while the dispersible subsoils will readily form gullies.

Cattle and sheep grazing on native and improved pastures are the main forms of land use on areas cleared of the native scrub vegetation.

Glossary

Gilgai - the presence of a regular pattern of small-scale surface undulations comprising hummocks and hollows - also known as 'melon-hole' or 'crab-hole'

Macro-porosity - a measure of the abundance of large spaces between soil particles: in a freely drained soil these spaces, such as worm channels, are full of air

Pedal - containing peds (natural soil aggregates)

Sodic - containing greater than 5% exchangeable sodium in the subsoil horizon/s

Solum - that part of the soil profile that is influenced by current soil processes

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11. VEGETATION

The natural vegetation of an area is determined largely by the physical factors of the site - climate, aspect, topography, and soils and their parent materials. The variation between plant communities can most often be explained in terms of changes in one or more of these factors. However, both the structure and content of plant communities can also be influenced by factors such as logging, fire, and grazing. The last two are particularly important in determining the characteristics of the understorey.

Originally the Wimmera plains were covered by woodlands of yellow gum, bull-oak, black box, and grey box, with large areas of natural grassland occurring between these woodlands. The northern Wimmera plains carried mallee vegetation that was typical of areas further to the north. Since European settlement, practically all the native grassland has been developed for agriculture. Most of the woodlands have also been cleared for agriculture, with only small (mostly altered) areas remaining, usually on public land.

The Little Desert contains a varied and very rich native flora - most of which remains in a natural or semi-natural condition, despite the grazing, burning, and roading activities of European man over the past century. Vegetation formations found in the Little Desert include brown stringybark woodlands and open scrub, heaths, and mallee--broom-bush. Stands of yellow gum grow in interdune depressions and may reach considerable heights.

Importance of Vegetation

Natural vegetation is particularly important when considering possible uses of land. It integrates, and quite sensitively reflects, subtle changes in environmental factors. For this reason - and because its main components can be readily seen and mapped in the field, or from aerial photographs - it provides a very convenient way of assessing site factors that, by themselves, would be hard to measure directly.

Moreover, the vegetation itself often provides for many of man's needs such as timber and recreation, protects other values such as soil stability and water quality and yield, provides habitats for animals, and makes an important aesthetic contribution to the landscape.

Table 15

STRUCTURAL FORMATIONS
[Modified from Specht (1970)]

Life form and height of tallest stratum*		Projective foliage cover of tallest stratum			
		Dense (70--100%)	Mid-dense (30--70%)	Sparse (10--30%)	Very sparse (10%)
**Trees	28--40 m		Open forest III	Woodland III	Open woodland
	15--28 m		Open forest II	Woodland II	Open woodland
	5--15 m	Low closed forest	Open forest I	Woodland I	Open woodland
**Shrubs	2--8 m	Closed scrub	Open scrub	Tall shrubland	Tall open shrubland
	0--2 m	Closed heath	Open heath	Low shrubland	Low open shrubland
Grasses	0--2 m		Grassland		

* Isolated trees (emergents) may project from the canopy of some communities. Heights are of mature communities.

** A tree is defined as a woody plant more than 5 m tall, usually with a single stem. A shrub is a woody plant less than 8 m tall, frequently with many stems arising at or near the base.

Classification and Mapping

Vegetation on public land in the Wimmera area has been classified into units according to the commonly occurring dominant tree or shrub species. This floristic framework of dominant species includes a number of structural forms, based on the height and form of the tallest stratum, and on the percentage projective foliage cover (see Table 15). It should be noted that the vegetation units are not the result of detailed study of species associations, but are determined by interpretation of aerial photographs and field inspections. They are, however, readily recognizable in the field.

The mostly closely related units have been loosely grouped into ten alliances, listed in Table 16, named after the most characteristic dominant species. For example, the gum--box--bull-oak alliance comprises eight related floristic units (2a to 2h).

Map 9 shows the distribution of these vegetation units. It should be emphasized that many small vegetation units have been combined with adjacent larger units because of difficulties of scale. Also depicted on the vegetation map are eucalypt plantations and areas of cleared public land.

Vegetation Units

The main vegetation units are set out in Table 16 and briefly described below.

River Red Gum

The river red gum alliance contains one unit of open forest II--woodland II that is regularly flooded, one unit of woodland II that grows on deep sands where flooding does not occur, and a unit of woodland I, each of which has river red gum as the dominant species of the tallest stratum.

Riparian open forest II of river red gum in a seasonally flooded billabong on the Wimmera River near Antwerp.

Open forest II--Woodland II (Unit 1a)

Unit 1a forms relatively narrow stands on the flood-plains of the major rivers (Wimmera, Avon, and Richardson), and around permanent swamps of the Wimmera plains, such as Yanac Swamp and Nhill Swamp. This unit generally has a woodland II structure, although river red gum does grow in open forests along many sections of the Wimmera River between Marma and Dimboola. The understoreys are primarily grassy, with woody species being scattered or uncommon except on the lower sub-saline reaches of the Wimmera River, where open shrublands of salt paper-bark *(Melaleuca halmaturorum)* occur as an understorey.

Away from the influence of sub-saline conditions, woody species present may include wattles *(Acacia* spp.*)*, palefruit ballart *(Exocarpos strictus)*, slender cypress pine *(Callitris preissii)*, scarlet bottlebrush *(Callistemon macropunctatus)*, prickly tea-tree *(Leptospermum juniperinum)*, and totem-poles *(Melaleuca decussata)*.

The suite of herbaceous species is dominated by grasses and sedges. The former include tussock grass *(Poa labillardieri)*, wallaby-grasses *(Danthonia* spp.*)*, blown grass *(Agrostis avenacea)*, cane grass *(Eragrostis australasica)*, kangaroo grass *(Themeda australis)*, weeping grass *(Microlaena stipoides)*, windmill grass *(Chloris truncata)*, *Enteropogon acicularis*, and brush wire-grass *(Aristida behriana)*. Sedges comprise *Carex* spp., spiny flat-sedge *(Cyperus gymnocaulos)*, and common spike-rush *(Eleocharis acuta)*. Other native species include flax-lilies *(Dianella* spp.*)*, raspwort *(Haloragis glauca)*, and yellow rush-lily *(Tricoryne elatior)*.

A wide range of exotic annuals and perennials have degraded the understoreys to a serious extent in many places.

Woodland II (Unit 1b)

On deep sands where flooding rarely, if ever, occurs - the margins of Lake Hindmarsh and Red Gum Swamp in the central block of the Little Desert - the understoreys are also essentially herbaceous, but contain species different from those of the riverine woodlands.

Knobby club-rush *(Scirpus nodosus)*, blue rod *(Morgania glabra)*, pale rush *(Juncus pallidus)*, and spiny flat-sedge are highly characteristic of this unit, and blue rod is evidently confined to these communities in the Wimmera. Cotton fireweed *(Senecio quadridentatus)* is sometimes very abundant, while other native species of structural importance include black-anther flax-lily *(Dianella revoluta)*, bluebells *(Wahlenbergia* spp.*)*, cudweeds *(Gnaphalium* spp.*)*, and couch *(Cynodon dactylon)*.

Introduced aliens include annual grasses and the invasive perennial veldt grass *(Ehrharta calycina)*.

Woody species, while rather uncommon, include prickly tea-tree and silver banksia *(Banksia marginata)* at Little Desert localities such as Red Gum Swamp. A bitter-pea *(Daviesia arenaria)* and creeping myoporum *(Myoporum parvifolium)* are both found at Lake Hindmarsh, while pale-fruit ballart may also be present.

Woodland I (Unit 1c)

The vegetation of this unit has strong affinities with that found in the Grampians and south-western Victoria. It occurs in depressions and basins in the wetter part of the Wimmera, the best examples being found on the south-western Wimmera plains.

The woodlands grow on yellow duplex soils with sandy loam topsoils and heavy clay B horizons. These are apparently less fertile than the alluvial soils supporting riverine woodlands and open forests of river red gum (Unit 1a).

Most examples of this unit in the study area have been drastically altered by grazing and it is hard to reconstruct their natural vegetation. Judging by the samples outside the Wimmera, the understoreys would have been species-rich, with a greater shrub, sedge, and

River red gum woodland I east of Goroke - typical of the red gum woodlands of the south-western Wimmera plains.

geophyte component than the riverine areas.

Where the woodlands are seasonally flooded, and support swamp communities, the vegetation appears relatively intact with little weed invasion. Only in very wet years, however, do such communities reach their best development.

Dominant species in these swamps include swamp wallaby-grass *(Amphibromus neesii)*, blown grass, Australian sweet-grass *(Glyceria australis)*, water-milfoil *(Myriophyllum propinquum)*, floating pondweed *(Potamogeton tricarinatus)*, common spike-rush, Pacific azolla *(Azolla filiculoides)*, grass cushion *(Isoetopsis graminifolia)*, common billy-buttons *(Craspedia glauca)*, and a daisy *(Brachycome basaltica)*. Where heavily shaded by eucalypt canopies the herbaceous vegetation may be very sparse.

Gum--Box--Bull-oak

Although such woodlands mainly occur as relict populations on small areas of public land and roadsides on the Wimmera plains, sizeable areas of gum--box--bull-oak woodland do remain in the Barrabool, Marma, and Brynterion forests and in the Barrett Timber Reserve.

The alliance is divided into eight units - four of which have yellow gum as the predominant species. There are two grey box units, and one each of black box and bull-oak.

Yellow gum woodland II (Unit 2a)

This unit generally has a grassy understorey. It occurs in mixture with grey box, black box, yellow box, and bull-oak in the Barrabool, Marma, and Brynterion forests, where it grades into grey box woodland II (Unit 2e) and black box woodland I (Unit 2g). At the Barrett Timber Reserve, it grows in mixture with bull-oak and some black box.

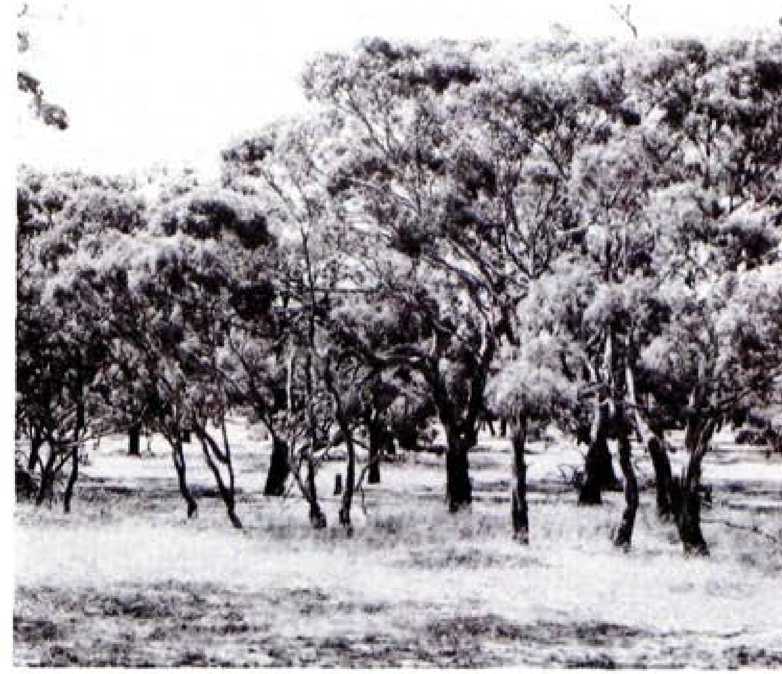
Understorey composition resembles that of Unit 2d, but has less of a shrub component.

Yellow gum woodland II (Unit 2b)

On sandy clay loam soils that may be seasonally waterlogged because of impeded drainage, yellow gum woodland II grows with understoreys dominated by a suite of shrubs or a mosaic of shrubs and sparse herbaceous associations.

It occupies interdune depressions in and around the Little Desert. The duration of waterlogging controls the occurrence of yellow gum, which often forms pure stands or may occur with black box and occasionally river red gum.

The principal shrubs in the yellow gum woodlands of the Little Desert are melaleucas, hakeas, eutaxias *(Eutaxia microphylla)*, fringe-myrtle *(Calytrix tetragona)*, scarlet bottlebrush, muntries *(Kunzea pomifera)*, holly grevillea *(Grevillea ilicifolia)*, wattles, bush-



Yellow gum woodland II, Barrabool Forest Reserve.

pea *(Pultenaea tenuifolia)*, erect guinea-flower *(Hibbertia stricta)*, daphne heath *(Brachyloma daphnoides)*, and bitter-pea *(Daviesia benthamii)*. Some of the shrubby species, such as muntries, dwarf hakea, beaked hakea, and holly grevillea, are confined to or are more frequent in the wetter south-west of the Little Desert.

The herbaceous component of these understoreys is dominated by sedges and several grasses and dicotyledons. Almost universal is black bristle-rush *(Chorizandra enodis)*, which may form an almost continuous cover. Other sedges include bare twig-rush *(Baumea juncea)*, common spike-rush, sword-sedges *(Lepidosperma* spp.*)*, and coarse twine-rush *(Leptocarpus brownii)*. Bristly wallaby-grass *(Danthonia setacea)* is frequent. Dicotyledons include the frequent grey germander *(Teucrium racemosum)*, prickfoot *(Eryngium vesiculosum)*, and raspwort *(Haloragis heterophylla)*.

Yellow gum--slender cypress pine woodland II--woodland I (Unit 2c)

On deeper sandy loams, yellow gum forms tall woodlands with an understorey showing greater structural diversity and species richness than elsewhere. Yellow gum tends to be the only eucalypt present but slender cypress pine, belah, and bull-oak are often co-dominant.

Little of this vegetation type remains, but good examples can still be found on the southern edge of the Little Desert, in the West Wail and Glenlee Timber Reserves, and on public land adjacent to the southern side of Lake Hindmarsh.

Apart from those mentioned, principal woody species include sweet bursaria *(Bursaria spinosa)*, wattles, small hop-bush *(Dodonaea bursariifolia)*, akeake *(D. viscosa)*, bitter-pea, ruby saltbush *(Enchylaena tomentosa)*, eutaxia, burrobunga *(Olearia pimeleoides)*, hooked needlewood *(Hakea tephrosperma)*, variable sida *(Sida corrugata)*, and turkey-bush *(Myoporum deserti)*. Some of these species are rare, but may be major structural components of the vegetation in which they occur.

The herbaceous stratum may be dominated by various combinations of the following species - spear-grasses *(Stipa* spp.*)*, wallaby-grasses, brush wire-grass, scented mat-rush *(Lomandra effusa)*, New Holland daisies *(Vittadinia* spp.*)*, sticky sword-sedge *(Lepidosperma viscidum)*, lamb-tails *(Ptilotus exaltatus)*, hairy-tails *(P. erubescens)*, tufted bluebell *(Wahlenbergia communis)*, lemon beauty-heads *(Calocephalus citreus)*, and black-anther flax-lily. Annual species such as buttons *(Leptorhynchos medius)* may also be conspicuous, but invasion by the suite of exotic annual grasses has doubtless caused the demise of many indigenous annuals.

Yellow gum woodland I (unit 2d)

Grassy understoreys typically occur in yellow gum--grey box woodland I grading into bull-oak woodland I (Unit 2h). Examples of these woodlands are found at Mount Jeffcott and on the public land to the north-west of Charlton, as well as many smaller areas of public land, especially in the Charlton area. The understorey composition of these woodlands has been greatly altered by grazing and weed invasion.

Common wallaby-grass *(Danthonia caespitosa)* and spear-grasses are, and probably were, the dominant herbaceous species.

A suite of exotic annual *Bromus, Vulpia, Avena, Hordium, and Lolium* species are abundant in most areas.

Shrubby species include the frequent golden wattle *(Acacia pycnantha)* and gold-dust wattle *(A. acinacea)*, and the succulent chenopods, especially ruby saltbush and bluebushes *(Maireana* spp.*)*.

Grey box woodland II (Unit 2e)

Although most of the grey box in the study area grows in a woodland I formation (Unit 2f), stands of grey box woodland II occur in the Barrabool, Brynterion, and Marma forests, in mixtures with yellow gum, yellow box, and black box. These stands intergrade with yellow gum woodland II (Unit 2a) and black box woodland I (Unit 2g).

Understoreys are primarily grassy, with similar species composition to Unit 2f but without a shrub component.

Grey box woodland I (Unit 2f)

Stands of grey box woodland I in the Wimmera are invariably associated with yellow gum, black box, and bull-oak. Many small parcels of public land in the eastern half of the study area support this unit. Mitre Rock is the only locality in the Wimmera where grey box is the sole overstorey dominant, although pure stands were probably widespread in the past, since they occur to the east and in South Australia.

The understoreys of grey box woodland are essentially grassy. Grey box prefers fertile loam soils, but on better-drained sites than those supporting black box.

In most samples of this unit in the Wimmera the grassy understorey is dominated by exotic annual grasses or by common wallaby-grass and variable spear-grass *(Stipa variabilis)*. Kangaroo grass was probably a dominant in these woodlands, but grazing has eliminated it.

Grey box woodland I in mixture with yellow gum on Crown land adjacent to the Calder Highway east of Charlton.

On the low rises around Charlton in the eastern Wimmera the understorey contains some woody elements. In this region, gold-dust wattle, hedge wattle *(Acacia paradoxa)*, sweet bursaria, and ruby saltbush occur fairly frequently, but numbers are low.

Black box woodland I (Unit 2g)

Black box forms woodlands and open woodlands over much of the Wimmera on low-lying clay soils subject to inundation or periodic waterlogging. The species

Black box woodland I near the southern edge of Lake Hindmarsh.

is less tolerant of flooding or water-logging than river red gum; thus the two species replace each other along moisture gradients.

Almost every remaining stand of black box in the Wimmera has been subject to grazing or weed invasion, except where high moisture levels have permitted largely indigenous species to survive.

Black box frequently forms pure stands, but overlaps in ecotone zones with river red gum, yellow gum, and grey box woodlands. Its most frequent and characteristic associate over wide areas, however, is bull-oak.

Black box woodlands in the study area are predominantly grassy, but in places the understorey is almost non-existent or comprises mainly shrubs. In many areas micro-relief features, especially on 'gilgai' soils, produce distinctive variations in the herbaceous understorey by determining how wet particular sites become during winter and spring.

The most frequent and characteristic shrubby dominant in understoreys of black box woodland is tangled lignum *(Muehlenbeckia cunninghamii)*. Some rare examples of this unit have nitre goosefoot *(Chenopodium nitrariaceum)* as a shrubby understorey dominant; also, some unusual communities have a very sparse herbaceous understorey but a well-developed monospecific stratum of grey mulga *(Acacia brachybotrya)*.

Several other woody species are found on sites less subject to inundation than those supporting lignum. These include saltbushes *(Atriplex* spp.*)*, bluebushes, *Sclerolaena muricata*, spiny lignum *(Muehlenbeckia horrida)*, hedge saltbush *(Rhagodia spinescens)*, ruby saltbush, quena *(Solanum esuriale)*, sweet bursaria, and umbrella wattle *(Acacia osswaldii)*.

The herbaceous understorey of black box woodland is grass- or sedge-dominated depending upon how wet the site is during winter and spring. Common spike-rush is very frequent, often forming extensive monospecific swards.

As well as grasses and sedges, many herbaceous perennial dicotyledons are often found and sometimes contribute significantly to the structure of the community. A fern - common nardoo *(Marsilea drummondii)* - also occurs very frequently, as do introduced annual grasses in remnant areas of black box woodland.

Bull-oak woodland I (Unit 2h)

Although bull-oak woodlands and open woodlands once covered vast areas on the fertile soils of the Wimmera plains they are now represented only by fragments on roadsides and small areas of public land. Bull-oak is frequently associated with yellow gum, and especially black box, but occasionally is found in pure stands.

Nearly all the remaining fragments have been subject to a long grazing history, and exotic annual grasses now dominate most of the understoreys. In the few samples where any woody species remain, they include gold-dust wattle, sweet bursaria, berrigan *(Eremophila longifolia)*, bluebushes, and hedge saltbush.

The herbaceous component of these woodlands is dominated by exotic annual grasses, and by common wallaby-grass and variable spear-grass. Composites are the most conspicuous native plants still

Bull-oak woodland with an essentially grassy (exotic) understorey.

present in terms of number of species, with beauty-heads *(Calocephalus* spp.), buttons *(Leptorhynchos* spp.), daisies *(Brachycome* spp.), Minnie daisy *(Minuria leptophylla*, and sunray *(Helipterum corymbiflorum)*. Other perennials include common spike-rush, hairy-tails, lamb-tails, variable sida, grey germander, small-leaf goosefoot *(Chenopodium pseudomicrophyllum)*, and Broughton pea *(Swainsona procumbens)*.

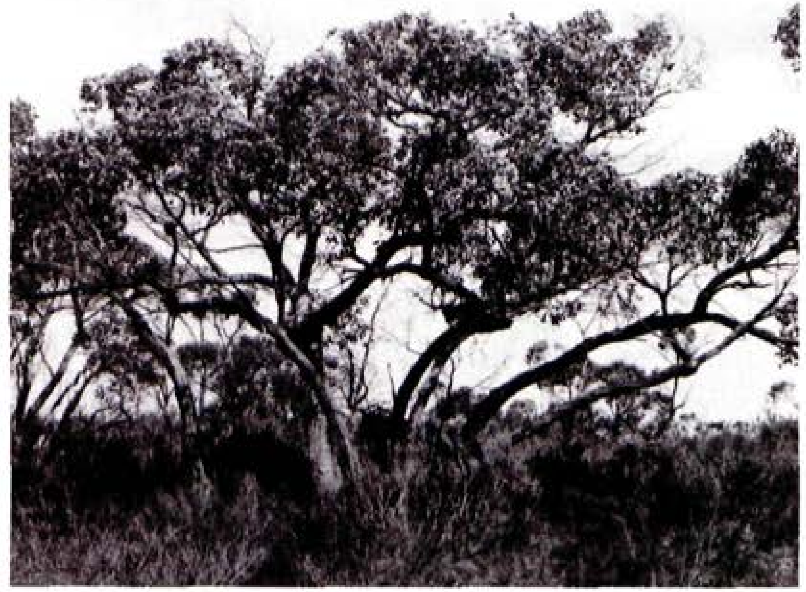
Sterile plants of bull-oak are not easily distinguished from those of belah (another member of the genus *Casuarina)*. The species, however, appear to be mutually exclusive, the latter occurring on sandy soils. In the Glenlee Timber Reserve, neat and complete replacement of one by the other can be observed along topographic and soil gradients. There is no similar dramatic change in understorey species.

Brown Stringybark

Woodland I--open scrub (Unit 3)

Brown stringybark grows in formations varying from woodland I or open scrub to open woodland I or tall open shrubland and eventually to heath, with few if any emergent eucalypts (Unit 8). The understoreys are invariably heathy and usually these and heaths (Unit 8) are indistinguishable.

Brown stringybark communities are found in and around the Little Desert, and in



Brown stringybark woodland I in the central block of the Little Desert - note the heathy understorey.

the Big Desert (the northern limit of the tree in Victoria). They grade into heath (Unit 8), mallee--broombush (Unit 4), and yellow gum woodland II (Units 2b, 2c).

In the south-west of the Little Desert several woody species appear in brown stringybark communities and are evidently confined to this part of the Wimmera where the rainfall is high. Oyster Bay pine *(Callitris rhomboidea)* is a frequent co-dominant here, with several eucalypts being rare co-dominants.

The principal woody dominants found in brown stringybark shrubby understoreys are heath tea-tree *(Leptospermum myrsinoides)*, desert banksia *(Banksia ornata)*, silver banksia, guinea-flowers *(Hibbertia* spp.*)*, bitter-peas *(Daviesia* spp.*)*, myrtles *(Calytrix* spp.*)*, she-oaks *(Casuarina* spp.*)*, hakeas, parrot-peas *(Dillwynia* spp.*)*, baeckeas, wattles, and beard-heaths *(Leucopogon* spp.).

The herbaceous stratum is dominated by the perennial sedges typical of heath communities: tassel rope-rush *(Hypolaena fastigiata)*, scale-shedder *(Lepidobolus drapetocoleus)*, sticky sword-sedge, and black rapier-sedge *(Lepidosperma carphoides)*. Austral bracken *(Pteridium esculentum)* is abundant in brown stringybark communities on the southern edge of the western block of the Little Desert, but is otherwise absent from the study area.

Mallee--broombush

Shrubby open scrub (Unit 4)

Mallee--broombush is a very distinctive community both structurally and floristically. An overstorey is almost always provided by yellow mallee, frequently in combination with other eucalypts - most usually slender-leaf mallee, green mallee, or dumosa mallee.

A dense to open mid stratum of shrubs 2--3 m high dominated by broom honey-myrtle *(Melaleuca uncinata)* and broom baeckea *(Baeckea behrii)* is the most characteristic feature.

Mallee--broombush grows over large areas in the Little and Big Deserts, where it intergrades with brown stringybark communities (Unit 3), heath (Unit 8) and yellow gum woodland II (Unit 2b). It is found on shallower soils over a hardpan that causes seasonal waterlogging. These soils occur on the laterized sandstone ridges of the former shorelines, in swales between dunes, and around claypans.

Apart from the emergent mallee eucalypts, several other small trees are frequently present, including Oyster Bay pine, which may be abundant, and less frequently broom ballart *(Exocarpos sparteus)*.

A large suite of shrubs is found in mallee--broombush communities. Species include melaleucas, hakeas, slaty she-oak *(Casuarina muelleriana)*, eutaxia, pink velvet-bush *(Lasiopetalum behrii)*, bush-peas, myrtles *(Calytrix* spp.*)*, winged spyridium *(Spyridium vexilliferum)*, heaths *(Brachyloma* spp.*)*, and wattles.

The herbaceous stratum tends to be somewhat sparse but is species-rich because of the relatively fertile soil. Matted bog-rush *(Schoenus breviculmis)* is extremely frequent and characteristic of these sites. Other prominent perennial monocotyledons include sticky sword-sedge and scale-shedder. Geophytes are abundant, particularly orchids, lilies, and sundews *(Drosera* spp.). Many annuals are abundant, especially *Centrolepis* spp., crassulas, and composites. Weed invasion of these communities is slight and confined to annual grasses.

Mallee

Three units of open scrub make up this alliance, each with one of the following major species in the tallest stratum: yellow mallee, bull mallee, and dumosa mallee. Occasionally other mallee eucalypts, such as green mallee, slender-leaf mallee, or red mallee may be the dominant species of an area of open scrub.

Yellow mallee open scrub (Unit 5a)

Communities dominated by yellow mallee are widely distributed in the Wimmera on a variety of gradational, uniform, and duplex soils. Yellow mallee open scrub associated with broombush (Unit 4) has already been discussed, in the previous section.

On deeper sands with pH increasing down the profile, yellow mallee forms open scrub with a range of understorey dominants other than broombushes. The presence of porcupine grass *(Triodia irritans)* is characteristic of these communities, which occur in patches among the mallee--broombush of the Big Desert.

A particularly interesting and sizeable remnant of yellow mallee with a very different understorey occurs on a block of public land west of Ellam, where it grows with slender cypress pine and scrub cypress pine.

This community has a poorly developed shrub stratum containing small-leaved clematis *(Clematis microphylla)*, large-leaf ray flower *(Cyphanthera anthocercidea)*, golden wattle, and guinea-flower *(Hibbertia virgata)*. The herbaceous component is dominated by abundant velvet tobacco *(Nicotiana velutina)*, but sticky longheads *(Podosperma angustifolium)*, satin everlasting *(Helichrysum leucopsidium)*, and Mediterranean turnip *(Brassica tournefortii)* were also prominent.

This stand appears to be unique in the Wimmera, but was doubtless once common on the high sandy lunettes east of Lake Hindmarsh. It has strong affinities with vegetation further north.

Bull mallee open scrub (Unit 5b)

This mallee is associated with a number of tree species, not all of them mallees. Bull mallee open scrub was once widespread on the northern Wimmera plains, but is now restricted to roadsides and small areas of public land. Weeds have invaded here, so these pockets exhibit little of their original structural and floristic diversity. Soils carrying bull mallee are invariab-

A remnant bull mallee open scrub is found on many road reserves of the northern Wimmera plains - this road reserve is west of Lake Hindmarsh.

ly rather fertile red-brown calcareous earths.

Associated species include yellow gum, grey box, black box, red mallee, dumosa mallee, and bull-oak. Where other mallees are present, the non-mallee species are absent.

Shrubs or small trees common in bull mallee communities include wattles, pink velvet-bush, sugarwood *(Myoporum platycarpum)*, and ruby saltbush. The predominantly grassy herbaceous stratum is dominated by common wallaby-grass, spear-grasses, and windmill grass, while exotic annuals are extremely widespread and abundant. Black-anther flax-lily is frequent, and native herbaceous dicotyledons include New Holland daisies and pointed twin-leaf *(Zygophyllum apiculatum)*. The noxious Mediterranean turnip has caused extensive degradation of these communities.

Dumosa mallee open scrub (Unit 5c)

Dumosa mallee may form pure or mixed stands with yellow mallee, green mallee, grey mallee, red mallee, bull mallee, or yellow gum in an open scrub formation. The pure stands are found on very heavy-textured clay soils, especially in small interdune depressions in the Little Desert.

With an increasing sand fraction, the other eucalypts appear in the community

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and, where soils become very sandy, yellow mallee--broombush (Unit 4) takes over from this unit. Soils carrying dumosa mallee are prone to seasonal waterlogging because of impeded drainage.

Understoreys may be very sparse or contain a range of woody species, some of which are characteristic of the community, but most of which are shared by mallee--broombush communities (Unit 4), as occurs in the Dimboola Flora and Fauna Reserve. The herbaceous layer is usually very sparse.

The principal shrubs in the understorey are melaleucas, broom baeckea, eutaxia, wattles, bush-peas, woolly daisy-bush *(Olearia lanuginosa)*, holly grevillea, scarlet mint-bush *(Prostanthera aspalathoides)*, coccid emu-bush *(Eremophila gibbifolia)*, and goodenias. The melaleucas frequently form dense thickets, sometimes without a eucalypt overstorey.

Salt Paper-bark

Low closed forest--tall open shrubland (Unit 6)

Monospecific communities of salt paper-bark from 2 to 8 metres high occur on the margins of salt lakes and brackish permanent water. They merge with the closely associated halophytic low shrubland formations, or may be quite discrete with sharp boundaries. Communities of chaffy saw-sedge *(Gahnia filum)* are often associated with salt paper-bark.

The main location of this unit in the Wimmera is around the salt lakes on the south-western Wimmera plains. The best development by far occurs at Lake Wyn Wyn, on the southern and north-western edges, and the northern end of the channel connecting it to Lake Natimuk. Small stands occur in several salt lakes around Wyn Wyn, and to the west at the northern end of Mitre Lake.

At maximum development these low forests or shrublands contain very few species in the ground stratum, which may be heavily shaded. The main native species are glassworts *(Sarcocornia quinqueflora* and *Halosarcia* spp.*)*, coast sand-spurrey *(Spergularia media)*, Australian salt grass *(Distichlis distichophylla)*, karkalla *(Carpobrotus rossii)*, rounded noon-flower *(Disphyma clavellatum)*, and glaucous goosefoot *(Chenopodium glaucum)*.

However, understoreys in localities that are not excessively saline now contain more or less continuous swards of exotic grasses.

Near the Wimmera River's outlet into Lake Hindmarsh, zones of salt paper-bark occur along the water and some distance inland, according to the distribution of saline conditions. In this locality interesting mosaics occur with other communities, especially succulent halophytic shrublands and sedgelands dominated by swamp club-rush *(Bolboschoenus medianus)* and common reed *(Phragmites australis)*.

Rock Outcrop Communities

Tall open shrubland (Unit 7)

The dominant vegetation of this unit is widely spaced shrubs or small trees of lightwood *(Acacia implexa)*, while wallowa *(A. calamifolia)* may form a second stratum. Understorey vegetation is sparse, and includes extensive areas of bare rock.

The unit is restricted to rock outcrops in the far east of the study area, in particular the granitic outcrops of Yowang Hill and Mount Gowar.

Right: Granite outcrop community of lightwood and wallowa - Yowang Hill.

Below: Low forest of salt paper-bark - south of Lake Hindmarsh.

The eastern shore of Mitre Lake - showing the zoning of halophyte communities - with Mount Arapiles rising in the background.

Understorey species include rock correa *(Correa glabra)* slender rice-flower *(Pimelea linifolia)*, and wedge-leaf hop-bush *(Dodonaea cuneata)*.

Species typical of granite outcrops, such as rock fern *(Cheilanthes austrotenuifolia)*, frequently occupy suitable habitats in these communities.

On deeper soils, particularly towards the base of the outcrops, wallaby-grass, spear-grasses, and exotic grasses become the major species.

Heath

Open heath (Unit 8)

Extensive areas of heath vegetation are found on the siliceous acid sands of the Little Desert. There are also areas of heath interspersed in the mallee--broombush communities of the southern Big Desert.

These communities grade into brown stringybark communities (Unit 3) along a continuum from heath with occasional

TABLE 16 VEGETATION UNITS

Alliance	Map symbol	Typical structural form at maturity	Major species of tallest stratum	Associated tree or shrub species	Common understorey species
RIVER RED GUM	1a	OPEN FOREST II/ WOODLAND II (15--28 m height)	River red gum	Generally as pure stands, occasionally with black box, yellow gum	Wattles, pale-fruit ballart, slender cypress pine, scarlet bottlebrush, prickly tea-tree, totem-poles, salt paper-bark, grasses and sedges
	1b	WOODLAND II (15--28 m height)	River red gum	Generally as pure stands, occasionally with black box, yellow gum	Prickly tea-tree, silver banksia, creeping myoporum, pale-fruit ballart, grasses, knobby club-rush, blue rod, pale rush, spiny flat-sedge
	1c	WOODLAND I (5--15 m height)	River red gum	Black box	Swamp wallaby-grass, blown grass, Australian sweet-grass, water-milfoil, floating pondweed, common spike-rush, Pacific azolla, grass cushion. Less moist parts carry exotic grasses
GUM--BOX--BULL-OAK	2a	WOODLAND II (15--28 m height)	Yellow gum	Grey box, yellow box, bull-oak, black box, river red gum	Golden wattle, gold-dust wattle, ruby saltbush, common wallaby-grass, spear-grasses, exotic grasses
	2b	WOODLAND II (15--28 m height)	Yellow gum	Black box, river red gum	Melaleucas, hakeas, eutaxia, fringe-myrtle, scarlet bottlebrush, muntries, holly grevillea, wattles, bush-pea, erect guinea-flower, daphne heath, sedges (esp. black bristle-rush), bristly wallaby-grass, grey germander, prickfoot, raspwort
	2c	WOODLAND II/ WOODLAND I (5--28 m height)	Yellow gum Slender cypress pine	Bull-oak, belah	Sweet bursaria, wattles, small hop-bush, akeake, ruby saltbush, eutaxia, burrobunga, hooked needlewood, desert cassia, leafless currant-bush, variable sida, turkey-bush, grasses, sedges
	2d	WOODLAND I (5--15 m height)	Yellow gum	Grey box, bull-oak, black box	Golden wattle, gold-dust wattle, ruby saltbush, bluebushes, common wallaby-grass, spear-grasses, exotic grasses
	2e	WOODLAND II (15--28 m height)	Grey box	Yellow gum, yellow box, bull-oak, black box	Common wallaby-grass, variable spear-grass, exotic grasses
	2f	WOODLAND I (5--15 m height)	Grey box	Yellow gum, bull-oak	Gold-dust wattle, hedge wattle, sweet bursaria, ruby saltbush, common wallaby-grass, variable spear-grass, exotic grasses
	2g	WOODLAND I (5--15 m height)	Black box	Bull-oak, river red gum, yellow gum, grey box	Tangled lignum, saltbushes, blue-bushes, quena, sweet bursaria, umbrella wattle, common spike-rush wallaby-grasses, windmill grass, spear-grasses, rigid panic, Australian salt grass, couch, common nardoo, exotic grasses
	2h	WOODLAND I (5--15 m height)	Bull-oak	Black box, yellow gum, belah	Gold-dust wattle, sweet bursaria, berrigan, bluebushes, hedge saltbush, harlequin mistletoe, common wallaby-grass, variable spear-grass, composites, common spike-rush, exotic grasses
BROWN STRINGYBARK	3	WOODLAND I/ OPEN SCRUB (2--15 m height)	Brown stringybark	Oyster Bay pine, heath tea-tree	Desert banksia, silver banksia, she-oaks, guinea-flowers, bitter-peas, fringe-myrtle, hakeas, Austral grass-tree, parrot-peas, horny cone-bush, baeckeas, wattles, beard-heaths, sedges
MALLEE--BROOMBUSH	4	SHRUBBY OPEN SCRUB (2--8 m height)	Yellow mallee (occasionally other mallee species or mallees absent)	Broom honey-myrtle, broom baeckea, slender-leaf mallee, green mallee, dumosa mallee	Oyster Bay pine, melaleucas, hakeas, slaty she-oak, eutaxia, bush-peas, matted bog-rush, sword-sedges, orchids, lilies, sundews, ephemeral annuals
MALLEE	5a	OPEN SCRUB (2--8 m height)	Yellow mallee	Slender cypress pine, scrub cypress pine	Small-leaved clematis, large-leaf ray-flower, golden wattle, guinea-flower, velvet tobacco, sticky longheads, satin everlasting
	5b	OPEN SCRUB (2--8 m height)	Bull mallee	Bull-oak, grey box, yellow gum, other mallee species	Wattles, pink velvet-bush, sugarwood, ruby saltbush, common wallaby-grass, spear-grasses, windmill grass, black-anther flax-lily, New Holland daisies, pointed twin-leaf, exotic grasses
	5c	OPEN SCRUB (2--8 m height)	Dumosa mallee	Green mallee, yellow mallee, other mallee species	Melaleucas, broom baeckea, eutaxia, wattles, bush-peas, woolly daisy-bush, holly grevillea, scarlet mint-bush, coccid emu-bush, goodenias, rough halgania
SALT PAPER-BARK	6	LOW CLOSED FOREST -- TALL OPEN SHRUBLAND (2--8 m height)	Salt paper-bark		Beaded glasswort, grey glassworts, brown-head glasswort, coast sand-spurrey, Australian salt grass, karkalla, rounded noon-flower, glaucous goosefoot, exotic grasses (where conditions less saline)
ROCK OUTCROP COMMUNITIES	7	TALL OPEN SHRUBLAND (2--8 m height)	Lightwood	Wallowa	Rock correa, slender rice-flower, wedge-leaf hop-bush, raspwort, rock fern, wallaby-grasses, spear-grasses, exotic grasses
HEATH	8	OPEN HEATH (<2 m height)	Heath tea-tree Desert banksia She-oaks	Mallee honey-myrtle, baeckeas, beard-heaths, heaths, grass-trees, guinea-flowers	Tassel rope-rush, sword-sedges, coarse twine-rush, scale-shedder, spear-grass, bristly wallaby-grass, sticky longheads, annual bluebell

Alliance	Map symbol	Typical structural form at maturity	Major species of tallest stratum	Common associated species
HALOPHYTES	9	LOW OPEN SHRUBLAND (<2 m height)	Beaded glasswort Grey glassworts Brown-head glasswort Other glassworts	Creeping brookweed, wilsonias, Australian salt grass, prickly arrowgrass, pennywort, composites, Australian saltmarsh grass, toad rush, glaucous goosefoot, sea-heath, lawrencias, exotic grasses (where conditions less saline)
WETLAND COMMUNITIES	10a	LOW OPEN SHRUBLAND (<3 m height)	Tangled lignum	Common spike-rush, cane grass, blown grass, common nardoo, narrow-leaf nardoo, poison pratia, goodenia, swamp wallaby-grass
	10b	GRASSLAND	Cane grass, swamp wallaby-grass, blown grass, Australian sweet-grass, common spike-rush	Water-milfoil, floating pondweed, Pacific azolla, grass cushion, common billy-buttons
EUCALYPT PLANTATION	11	OPEN FOREST III/ OPEN FOREST II (15--35 m height)	Sugar gum is main species planted	Brown mallet, swamp yate, swamp mallet, yellow gum and black box have also been planted
CLEARED LAND/ GRASSLAND	12	GRASSLAND	Includes public land used for agriculture, gravel extraction, and water supply. Vegetation includes native grasses and remnants of former woodlands, but mostly comprises pasture species and exotic weeds, especially annual grasses	

emergent eucalypts to open woodland or shrubland with a heathy understorey.

Fires play a critical role in determining the floristics and hence structure of heath communities. Fire-sensitive species such as desert banksia will be eliminated if a site is burnt too often.

Structurally, heath vegetation consists of low (less than 2 m high) open to dense communities of sclerophyllous shrubs and perennial herbs. The woody shrubs are dominated by members of the families Proteaceae, Fabaceae, Epacridaceae, Casuarinaceae, Xanthorrhoeaceae, and Myrtaceae. Heath tea-tree is an almost universal dominant or co-dominant species.

Rushes and sedges dominate the herbaceous elements - grasses and geophytes are much less abundant than in adjoining mallee--broombush (Unit 4) or yellow gum woodland II (Unit 2b). Tassel rope-rush is almost universal and may be very abundant.

Two different types of heath community occur in the Little Desert. The most widespread type occurs on low-nutrient siliceous sands and embraces a range of communities in which desert banksia is prominent.

The other type of Little Desert heath occurs in some swales, but is characteristically found around clay-pans and salt lakes. The most prominent species in these heaths is Mallee honey-myrtle *(Melaleuca neglecta)*, and several contain understoreys of small darwinia *(Darwinia micropetala)*, which, until recently, was thought to be extinct in Victoria.

Heath communities among the mallee--broombush of the north-west contain species typical of more northerly (Big Desert) heath communities. Dominant species include Mallee tea-tree *(Leptospermum coriaceum)* and common aotus *(Aotus ericoides)*.

Another heath community of interest is located on rises of siliceous yellow sand upslope of yellow mallee open scrub (Unit 5a) on the block of public land west of Ellam. This community is unique in the Wimmera and has strong affinities with the vegetation of the Big Desert. Soils here are evidently more fertile than is typical in heath communities.

Halophytes

Low open shrubland (Unit 9)

Of major biological interest in the Wimmera region is the halophytic vegetation of saline lakes and salt-pans. These communities are dominated by glassworts that form low open shrublands. A suite of seasonal annuals, also present, can occupy sites where salt has been leached from the A horizon of the soils by autumn rains. The best examples of this unit in the study area are found around the salt lakes of the south-western Wimmera plains, especially at Lake Wyn Wyn, where broad bands of halophytes are present.

Its principal shrubby dominants are beaded glasswort *(Sarcocornia quinqueflora)*, brown-head glasswort *(Halosarcia indica* ssp. *leiostachya)*, and several other species of glasswort *(Halosarcia* spp.*)*. Sea-heath *(Frankenia angustipetala)* and thorny lawrencia *(Selenothamnus squamatus)* on the outer edge of the glasswort shrublands are relatively rare. Dominant perennials in the outer zones include creeping brookweed *(Samolus repens)*, wilsonias, and Australian salt grass.

Ephemeral salt evaders on mounds at the base of glasswort plants or on the outer zones include prickly arrowgrass *(Triglochin mucronata)*, pennywort *(Hydrocotyle medicaginoides)*, clustered lawrencia *(Lawrencia glomerata)*, composites, Australian saltmarsh-grass *(Puccinellia stricta)*, toad rush *(Juncus bufonius)*, glaucous goosefoot, and introduced grasses, which have invaded the upper zones of the shrublands.

Extensive sedgelands of dense chaffy saw-sedge to about 1 m high may adjoin the halophytic shrublands or occur as scattered or grouped individuals. Salt paper-bark shrubland (Unit 6) occurs on the outer zones of halophyte communities and glassworts frequently occur sparsely in its understorey.

There is a strong correlation between the size of a salt lake and the development of the halophyte flora - the larger the lake the more structurally diverse and species-rich the vegetation is likely to be.

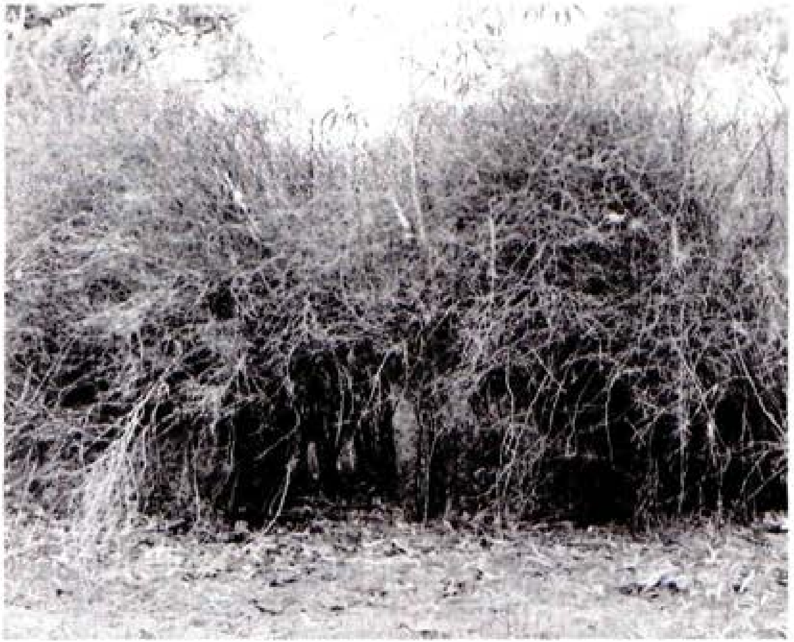
Wetland Communities

The study area contains a range of floristically and structurally diverse plant communities that occupy marshes, swamps, rivers, lakes, and artificial water bodies. Most of these are too small to map separately from the surrounding vegetation units (usually river red gum or black box woodlands). However, two units do cover areas large enough to be mapped: tangled lignum shrublands and grasslands of grass and rush species.

Tangled lignum low open shrubland (Unit 10a)

Tangled lignum shrublands up to 3 m high occur on clay soils of plains, streamsides, and around lakes. These shrublands are periodically flooded and are almost always associated with black box woodlands (Unit 2g). Associated species include common spike-rush, cane grass, blown grass, common nardoo, narrow-leaf nardoo *(Marsilea angustifolia)*, poison pratia *(Pratia concolor)*, goodenia *(Goodenia gracilis)*, and swamp wallaby-grass.

Tangled lignum communities are widely distributed over the Wimmera plains, and



Tangled lignum low shrubland near the Wimmera River downstream of Jeparit.

well-developed examples occur along the lower reaches of the Wimmera River, behind the dunes along the south shore of Lake Hindmarsh, and around lakes and swamps near Dimboola and Horsham. Darlot Swamp contains the largest representation in the study area.

Grassland (Unit 10b)

Grassy swamps associated with river red gum woodland I (Unit 1c) occur south of the Little Desert on the south-western Wimmera plains - the wettest part of the study area. They are usually internally drained basins, often circular and usually flat-bottomed. Soils in these communities usually have a prominent sand fraction with a heavy clay B horizon.

Depth of water varies but it is seasonal, drying out over summer. Communities reach their best development in very wet years. Dominant species in these swamps are the same as those listed in Unit 1c.

Different wetland communities occur on small seasonally flooded areas in other parts of the Wimmera. Common spike-rush sedgelands occur in seasonal swamps on clay soils throughout the Wimmera plains. Common nardoo is also frequent and abundant in the swamps, which are usually surrounded by black box woodland I (Unit 2g).

Black bristle-rush sedgelands on low-lying sandy clay soils or sandy loams over shallow impervious clay occur in or adjacent to yellow gum woodland II (Unit 2c) in the Little Desert. They are of irregular shape and may occupy several hectares.

Cane grass grasslands on seasonally inundated sites are a feature of fertile clay soils on the Wimmera plains. They are found on alluvial flats, on plains subject to inundation, or on internally drained basins. The best example in the study area occupies public land 6 km south-east of Mount Jeffcott. Well-developed examples also occur on Natimuk Creek and at Darlot Swamp.

Marsh club-rush sedgelands and common reed grasslands (on less saline sites) occur along the lower reaches of the Wimmera River, with the latter reaching nuisance levels in places as a result of nutrient levels in the river. Cumbungi (*Typha* spp.) closed herblands are widespread along the larger rivers in the study area.

Sparse communities of round-leaf wilsonia (*Wilsonia rotundifolia*) occur on flat seasonally flooded sub-saline claypans in the central and eastern blocks of the Little Desert. These are usually surrounded by heath (Unit 8) dominated by Mallee honey-myrtle.

Eucalypt Plantation

Plantations of eucalypt species were established by the Forests Commission at Wail early this century, and in other parts of the Wimmera in the 1950s. The main species planted is sugar gum. Others used include Western Australian eucalypts such as brown mallet, swamp yate, and swamp mallet, and the local species yellow gum and black box. These plantations are shown on the vegetation map as Unit 11. They are discussed further in Chapter 17.

Grasslands

Since natural grasslands typically occur on fertile soil they have been cleared or eliminated by grazing over much of the Wimmera. Many of the now-cleared woodlands on the Wimmera plains would also have carried grassy understoreys.

Wallaby-grasses and spear-grasses still persist, but mostly grazing and agricultural practices have led to replacement by introduced pasture or weed genera such as *Bromus*, *Dactylis*, *Hordeum*, *Lolium*, *Vulpia*, *Phalaris*, *Ehrhata*, and *Paspalum*. Many of the smaller blocks of public land support ground flora of this kind, sometimes with scattered remnants of the original tree cover.

Significant Species

Extinct, endangered, rare, restricted, and significant plant species of the Wimmera are listed in Appendix I. The large number of significant species is largely a function of the clearing for agriculture or degradation of most of the native vegetation in the region - most of the rarest species now exist as relict populations and must have been formerly more widespread.

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12. FAUNA

Although much of the natural vegetation has been cleared for agriculture, the study area is noteworthy for its fauna.

The Little Desert, which is the only extensive area of public land (and natural vegetation) remaining in the Wimmera, contains many interesting species that have adapted to semi-arid conditions. The remnant woodland communities on the Wimmera plains contain significant bird populations, while the numerous fresh- and salt-water lakes attract considerable numbers of water birds.

A total of 363 vertebrate species has been recorded in the study area, comprising 33 mammals, 266 birds, 41 reptiles, 10 amphibians, and 13 fish. A full list of species recorded, along with their habitats, can be found in Appendix 2.

The vertebrate fauna can be divided into three categories:

* species typical of the warm-temperate Bassian biogeographic zone of south-eastern Australia, whose distributions extend across central Victoria to the south of the study area

* species typical of the hot, dry Eyrean biogeographic zone, which reach the south-eastern limits of their distributions in the study area

* species widespread in Australia that occur in both biogeographic zones

Table 17 gives examples of species from each group.

Little is known of the invertebrate fauna here. The total number of species greatly exceeds the number of vertebrates, but most have scarcely been studied, making a comprehensive discussion impossible. They include worms, terrestrial and aquatic molluscs (slugs and snails), and innumberable species of arthropods, particularly insects.

The information on which most of this chapter is based was supplied by the Fisheries and Wildlife Service, the Museum of Victoria, and local naturalists.

Vertebrate Habitats

Nine broad vertebrate habitats, based on the vegetation alliances described in Chapter 11, have been recognized. These

Table 17

EXAMPLES OF ZOOGEOGRAPHIC AFFINITIES OF VERTEBRATES
FOUND IN THE WIMMERA STUDY AREA

South-eastern Australia (Bassian)	Inland Australia (Eyrean)	Widespread in Australia
Yellow-footed antechinus	Western pygmy-possum	Short-beaked echidna
Common ringtail possum	Western grey kangaroo	Common brushtail possum
Feathertail glider	Little mastiff-bat	Chocolate wattled bat
Swamp wallaby	Silky mouse	Wedge-tailed eagle
King River eptesicus	Mallee fowl	Galah
Yellow-tailed black cockatoo	Australian bustard	Southern boobook
Crimson rosella	Blue bonnet	Welcome swallow
Eastern yellow robin	Chestnut quail-thrush	Willie wagtail
Brown thornbill	Splendid fairy-wren	
Little wattlebird	Rufous calamanthus	
	Slender-billed thornbill	

are discussed below and the species using them are listed in Appendices 2a to 2d.

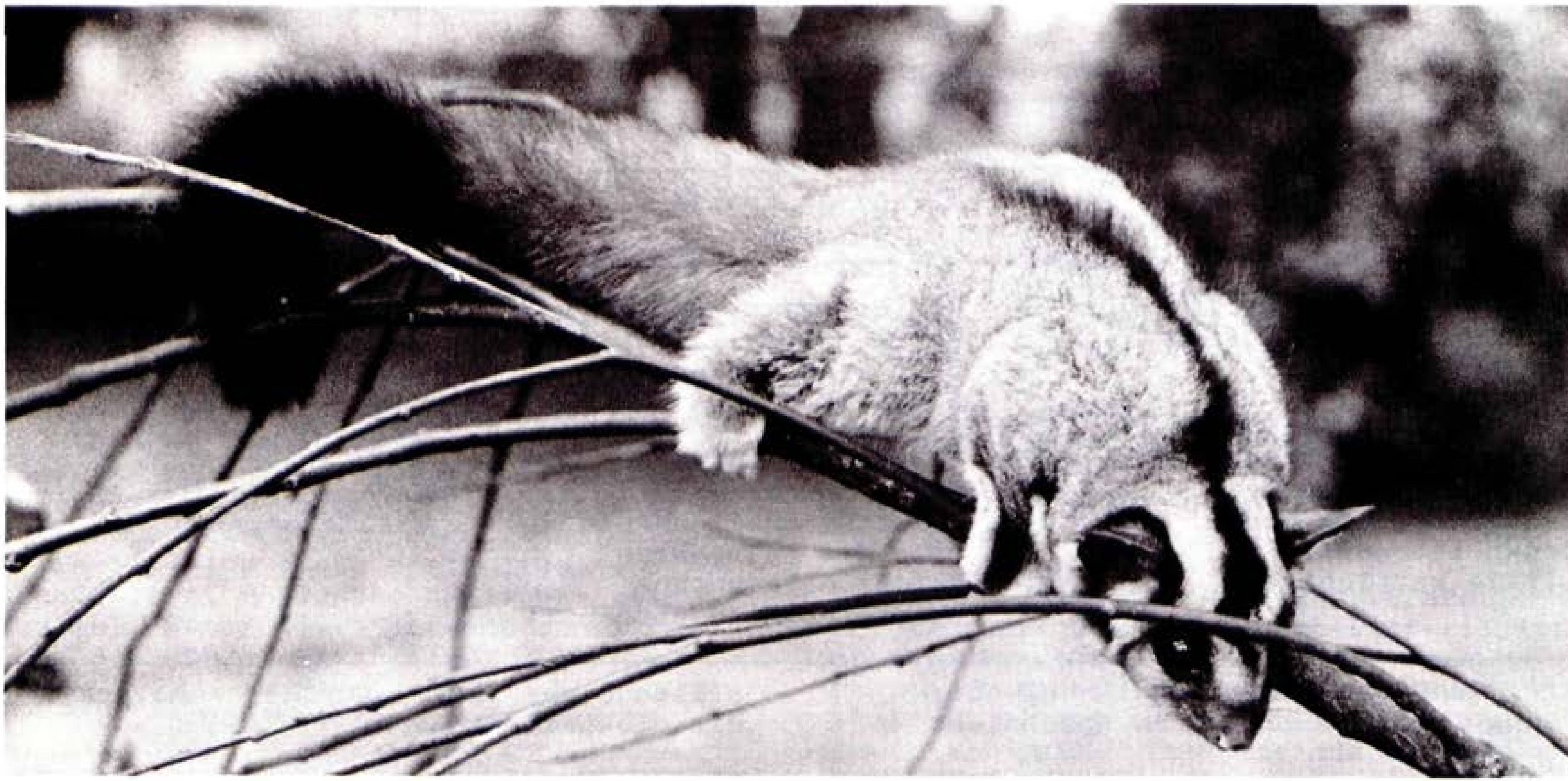
The vegetation alliances are described primarily by the overstorey species of plants, which often have characteristic understoreys. However, understoreys may vary widely within an alliance, or overlap with other alliances. As many species of fauna depend on particular understorey characteristics, they may not be distributed uniformly within a particular habitat or show a good correlation with any one habitat. In addition, the structure (and occasionally species composition) of the overstorey within an alliance may vary - further complicating distribution patterns.

River red gum

This habitat includes the open forest II, woodland II, and woodland I structural forms.

Occurring along major watercourses and areas subject to inundation in the study area, this alliance often includes black box and yellow gum woodlands, lignum, grasslands, and freshwater swamps.

It supports the second-highest species diversity of any in the study area.



Sugar gliders are found in river red gum habitat.

Most species requiring hollows are found here, including the common brushtail possum, sugar and feathertail gliders, yellow-footed antechinus, sulphur-crested cockatoo, regent parrot, Mallee ringneck, sacred kingfisher, and tree martin.

The 107 species of birds recorded in this alliance include the threatened bush thick-knee. Characteristic species are the white-plumed honeyeater, brown treecreeper, striated pardalote, red-rumped parrot, sulphur-crested cockatoo, and peaceful dove. After seasonal inundation, the alliance provides extensive breeding habitat for water birds.

Various components of the river red gum alliance support different species of reptiles. The lace monitor requires hollows in trees, while the marbled gecko and snake-eyed skink inhabit leaf and bark litter at the bases of trees. Six species of frog occur here.

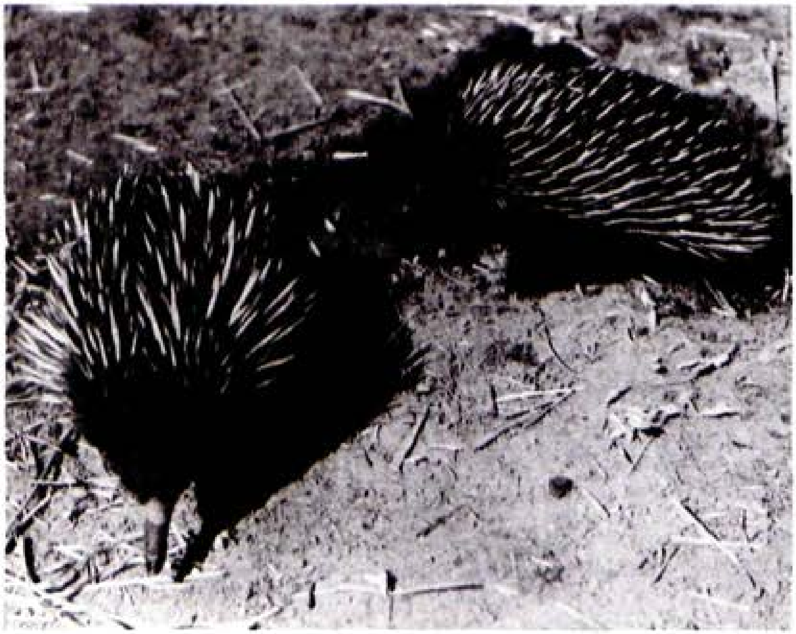
Gum--box--bull-oak

This alliance includes a range of communities dominated by combinations of grey box, yellow gum, yellow box, black box, bull-oak, and slender cypress pine. It has the highest species diversity of the alliances in the study area, but has suffered through clearing for agriculture more than any other. Consequently, its original mammalian fauna has all but vanished, western grey kangaroos and common brushtail possums being the only common native species. The introduced European rabbit, brown hare, and fox are also common.

Birds, however, are diverse and abundant and this alliance has a greater species richness than the river red gum habitat. Notable species include the bush thick-knee, blue bonnet, black-eared cuckoo, Gilbert's whistler, grey-crowned babbler, and diamond firetail. Common ones include sacred kingfisher, buff-rumped thornbill, red-capped robin, hooded robin, white-browed babbler, white-winged triller, rufous songlark, rufous whistler, and white-winged chough.

The 11 reptiles recorded here include the marbled gecko, bearded dragon,

A bearded dragon in the process of laying. One female may lay more than 25 eggs.



Echidnas are among the more common mammals in the brown stringybark alliance.

snake-eyed skink, delicate skink, and shingle-back. Six species of frog have been recorded.

Brown stringybark

Restricted to the sand sheets of the 'desert' areas, this alliance has a relatively low vertebrate species richness. The low, stunted trees provide few arboreal niches and few hollows for arboreal mammals. Consequently, except for the diminutive western pygmy-possum, the mammal fauna consist of terrestrial or aerial species (bats). The most common species are the echidna, western grey kangaroo, Gould's wattled bat, lesser long-eared bat, and silky mouse.

Relatively few bird species inhabit the brown stringybark alliance, but these include several notable species: painted button-quail, variegated fairy-wren and crested bellbird. Reptiles are better represented and include sand goanna, common scaly-foot, bearded dragon, painted dragon, jacky lizard, *Morethia obscura*, and bardick. Four species of amphibian have been recorded, including two species of *Neobatrachus*.

Mallee--broombush

The major occurrence of this alliance in the study area is on gravelly rises in the Little Desert. Few mammals inhabit this alliance and it has a low bird species richness. However, some species are characteristically found here: Mallee fowl, spotted nightjar, southern scrub-robin, red-lored whistler, chestnut quail-thrush, shy hylacola, and purple-gaped honeyeater. The chestnut quail-thrush and purple-gaped honeyeater are virtually restricted to a stand of mature mallee--broombush in the Little Desert National Park south of Kiata.

Large, diurnal reptiles are well adapted to the open ground that occurs beneath the broombush communities and dragons (*Amphibolurus* spp.), *Ctenotus uber*, and shingle-backs are abundant. Four species of amphibians also occur in this alliance.

Mallee

The mammal and bird faunas found here are very similar to those described for the mallee--broombush alliance. The Mallee emu-wren is restricted to patches of yellow mallee open scrub, which occur among the mallee--broombush of the Big Desert. Porcupine grass is a major component of the understorey in these patches, and is a vital component of the habitat of the Mallee emu-wren, one of Victoria's most threatened bird species.

The sandy substrate usually associated with mallee vegetation provides burrow sites for several reptiles, including *Aprasia striolata*, dragons (*Amphibolurus* spp.), and the sand goanna. The brown toadlet is the only amphibian recorded.

Salt paper-bark

No fauna survey was conducted in this limited vegetation type. Birds associated with the wetlands and surrounding farmland use the dense cover it provides for shelter.

Heath

This alliance is restricted in the study area to the Little Desert, where it covers a high proportion of the area and much of the present National Park.

Because of its structural simplicity, it provides a reduced range of niches for vertebrates.

The mammal fauna is species-poor and is characterized by the western pygmy-possum and silky mouse. Several other small mammals occur in similar habitats in the Big Desert and in South Australia and were expected to occur in the Little Desert, but have not been found there. These species are the common dunnart, ningaui, little pygmy-possum, and Mitchell's hopping-mouse.

The 28 bird species recorded included several species largely restricted in the Wimmera to this habitat: variegated fairy-wren, rufous calamanthus, slender-billed thornbill, singing honeyeater, white-fronted honeyeater, and tawny-crowned honeyeater.

The heath of the Little Desert is particularly significant as the major habitat of the slender-billed form of the rufous calamanthus, a taxon currently the subject of much taxonomic debate. It is also the major Victorian habitat of the slender-billed thornbill, which is patchily distributed in saltbush and heath communities across arid southern Australia.

Of the 12 reptilian species recorded in heath, dragons, the common scaly-foot, and burrowing species such as *Aprasia striolata* and the blind snake *Ramphotyphlops bituberculata* are typical. Two small skinks, *Morethia obscura* and the delicate skink, are also common. Five amphibian species have been recorded in heath following rain.

Grasslands

This includes wet grasslands associated with river red gum forests, natural dry grasslands widespread in the area (now mostly agricultural land with a predominance of introduced pasture species), and volunteer grasslands (usually of introduced species) resulting from clearing of woodlands. The original native grasslands of the central portion of the study area have been almost completely cleared for cereal cropping, and as a result their associated fauna have virtually disappeared.

Grassland near forested areas can be used by some species such as the echidna and western grey kangaroo. Other species that can survive, if given remnant trees to provide hollows, include the common brushtail possum and at least four species of bat. The fat-tailed dunnart is one native mammal that has persisted in grazing land, and occurs throughout this community.

Common and characteristic birds include the Australian magpie, Australian magpie-lark, willie wagtail, Richard's pipit, yellow-rumped thorn-bill, eastern rosella, galah, sulphur-crested cockatoo, brown falcon, and Australian kestrel. The less common ones include the spotted harrier, black falcon, Australian pratincole, banded lapwing, blue-winged parrot, stubble quail, and singing bushlark, all of which were recorded only in this alliance.

A small population of the Australian bustard occurs in the area north of Yanac and Telopea Downs, where small remnants of uncleared mallee--broombush provide important shelter. This is the only part of Victoria where bustards are

A peregrine falcon with its kill - a bearded dragon.

regularly found. The rare and endangered plains wanderer has been recorded on several occasions in the central portion of the study area.

Some natural grassland reptiles (such as the legless lizard *Delma inornata* and the hooded scaly-foot) have suffered due to agriculture, as they cannot tolerate the change in habitat that results from grazing and compaction of the soil by stock. Other species recorded in grasslands include the skinks, *Morethia adelaidensis*, shingle-back, and eastern blue-tongued lizard.

Six species of amphibian were found in grasslands associated with water, including Peron's tree frog and the spotted grass frog.

Swamp and lake communities

This habitat includes saline lakes as well as freshwater swamps and rivers, and often occurs in association with river red gum and black box communities. Two species of mammals are particularly adapted to wetlands: the water-rat is found throughout the study area, while the platypus is restricted to the Wimmera River, where a population is isolated within that enclosed drainage system.

Water birds are well represented in the study area because of the many excellent fresh and saltwater lakes and swamps. Lakes Hindmarsh, Buloke, Natimuk, Lawloit, Whitton, and Wyn Wyn, Mitre Lake, Holland's Lake, Walker's Lake, and Wooroonook Lakes are permanent water bodies and provide important refuges during droughts. Other less permanent waters such as Peechember Swamp, Nhill Swamp, Connan Swamp, Telfer Swamp, Mortat Swamp, and Darlot Swamp support large populations of waterfowl and waders when they hold water.

The long-necked tortoise and, in the far south of the study area, the tiger snake, are the only reptiles largely

The rare plains wanderer has been recorded in Wimmera grassland habitat.

restricted to wetlands. Seven amphibian species were recorded, comprising two froglets, three tree frogs, and two 'bullfrogs'.

Habitat corridors

Over much of the Wimmera study area the only remaining natural vegetation grows along roadside and streamside reserves. These narrow strips of trees, shrubs, and grasses can provide very important corridors for dispersal of wildlife, particularly birds. They facilitate the movements of migratory and nomadic birds across the vast grain fields and pastures to the extensive tracts of natural vegetation to the north and south of the study area.

Near Dimboola, in a roadside reserve carrying remnant gum--box--bull-oak woodland, 78 species of dryland birds have been recorded, including 30 migrant or nomadic species. Roadside reserves also provide habitat remnants for resident birds, mammals, and reptiles.

Mammals

Among the 33 mammalian species recorded in the Wimmera study area, eight introduced species have established feral populations. Appendix 2a lists the species and summarizes their status and the habitats they use.

Western grey kangaroo with joey in grassland habitat.

This number of mammalian species is slightly lower than that in other similarly sized areas of northern Victoria. For example, 40 mammalian species were recorded in the North Central study area and 41 in the Murray Valley study area.

The lower species richness in the Wimmera results from its relative lack of small ground and climbing carnivores, fewer arboreal herbivores, and a smaller range of bats. Additionally, the abundance of mammals is often lower here: the Fisheries and Wildlife Service had a trapping success rate for small ground mammals of only 2%, compared with 3.6% in the North Central and 5.5% in the Murray Valley study areas.

The reasons for this low diversity and abundance of mammals remain unclear, but probably relate to several factors - including the relatively low rainfall, lack of structural diversity in the vegetation, and highly disturbed habitats over much of the area, particularly in the east.

Highest mammal species diversity occurs in the gum--box--bull-oak woodlands and river red gum woodlands, which support 25 and 23 species respectively. These two alliances are the only habitats that provide the large tree hollows arboreal species require. Brown stringybark woodland is intermediate in species richness, and mallee--broombush, mallee, and heath support only 9 to 13 species, about half of which are bats that forage over and between the canopy.

History of mammal populations

Analyses of Pleistocene and Holocene bone deposits in caves in south-western Victoria and the records of the 1857 Blandowski expedition suggest that several species have become extinct in northern and western Victoria since European settlement. Several of these may have occurred in the Wimmera.

In the 1860s Edward Townsend described, among others, 'wallabies, kangaroo-rats, native cats and dingoes' as occurring in the Nhill area. In 1861 William Lockhart Morton travelled north from Antwerp to Pine Plains and into the Big Desert. He describes kangaroos, wallabies, pademelons, and kangaroo-rats. From his behavioural notes, however, these may have been the western grey kangaroo, bridled nailtail wallaby, eastern hare-wallaby, and brush-tailed bettong respectively.

Species of mammals probably present in the Wimmera at the time of European settlement but no longer present are listed in Table 18. These species are predominantly woodland inhabitants and disappeared soon after selectors moved into the area with their flocks of sheep in the 1840s and 1850s. Large-scale clearing of woodlands and mallee for grain crops took place in the 1880s, and the plagues of rabbits that occurred in the 1880s may have hastened the decline of the small macropods through competition for food and shelter.

Today, populations of species inhabiting heath or brown stringybark woodlands are found in the extensive public land of the Little Desert and Wail Forest Reserve. Very few undegraded examples of the gum and box woodland communities remain here, however, and the continuing survival in the study area of species dependent upon these communities is thus doubtful. Such species include the yellow-footed antechinus, feathertail glider, sugar glider, common ringtail possum, red-necked wallaby, and black wallaby.

Table 18

MAMMAL SPECIES PROBABLY PRESENT IN THE WIMMERA AT THE TIME OF EUROPEAN SETTLEMENT BUT NO LONGER PRESENT (with an indication of their broad habitat and current status in Australia)

Species	Habitat		Current status in Australia
	Mallee/ heath	Woodland	
Eastern quoll		x	extinct in Victoria, common in Tasmania, declining in New South Wales
Brush-tailed bettong		x	extinct in the east, restricted in south-western Western Australia
Eastern hare-wallaby	x	x	extinct
Bridled nailtail wallaby	x	x	restricted to a small colony in Queensland
Rabbit-eared tree-rat		x	extinct
Dingo	x	x	rare in Victoria, widespread elsewhere

Birds

More than 260 avian species have been recorded in the study area. These are listed in Appendix 2b, together with their status and the habitats each uses. As with the mammals, the study area contains a mixture of species typical of south-eastern Australia, which approach their north-western limits here, and species typical of the inland, which approach their south-eastern limits (see Table 17). The greatest mixing of inland and south-eastern species occurs in the Little Desert, which therefore has a high avian species richness.

Among habitats, species richness is again highest in the gum--box--bull-oak alliance and the river red gum alliance. These two communities provide the main sources of tree hollows for the many hollow-nesting species in the study area. Brown stringybark woodland supports only half as many species, while mallee--broombush, mallee, and heath support one-quarter to one-third as many species as the two richest alliances. However, many of the species that inhabit the mallee and heath alliances are specialized to these habitats, and reach their southern and eastern limits in the Little Desert. Thus, the Little Desert has a high conservation significance for these species, which include Mallee fowl, southern scrub-robin, chestnut quail-thrush, variegated fairy-wren, rufous calamanthus, slender-billed thornbill, and purple-gaped honeyeater.

In addition to the 94 species of native birds recorded associated with water bodies, including the rare freckled duck, the uncommon brolga is known to frequent some of these wetlands. During summer, wetlands support a significant proportion of the Victorian population of some waders, especially the red-kneed dotterel, double-banded plover, red-capped plover, banded stilt, red-necked avocet, and sharp-tailed sandpiper. Common water birds include the hoary-headed grebe, Australasian grebe, Little pied cormorant, Pacific heron, white-faced heron, Australian shelduck, Pacific black duck, grey teal, purple swamphen, Eurasian coot, masked lapwing, and marsh harrier.

Some uncommon species are the glossy ibis, plumed whistling duck, blue-billed duck, painted snipe, spotless crake, rufous night heron, little bittern, and white-bellied sea-eagle.

Several bird species have disappeared from the study area or become very rare since European settlement. These include the magpie goose, plains wanderer, Australian bustard, bush thick-knee, night parrot, grey-crowned babbler, and apostlebird. Except for the magpie goose and night parrot, these species inhabited the gum and box woodland alliances and have suffered from a combination of the effects of land clearing, grazing of stock, changed fire regimes, and the introduction and subsequent effects of European rabbits.

Delma impar - *a legless lizard.*

Reptiles

The 41 reptilian species recorded in the Wimmera study area and their broad habitat preferences are listed in Appendix 2c. Species richness here is slightly higher than that for the North Central and Murray Valley study areas, but not as high as for the Mallee study area, which has the richest reptilian fauna in Victoria.

Within the study area species richness is highest in the river red gum woodland, which supports 14 species. Gum--box--bull-oak woodlands, brown stringybark woodlands, mallee--broombush, and heath all support 10 to 12 species, while mallee and farmland support 6 and 7 species respectively.

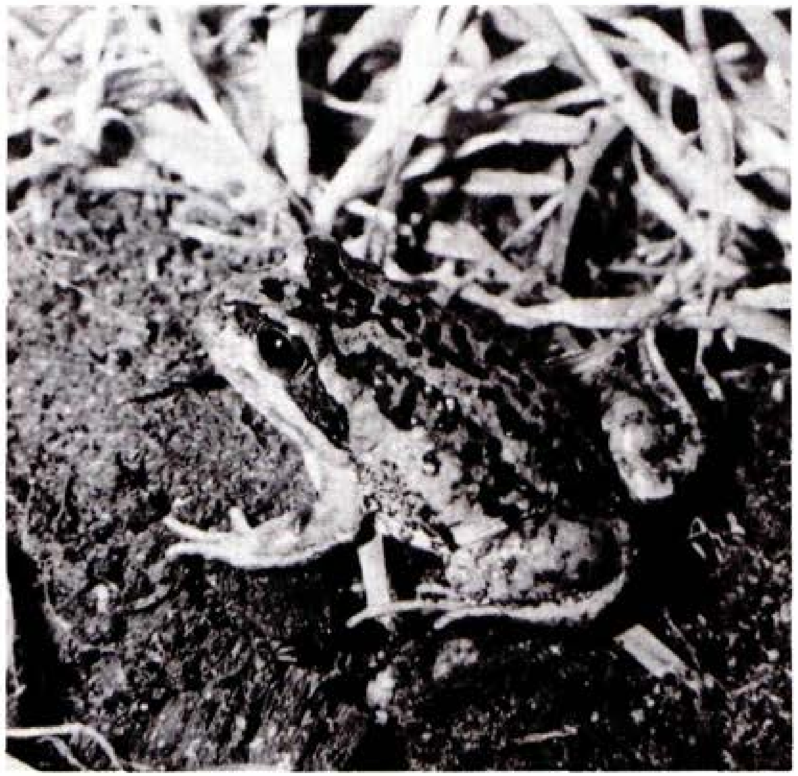
Within the study area, two species - the Mallee dragon and *Drysdalia marstersi* - are known only in the southern Big Desert. *Unechis brevicaudis* was recorded only in the Little Desert and three species - the painted dragon, *Ctenotus uber,* and *Morethia obscura* - occur only in the Little and Big Deserts.

A further 20 species (48%) have restricted distributions here and for six of these only a few specimens have been collected in the 19th century or early 1900s (tesselated gecko, *Delma impar,* hooded scaly-foot, *Ramphotyphlops nigrescens, R. proximus,* and bandy-bandy).

Although widespread in the study area, both the lace monitor and sand monitor are rare and there are very few documented records. *Hermiergis decresiensis* is known in the study area only at Mitre Rock.

Amphibians

The 10 amphibian species recorded in the study area are listed in Appendix 2d. All are widespread and common in Victoria and most occur in a variety of habitats. The *Neobatrachus* species and the brown toadlet are most abundant in the Little Desert.



The eastern banjo frog.

Murray cod - a native species introduced to the Wimmera.

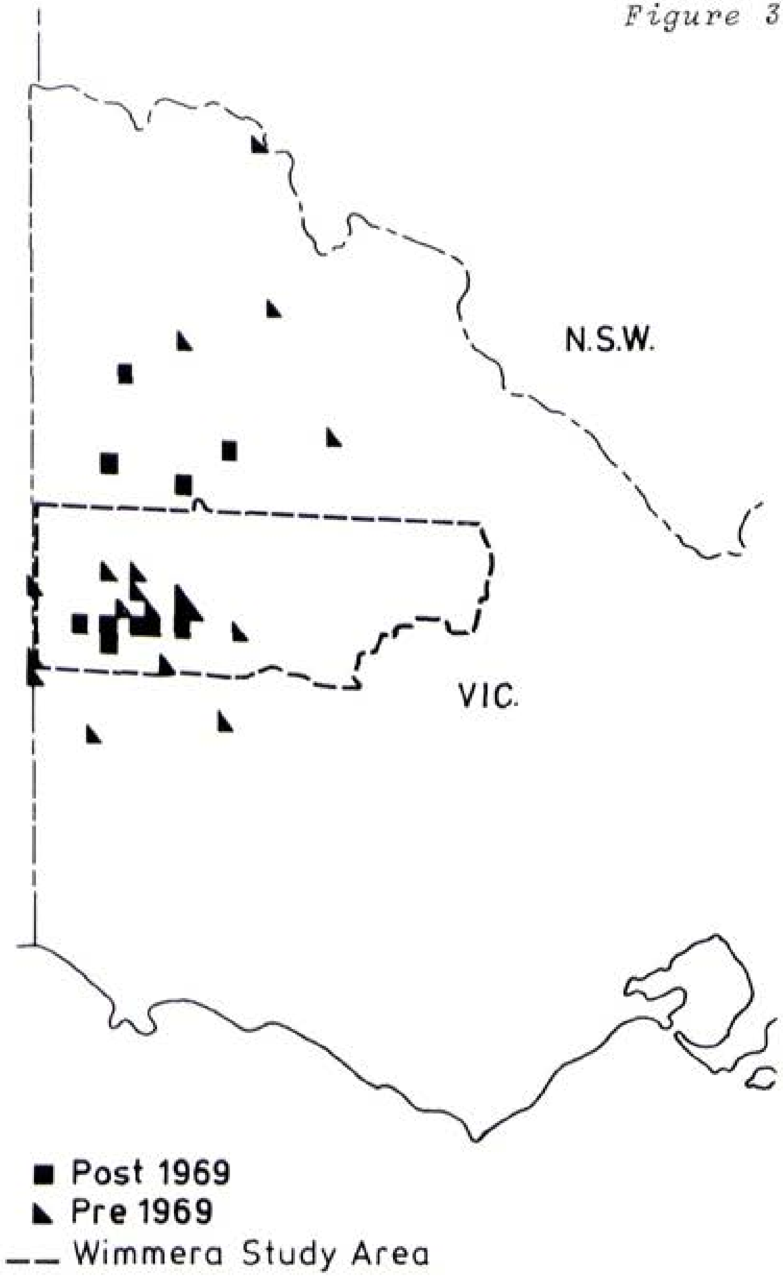
Fish

Of the 13 fish species that occur in the study area (see Appendix 2e), seven are introduced exotic species and four are introduced natives (Murray cod, freshwater catfish, golden perch, and western carp gudgeon).

The study area originally carried good stocks of warmwater native fish species, but the introduced exotic fish have largely replaced them. English perch are now the most abundant fish and are present in all waters, while carp, goldfish, and tench are also numberous, although not as widely distributed.

The small-sized native fish - western carp gudgeon, flat-headed gudgeon, and Australian smelt - have a limited distribution and are restricted to the river systems. The larger native fish - Murray cod, freshwater catfish, and golden perch - are present as remnant populations in a few waters.

Figure 3



Significant Species

The Wimmera study area contains important populations of several species considered to be of special interest, due to their rarity, restricted distributions, or scientific interest. A short account of such species for which the Wimmera provides significant habitat is given below.

Western pygmy-possum

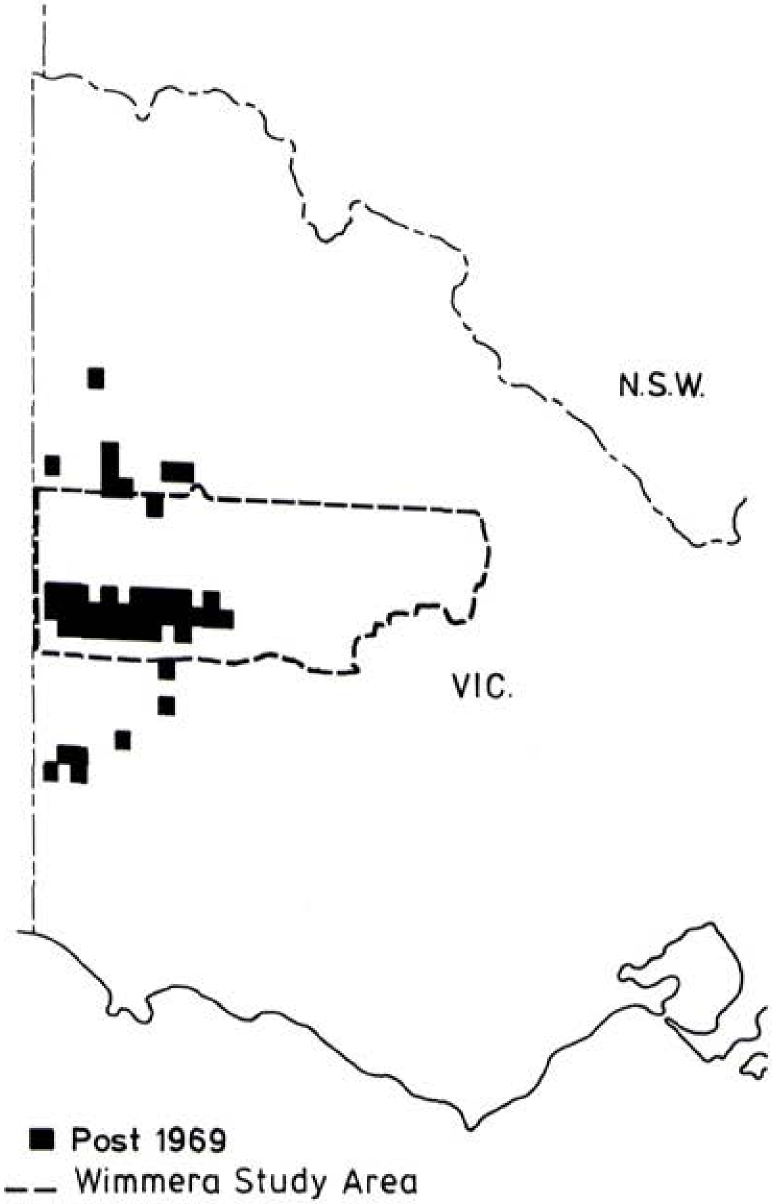
Inhabiting semi-arid heath and woodlands, the western pygmy possum *(Cercartetus concinnus)* is restricted in Victoria to the Little Desert regions and surrounding shrubby woodlands (see Figure 3). Most Victorian records have come from the Little Desert, where the species inhabits the brown stringybark alliance and yellow gum woodland.

Silky mouse

Zoologists first became aware that the silky mouse *(Pseudomys apodemoides)* occurred in Victoria as recently as 1963, when specimens from the Little Desert were correctly identified. It has since been shown to be widespread in both the Little and Big Deserts and in

The figures show the distribution in Victoria of the western pygmy-possum (Cercartetus concinnus) *- Figure 3 - and the silky mouse* (Pseudomys apodemoides) *- Figure 4 - in relation to the Wimmera study area.*

Figure 4



heathy woodland patches to the south (see Figure 4). The species occurs on deep sands carrying heath and mallee--heath communities. It particularly favours species-rich dense low vegetation containing desert banksia, beneath which its deep burrow systems are located.

Silky mice feed on seeds, some insects, and, during winter, flowers, particularly those of desert banksia. In the Little Desert breeding usually occurs in spring and summer, although in highly productive regenerating habitat it may occur year-round.

Mallee fowl

The Mallee fowl *(Leipoa ocellata)* is the only megapode, or mound-building bird, that occurs in semi-arid or arid environments. To incubate the eggs, the male regulates both solar energy and heat from decaying vegetation to maintain a constant temperature within the incubation chamber of the mound.

The unique incubation method of the Mallee fowl, in which the bird uses its tongue or bill to measure the temperature within the mound and then either adds or removes sand covering the egg chamber to achieve the desired temperature, is of extreme scientific interest.

All other species of megapode occur in the tropics or subtropics and use either heat generated by decaying vegetation or solar-heated sand to incubate their eggs, but do not actively regulate the temperature within the mound.

The Mallee fowl's range has declined greatly due to clearing of scrub for agriculture and the destruction of its food supply by sheep and rabbits. Within Victoria the species is now restricted to the three large remaining tracts of mallee vegetation - the Little Desert, Big Desert, and Sunset Country - with a small population around Wychitella in central Victoria.

The district south of Kiata, including the former Lowan Sanctuary, held one of the densest populations known. In recent years, however, the density of active mounds appears to have declined and concern has been expressed for the survival of Mallee fowl in the Little Desert. Mallee fowl prefer mature stands of mallee and mallee--broombush with a well-developed herb layer and dense litter. These conditions occur between about 20 and 60 years after disturbance by fire or clearing. Such habitat is becoming increasingly scarce due to wildfires and fuel-reduction burning programs throughout its Victorian range.

Australian bustard

Although widespread in inland and northern Australia, the Australian bustard *(Ardeotis australis)* is now common only on Cape York Peninsula and the Barkly Tablelands, and in the Kimberley region. It was virtually wiped out in Victoria before the turn of the century through destruction of native dry grasslands by grazing stock and rabbits. Shooting and predation by introduced carnivores have also contributed to its decline.

In Victoria, the Australian bustard regularly occurs along the southern edge of the Big Desert north of Yanac and Telopea Downs. Here small numbers of bustards feed in stubble and grazing paddocks and shelter in blocks of uncleared Crown land. Scrub-covered refuges are vital to the species, which is rarely far from such cover.

Banded stilt

The banded stilt *(Cladorhynchus leucocephalus)* inhabits saline lakes and shallow coastal inlets across southern Australia. It breeds in sometimes vast colonies on islands and spits in large, remote salt lakes in inland Western Australia and South Australia. Its food apparently consists entirely of brine shrimps.

In the Wimmera study area, banded stilts occur at salt-water lakes around the Little Desert, particularly at Mitre Lake, Lake Natimuk, Lake Wyn Wyn, the un-named lake north-east of Lake Wyn Wyn, and Loch Iel. The species is highly nomadic and numbers fluctuate enormously. Flocks of more than 6,000 have been recorded at Mitre Lake.

Opposite: a Mallee fowl mound.

Mallee emu-wren

The Mallee emu-wren *(Stipiturus ruficeps mallee)* occurs only in mallee vegetation with porcupine grass hummock grassland as an important component of the understorey. Porcupine grass is a key element of its habitat, being used for shelter and breeding as well as harbouring most of the emu-wren's insect food.

In Victoria, Mallee emu-wrens occur only in the Big Desert and Sunset Country, where patches of porcupine grass occur. Given the extreme flammability of porcupine grass, fire could easily wipe out family groups of Mallee emu-wrens and, in an extensive fire, whole populations could be destroyed.

Within the Wimmera study area, fine stands of porcupine grass hummock grassland with populations of Mallee emu-wrens occur on private land along the southern fringe of the Big Desert in areas once cleared for agriculture but since allowed to regenerate.

Rufous calamanthus

The low heaths of the Little Desert and adjacent Ninety Mile Plain in South Australia provide habitat for the slender-billed form (race *winiami*) of this species (*Sericornis campestris*). The species' several inland rufous forms (including *winiami*) are uncommon and patchily distributed and are presently the subject of much taxonomic debate. The Little Desert provides the most extensive and secure habitat of the slender-billed form.

Slender-billed thornbill

This little-known species *(Acanthiza iredalei)* is sparsely distributed across arid and semi-arid southern Australia in three isolated populations. It is not common anywhere. The easternmost race *(hedlyi)* is restricted to low heath in the Little Desert, Big Desert, and Ninety Mile Plain of South Australia, with a patchy distribution. While its precise habitat requirements are poorly understood, it appears to require dense low shrubs such as casuarinas, banksias, and hakeas. The Little Desert is the eastern limit of the species and supports the best population in Victoria.

Several other species of birds that are rare or threatened in Victoria are still recorded in the study area: plains wanderer, bush thick-knee, blue-bonnet, and grey-crowned babbler.

Aprasia striolata

Three species of these small, worm-like burrowing legless lizards occur in Victoria and all are restricted to sandy soils in the far west and north-west. Most records of *Aprasia striolata* come from the west of the Wimmera study area, where the species occurs in sandy loam soils along the northern edge of the Little Desert. Little is known of its specific requirements or conservation status because its burrowing habitats make it difficult to locate.

Pygopus species

Two species of these large legless lizards have been recorded in the study area. The common scaly-foot is widespread in the Little Desert, where it forages beneath dense heath vegetation. However, the hooded scaly-foot, which occurs on the cracking clay soils of the Wimmera plains and Murray Valley plains, has been recorded only once in the Wimmera study area - at Kewell in 1886. Clearing of the plains for agriculture and compaction of the soil by grazing stock have probably eliminated the hooded scaly-foot from the region.

Western blue-tongue lizard

This species *(Tiliqua occipitalis)* is widely distributed across semi-arid and arid southern Australia, where it is often associated with mallee or porcupine grass vegetation. In Victoria, it is known only in the north-west, including several records from mallee--broombush communities in the Little Desert. This represents the south-eastern limit of its range.

Bardick

This nocturnal thickset snake *(Echiopsis curta)* is the only member of its genus and occurs over much of semi-arid southern Australia. In Victoria it is restricted to the north-west and several records come from the northern edge of the Little Desert, the south-eastern limit of its range. Here, it seems to be associated with the ecotone between grassy box--gum--casuarina woodlands and heathy brown stringybark woodlands.

Bandy-bandy

The highly specialized burrowing snake, *Vermicella annulata*, feeds entirely on blind snakes *(Ramphotyphlops* spp.*)*. As blind snakes themselves have become rare in the Wimmera, the bandy-bandy is probably dying out there also. Several early records came from areas that formerly carried grassy box woodland but are now almost entirely cleared farmland.

Delicate skink

Of two populations of this species *(Lampropholis delicata)* known in Victoria, one extends across eastern Victoria to near Melbourne and another isolated population lives in and around the Little Desert. These two populations, separated by more than 300 km, are morphologically distinct and may be specifically distinct.

Effects of Fire on the Vertebrate Fauna

Fires affect faunal populations both directly - by burning individuals - and indirectly - by the destruction of the existing shelter and food resources and the subsequent regeneration of a new vegetation that differs structurally and sometimes floristically from the original.

The indirect effects are usually more significant as, although fires often kill individuals (mortality rates of up to 50% have been reported for birds), many probably survive all but the hottest wildfires. However, surviving individuals of territorial species must remain within their burnt territories.

The subsequent effects of a fire vary for each species and with the season and intensity of the fire. Some species are advantaged by the increased productivity of regenerating vegetation communities, others are disadvantaged by the major changes to their habitat caused by the fire, or by the extreme shortage of food and cover and increased predation pressure immediately following it.

In the Wimmera study area fires are a frequent and significant feature of the environment, particularly in heath and brown stringybark woodlands. In the gum--box--bull-oak and river red gum alliances they are much less frequent and probably less significant. Most are caused by lightning strikes during the period October to March. Since European settlement, many fires have been deliberately lit to promote grazing values or to reduce fuel loads in bushland in an attempt to protect agricultural land from wildfires.

Prior to European settlement, Aborigines also frequently burned the bush to drive animals during hunting and to encourage game to the new growth. Thus the vegetation and the fauna probably evolved with fire for tens of thousands of years.

The available information on the effects of fire on the fauna of each of the major alliances in the Little Desert is summarized below. Little research has been conducted on the fire ecology of the river red gum or gum--box--bull-oak alliances.

Heath

The heath communities of the Little Desert (including brown stringybark woodland with a heathy understorey) reach their greatest plant species diversity about 2 years after a fire. Species composition changes, but diversity is maintained for the next few years, after which it gradually declines over time until only about half the number of species remain after 40 years. Animal species that rely on seeds and flowers, such as the silky mouse, reach greatest densities in floristically rich heath, which is more likely to provide adequate year-round food supplies.

In the Little Desert, the silky mouse moves into heath when it is about 5 years old and does not seem to use heath older than about 20 years. It breeds here in late spring and summer. A fire during or shortly after the breeding period could seriously deplete the new generation of offspring - due to lack of food and increased population after the fire.

Some small insectivorous birds prefer the dense low cover provided by heath up to about 25 years old. For example, the slender-billed thornbill feeds inside the shrub layer - in banksia, casuarina, hakea, and tea-tree bushes - and rarely moves into open spaces.

In contrast, the variegated fairy-wren prefers older heath, which is more open due to senescence of some shrub species, such as casuarinas. The openings caused by the death of some shrubs provide feeding areas adjacent to the dense cover so important to small birds.

Very old heaths (about 50 years) provide greater structural diversity, as they include tall shrubs, large openings, areas of bare ground, and much tangled litter. These habitats provide excellent feeding areas for birds such as the hooded robin and willie wagtail, which obtain food by diving on it from an exposed perch.

Clearly, fire is the major factor determining the structure of the Little Desert heaths and consequently determines to a large extent the distribution of the heath fauna. This has implications for management - any burning program should aim at maintaining a floristic and structural mosaic. Additionally the spread of age classes should be skewed towards the older stands so as to retain the option of further burns should these become desirable as our understanding of fire ecology increases, or to allow for widespread, unplanned wildfires.

A major problem with fuel-reduction burns in heath is the season of burning. Because heath is so flammable, controlled burns are only possible in the cooler, wetter months (April to November in the Little Desert). However, fires during this period can actually inhibit seed regeneration of many species, which may have serious long-term consequences for fauna. On the other hand, burning in spring is not desirable because many species of birds and mammals would be breeding then, and most plants would not have flowered or set seed.

Mallee--broombush

Unlike heath this alliance does not need fire to regenerate and is much longer-lived; even 80- to 90-year-old stands can maintain their vigour and have a similar plant species richness to young stands. Although it regenerates well after fire, subsequent growth of shrubs and trees can be very slow.

Some bird species prefer the dense low cover and bare ground provided by broombush stands up to about 20 years old. These include the shy hylacola, southern scrub-robin, and golden whistler.

Others occur mainly in tall, very old mallee--broombush such as the 80- to 90-year-old stand in the former Kiata Lowan Sanctuary. Such species include the chestnut quail-thrush and purple-gaped honeyeater. Very old mallee trees within this alliance are vital sources of nest hollows. Additionally, the heaps of bark litter that develop around the base of the trees provide the main source of

Mallee fowl chick. This species prefers mature stands of mallee and mallee--broombush - and does not breed for about 20 years after a fire passes through its habitat.

cover and nest sites for pygmy-possums, ground-nesting birds such as the southern scrub-robin, and many reptilian species.

Thus it is important that mallee--broombush communities be burnt far less frequently than heath - certainly not less than every 25 years. Indeed, the broombush community growing on the red sandstone and ironstone rises in the Little Desert probably does not require burning at all. Very old stands represent a unique fauna habitat.

Mallee open scrub

With its dense canopy, open scrub layer, and extensive areas of bare ground, mallee open scrub is a distinct habitat that supports a distinct fauna, particularly in the case of birds and reptiles.

Mallee is also extremely flammable and most fires destroy all the above-ground vegetation. Although it resprouts quickly from lignotubers and, under favourable conditions, from seeds, it may take decades before the original structure and shrub understorey return.

Virtually no birds breed in mallee vegetation for 3 or 4 years after a fire. Bird species richness is highest in mallee older than about 15 years, when a structurally diverse vegetation has developed. Some species are restricted to mallee older than 20 years; these include birds that nest in hollows, dense litter, or tall trees, those using the dense eucalypt canopy, and many ground-frequenting species.

In old very open mallee with few shrubs, bird species richness can be very low. Thus, changes in species richness with time after fire may primarily reflect the changing structural complexity of the vegetation.

Burning of mallee should not occur more often than every 20--25 years, and very old stands having hollows and accumulations of bark litter should be protected from fire because of the importance of the hollows and other sites they provide for mammals, birds, and reptiles.

Invertebrates

As in most other areas, invertebrates dominate both the terrestrial and aquatic faunas of the Wimmera on the bases of number of individuals, number of species, and biomass. This underlies their important roles in plant feeding, nutrient cycling (through decomposition), parasitism, predation, pollination, and as a food source for many higher animals. In general, invertebrates play an essential role in ecosystem structure and function.

Despite their vital role in the ecosystem, however, no systematic ecological study of the invertebrates within the region has been made. Early naturalists

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generally neglected the Wimmera. A few localized collections were made within the area, but published information is rare.

The following information was compiled from the reference collections and associated records of the Museum of Victoria.

Habitats

Both the Little and Big Deserts probably have their own characteristic invertebrate faunas, which differ from those of the areas outside the 'deserts'. The vegetation that characterized the latter before settlement has largely been cleared. Consequently the remnants left in the central and eastern Wimmera (such as reserves, roadside verges, and streamside reserves) would be the major refuges outside the 'deserts' for many of the native invertebrates.

These remnants would harbour a cosmopolitan and exotic invertebrate fauna, with fewer species but larger populations than the 'deserts', and the potential for pest outbreaks would be greater.

The Wimmera would be expected to share many species with the adjacent regions of South Australia, but these areas have also been extensively cleared. Several species have a disjunct distribution between western Victoria and west of the Eyre Peninsula, presumably a result of the incursion of the sea in the past. Consequently the Wimmera would represent the easternmost distribution of several species in Australia.

The distribution of terrestrial invertebrates is determined by many different factors, ranging from climate, soil, and vegetation type down to individual plant species or the type of bark on a particular plant species. Herbivores can feed on plants by chewing leaves, sucking plant juices, making galls, or 'mining' leaves and stems, but many of them are host-plant species-specific and would not survive if their host plant was removed.

Many cryptic species rely on the maintenance of their microhabitats such as rotting logs, bark, litter, holes in trees, or a stable underground environment.

In aquatic habitats, the number of species and individuals of invertebrates increase with increasing detritus or vegetation in the water body. Furthermore, the fauna changes with increasing salinity from typical freshwater forms to saline species. True freshwater habitats in the Wimmera are becoming increasingly rare because of the growing salinity of the run-off, which is due to dryland salinity.

Insects

The Wimmera insect fauna contains many typical inland insects, and also has

Stigmodera yaralli *var.* elegans - *a jewel beetle. These are common in the Wimmera.*

Scaraphites linaeus - *a ground-dwelling carab beetle, also found in the study area.*

affinities with some Western Australian forms. In general, the orders Coleoptera (beetles), and Blattodea (cockroaches), Hemiptera (bugs and scales), and Isoptera (termites) are well represented here.

The local eucalypts and acacias have a large suite of bugs (Hemiptera) that are specific to host-plant species. These bugs include coreids, eurymelids, cicadellids, fulgorids, and psyllids, many of which are protected by ants that feed off the honeydew they excrete.

Foliage-feeding beetles such as chrysomelid, curculionid, and scarab species can also be restricted to particular host species. The jewel beetles (Buprestidae), especially *Stigmodera* spp., abound on the flowers of eucalypts, teatrees, and melaleucas. More than 83 species of buprestids are present in the Wimmera, of which some also occur in Western Australia.

The flowers of eucalypts and melaleucas also provide food for the native bees (Colletidae and Halictidae), of which at least 13 species occur in the Wimmera. The introduced honey bee *Apis mellifera* is expanding its range, and its effect on the native fauna is unknown.

Many butterflies occur in the Wimmera, and these rely on plants such as matrushes, sedges, quandongs, and mistletoes for reproduction. Many of the more colourful and large insects are vulnerable to over-collecting.

At the ground level, many insects depend on the litter layer, fallen logs, rocks, or even the clumps of porcupine grass for shelter. Many large species of cockroaches shelter in the porcupine grass clumps during the day and emerge to forage at night. Several springtail species (Collembola) rely on litter, logs, or rocks for survival, and leave these shelters only when the weather is cool and moist enough.

Many species of ground-dwelling carab beetles such as *Carenum*, *Neocarenum*, *Euryscaphus*, *Parroa*, and *Scaraphites* and the pie-dish beetle (Tenebrionidae) live in burrows underground or under porcupine grass clumps.

The weevil *Catasarcus* sp. occurs in the Big Desert, and has rarely been recorded outside Western Australia.

Ants are an abundant and important group of insects in the Wimmera - their activities include predation, scavenging, tending honeydew-producing bugs, and harvesting and dispersing seeds.

Aquatic insects commonly found here include dragonflies (Odonata), aquatic bugs (Corixidae and Notonectidae), aquatic beetles (Dytiscidae), and midges (Chironomidae). Caddis-flies (Trichoptera) are largely limited to fresh water with low salinity, and are thus vulnerable to rising salinity levels.

Crustacea

The majority of the crustaceans in the Wimmera are aquatic. These include ostracods, cladocera, copepods, decapods, and amphipods. The two species of *Notostracus* (tadpole shrimp) in Australia overlap here.

Arachnids

Arachnids found in the Wimmera include spiders, scorpions, pseudoscorpions, mites, and ticks. With the exception of some mites and ticks, all arachnids are predatory. Some are active hunters, while others rely on snares to catch their prey.

The Wimmera has a large complement of arboreal and ground-dwelling spiders. Plants harbour active hunting spiders such as salticids (jumping spiders) and thomisids (crab spiders). Web-builders that snare their food include orb-weavers (Argiopidae) and the colonial spider *Badumna* sp., whose messy webs and football-shaped retreats can be seen in many of the trees. Some of the larger hunting spiders, such as the huntsman, shelter beneath the bark of eucalypts.

The ground spiders include wolf spiders (Lycosids), the red-and-black spiders (*Nicodamus*), and the Mallee mouse spider

(Missulena sp.*)*.

Myriapods

The most common myriapod is the centipede (Chilopoda), a carnivore that dwells in plant litter and beneath logs on the ground.

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13. LAND ZONES

Within this report, separate chapters have been devoted to geology, geomorphology, climate, soils, and vegetation. These features are not distributed at random, nor do they occur independently. Rather, distinct environments consisting of characteristic patterns of geological material, land forms, soils, and vegetation can be recognized. These patterns often occur within a given range of climate, thus allowing large areas of land to be described in terms of 'land systems', each with a particular pattern of land features.

continued on page 164

The Wimmera River forms an almost flat alluvial plain (P2).

Table

LAND

Land form	Land zone	Map symbol	Geology	Native vegetation
Hills	Hills on granitic rocks	HG	Devonian granite and granodiorite	Woodland I grey box; yellow gum; light-wood
	Hills on sedimentary rocks	HS	Mainly meta-morphosed Ordovician sedimentary rocks	Woodland I grey box; yellow gum; light-wood
Alluvial aprons	Gentle outwash slopes flanking granitic hills	AG	Outwash derived from granitic rocks	Woodland I grey box; yellow gum; bull-oak
	Gentle outwash slopes flanking sedimentary hills	AS	Outwash derived from sedimentary rocks	Woodland I grey box; yellow gum; bull-oak

19

ZONES

Soils	Rainfall (average annual -mm)	Hazard	
		Form	Susceptibility
Coarse sandy soils of variable depth Uc 4.31 Rock outcrop common	375--425	Water erosion - sheet - gully Wind erosion	 High Moderate High
Shallow stony uniform loam soils Um 5.41 (steeper slopes) Stony red sodic duplex soils Dr 2.42 (gentler slopes)	375--425	Water erosion - sheet - gully	 High Moderate
Red calcareous sodic duplex soils Dr 2.23 Reddish-brown calcareous sodic uniform clay soils Ug 5.3 (minor)	375--425	Water erosion - sheet - gully Wind erosion	 High High High
Red calcareous sodic duplex soils Dr 2.43	375--425	Water erosion - sheet - gully Wind erosion	 Moderate High Moderate

Table 19 continued

Land form	Land zone	Map symbol	Geology	Native vegetation
Dunes, ridges, and sand-plains	East--west dunes and narrow inter-dune plains, sub-parabolic dunes and ridges trending NNW--SSE (Big Desert)	DS1	Quaternary aeolian sand (Lowan Sand)	Woodland I; shrubby open scrub brown stringybark; various mallees; broom honey-myrtle; broom baeckea; desert banksia; heathy vegetation
	Undulating sandplain with dunes and ridges trending NNW--SSE (Little Desert)	DS2	Quaternary aeolian sand (Lowan Sand)	Woodland I--II; shrubby open scrub; open heath yellow gum; brown stringy-bark; various mallees; slender cypress pine; broom honey-myrtle; broom baeckea; heathy vegetation
	Prominent ridges trending NNW--SSE	DS3	Quaternary aeolian deposits (Lowan Sand) Tertiary marine sandstone (Parilla Sand)	Woodland I; shrubby open scrub; open scrub yellow gum; bull-oak; brown stringybark; yellow mallee

Soils	Rainfall (average annual - mm)	Hazard	
		Form	Susceptibility
Deep uniform sand soils with colour B horizons Uc 2 Sandy mottled yellow duplex soils Dy 5.41 (plain)	350--475	Wind erosion	High
Deep sandy soils with colour B horizons Uc 2 (dune and plain) Sandy mottled yellow duplex soils Dy 5.41 (ridge and plain)	400-475	Wind erosion	High
Mottled yellow calcareous sodic duplex soils Dy 5.43 Uniform sandy soils with colour B horizons Uc 2	400--550	Wind erosion Water erosion - sheet - gully	High Moderate Moderate

Table 19 continued

Land form	Land zone	Map symbol	Geology	Native vegetation
Predominantly aeolian plains	Undulating clay plain with ridges trending NNW--SSE	Pa1	Quaternary aeolian deposits (Woorinen Formation) Minor tertiary marine sandstone (Parilla Sand)	Woodland I--II; open scrub yellow gum; bull-oak; black box; river red gum; various mallees
	Gently undulating to flat clay plain with occasional dunes trending E--W and subdued ridges trending NNW--SSE	Pa2	Quaternary aeolian deposits (Woorinen Formation) Tertiary marine sandstone (Parilla Sand)	Woodland I--II; open scrub yellow gum; bull-oak; black box; various mallees (north only)
	Undulating plain with E--W dunes	Pa3	Quaternary aeolian deposits (Woorinen Formation)	Woodland I-II; open scrub various mallees; black box; bull-oak; yellow gum

Soils	Rainfall (average annual - mm)	Hazard	
		Form	Susceptibility
Uniform grey calcareous sodic clay soils Ug 5.2	375--525	Wind erosion	High (ridge)
Red calcareous sodic duplex soils Dr 2		Water erosion	
		- sheet	Moderate (ridge)
Mottled yellow calcareous sodic duplex soils Dy 3.43 (plain), Dy 5.43 (ridge)		- gully	Low (ridge)
Uniform grey and reddish brown calcareous sodic clay soils Ug 5.2, Ug 5.3	350--450	Wind erosion	Moderate
Red sodic calcareous duplex soils Dr 2 (minor)		Dryland salting	Moderate
Brown calcareous gradational soils Gc 1.1 (Wilkur area)			
Dunes, ridges, and plain - Brown calcareous gradational soils Gc 1.1 Sandy mottled yellow calcareous sodic duplex soils Dy 5.4 Red calcareous sodic duplex soils Dr 2 (minor)	350--425	Wind erosion	High (ridges)
		Dryland salting	Moderate (depressions)
Depressions - Grey calcareous sodic uniform clay soils Ug 5.2			

Table 19 continued

Land form	Land zone	Map symbol	Geology	Native vegetation
Predominantly aeolian plains (continued..)	Undulating plain with numerous saline lakes and associated lunettes	Pa4	Quaternary aeolian deposits (Woorinen Formation) and Quaternary alluvium (includes gypsum flats and salt flats)	Woodland I; open shrubland; open scrub yellow gum; various mallees; black box (depressions); river red gum (lake and stream frontages); salt paperbark, halophytes (salt lake frontages)
Alluvial plains	Almost flat alluvial plain of the Avoca River and adjacent areas	P1	Quaternary alluvium	Woodland I--II grey box; yellow gum; bull-oak; black box (depressions); river red gum (stream frontages)
	Almost flat alluvial plain of the Wimmera and Richardson Rivers and Yarriambiack Creek	P2	Quaternary alluvium	Open forest II; woodland I--II river red gum; black box; yellow gum; grey box; bull-oak; yellow box

Soils	Rainfall (average annual - mm)	Hazard	
		Form	Susceptibility
Lunettes and other rises - Brown calcareous gradational soils Gc 1.1 Red calcareous sodic duplex soils Dr 2 (minor)	375--450	Wind erosion	High (rises) Moderate (plain)
Plain - Grey calcareous sodic uniform clay soils Ug 5.2 Mottled yellow calcareous sodic duplex soils Dy 3.43		Dryland salting	High (depressions)
Lake floor - Saline soils			
Red calcareous sodic duplex soils Dr 2.23 Grey calcareous sodic uniform clay soils Ug 5.2 (minor)	350--425	Wind erosion	Moderate
Grey calcareous sodic uniform clay soils Ug 5.2 Red calcareous sodic duplex soils Dr 2 (minor)	350--450	Wind erosion Dryland salting	Low Moderate

Table 19 continued

Land form	Land zone	Map symbol	Geology	Native vegetation
Alluvial plains with aeolian ridges	Alluvial plain with numerous lakes and lunettes, and ridges trending NNW--SSE	Paa	Plain - Quaternary alluvium Ridges - Tertiary marine sandstone (Parilla Sand) and Quaternary aeolian deposits	Woodland I; open scrub yellow gum; bull-oak; black box; river red gum; brown stringybark (sandy ridges); various mallees
Lakes and lunettes	Lakes and lunettes in Lake Buloke area	LL1	Quaternary alluvium and aeolian deposits	Woodland I--II; swamp and lake communities black box (depressions); river red gum (lake frontages); yellow gum
	Lakes and lunettes in Lake Hindmarsh area	LL2	Quaternary alluvium and aeolian lunette deposits	Woodland I--II; open scrub; swamp and lake communities yellow mallee; bull-oak; slender cypress pine; black box (depressions); river red gum (lake frontages)

Soils	Rainfall (average annual - mm)	Hazard Form	Hazard Susceptibility
Mottled yellow sodic duplex soils frequently calcareous Dy 3.43 (plain), Dy 5.43 (ridge)	450--550	Wind erosion	High (ridge and lunettes)
Red calcareous sodic duplex soils Dr 2 (plain and lunettes)		Water erosion - sheet	Moderate (ridge and lunettes)
Uniform grey calcareous sodic clay soils Ug 5.2 (plain)		- gully	Low (ridge)
Uniform sand soils with colour B horizons Uc 2 (ridge)			
Red calcareous sodic duplex soils Dr 2 (lunettes)	350--400	Wind erosion	High (lunettes)
Grey calcareous sodic uniform clay soils Ug 5.2 (depressions)		Water erosion - sheet and gully	Moderate (lunettes)
		Dryland salting	High (depressions)
Brown calcareous gradational soils Gc 1.1 (lunettes)	350--400	Wind erosion	High (lunettes)
Grey calcareous sodic uniform clay soils Ug 5.2 (depressions)		Water erosion - sheet	Moderate (lunettes)
Deep sand soils Uc (lunettes)		Dryland salting	Moderate (depressions)

This approach allows other attributes of the land - such as erosion hazard or problems of development - to be incorporated. Thus an understanding of the nature of land systems and a knowledge of their distribution is a valuable base for land-use planning.

The most detailed and fundamental unit for mapping and description is the land component, in which the climate, parent material, soil, position on land form, and vegetation have a narrow range of variation. Components usually occur in a limited number in a repetitive sequence, and an area containing such a sequence is termed a land system.

For the purpose of this report land systems have been grouped into land zones to highlight the major differences on a regional basis. Sixteen land zones have been recognized within the Wimmera area, and these are shown on Map 10.

In Table 19 the land zones are grouped according to their dominant land form, and details of the geology, vegetation, soils, rainfall, and susceptibility to various forms of land deterioration are given for each land zone.

More detailed descriptions of the hazards of soil deterioration may be found in Chapter 14, Hazards.

PART III

LAND USE

14. HAZARDS

Over millions of years, the interactions between such factors as climate, topography, geology, and living organisms have established a dynamic equilibrium between water regimes, soils, vegetation, and fauna.

Since European settlement, however, major alterations to the natural environment have taken place. Native vegetation and fauna have been removed or displaced by exotic pastures and introduced animals, soils have been cultivated, rivers dammed, and native forests managed for timber production.

The land has reacted in different ways according to its characteristics, and according to the type of use and management applied. Some land types are particularly sensitive to the changes being wrought on them; others are less so.

Anything that reduces the land's ability to sustain production of commodities required by the community at satisfactory levels of quantity and quality (and that may also threaten the productivity of adjacent land) is regarded as a hazard. Hazards associated with the management of land in the study area are discussed below.

Dryland Salting

Dryland salting has reduced agricultural production, initiated soil erosion (such as sheet and gully erosion), and increased the salinity of water in the dams and rivers.

Within the study area, it results mainly from the discharge of saline groundwater and may be either primary, where saline discharges were occurring long before European settlement, or secondary, where salinity has occurred since settlement as a result of clearing the natural vegetation for agriculture.

Of course, the two types often overlap somewhat, as development for agriculture has caused areas of primary salting to expand.

Secondary dryland salinity occurs because many of the plant species used in agriculture take less water from the soil than does the natural vegetation. So the soil saturates more readily and for longer periods and more water percolates down to the groundwater. This causes the saline water table to rise, eventually reaching the surface as saline seeps or stream contamination.

Secondary salting takes two forms: catchment and regional.

Where the topography is undulating and the groundwater surface appears as a subdued expression of the natural surface, salinity problems are mostly self-contained within a catchment or sub-catchment. Within the area, this kind of water table is generally associated with deeply weathered, very slowly permeable bedrock.

Where the groundwater surface is independent of the surface topography, the groundwater can probably flow across catchment boundaries. Saline areas caused by rising regional water tables are seldom the result of the management within just one catchment. The sub-surface materials associated with this salting are more permeable - fractured rock in the uplands or the major limestone and sand aquifers of the north-west.

Occurrences

Four types of dryland salinity occur within the study area.

Secondary catchment salinity is confined to the eastern section of the area, especially along the northern foothills of the Western Highlands. Although this type of salting causes serious damage in some of the valleys, its growth may be the easiest to reverse by land use management, as the saline areas result directly from activities in the catchment above them.

Secondary regional salinity occurs where groundwater from the extensive regional aquifer, known as the Parilla Sand, has risen to the surface. This groundwater has a salt content close to that of sea water, except where it overlies limestone beds in the west.

As a result, extensive saline areas are found north-east of Horsham, in locations both sides of the Richardson River, and sporadically through the Wimmera--Mallee area. They occur mainly in lower components of the landscape and where seepage from channels and storages means local humps in the otherwise generally planar groundwater surface.

Primary regional salinity, aggravated by secondary salinity, occurs east of Lake Hindmarsh, where saline discharge has appeared in many natural depressions that were not salt-affected immediately prior to European settlement. However, many are now thought to be the result of reactivation of ancient groundwater discharge sites that existed in a wetter climate 15--20,000 years ago. Saline discharge is also evident on the western side of Lake Hindmarsh for similar reasons, and many such areas are found south and east of Lake Buloke.

Primary salinity occurs throughout the central portion of the study area and in the Lake Buloke area to the east.

A chain of natural saline lakes to the west of the Wimmera River enters the study area near Mitre Rock. Lake Wyn Wyn and Mitre Lake belong to this series, which runs northward parallel to the river as far as Lake Hindmarsh.

While the origin of the salt in these lakes is unknown, possibly the ancient river that apparently formed the lakes dissected the alluvium and exposed the saline groundwater of the underlying Parilla Sand aquifer.

The Lake Buloke area north of Donald exhibits evidence of natural groundwater discharge. Clay lunettes on the eastern shores were formed during arid times by the blowing of saline mud from the lake floor. Saline groundwater was also recorded in pools formed in the lake floor during the 1982/83 drought.

Effects

Salted areas suffer a reduction in productivity or become completely unproductive. Problems arise because they are usually scattered through unaffected areas. The two types of land are therefore cultivated or grazed together, which results in an average loss of their productivity and an increase in erosion hazard.

In addition, where dryland salting occurs, the salinity of water in the drainage system usually increases. This results in increased levels of salt in the natural rivers and streams and can render water in farm dams unsuitable for domestic, irrigation, or stock purposes.

Dryland salting also spoils the landscape by causing the death of farm trees and shrubs along natural watercourses.

Since many of the smaller pockets of public land remaining in the area are associated with lakes, depressions, and creeks, the growth of saline areas as a result of land use practices on the surrounding private land is of some concern to managers of public land.

Bare salt-affected land west of Donald. Grass species have been replaced by salt-tolerant species, reducing productivity of the land.

Salting spoils the landscape by causing the death of farm trees.

Prevention and restoration

Dryland salinity is a complex problem and may demand different solutions, depending on its location, type, and severity.

On affected land, salt-tolerant plant species can be grown and the surface soil mulched to encourage transpiration and reduce surface evaporation.

The real cause of the problem, however, lies in the upper part of the catchment (the 'recharge area'). Land management must be changed so that more efficient water use by plants, trees, and shrubs can reduce the quantity of water infiltrating to the groundwater.

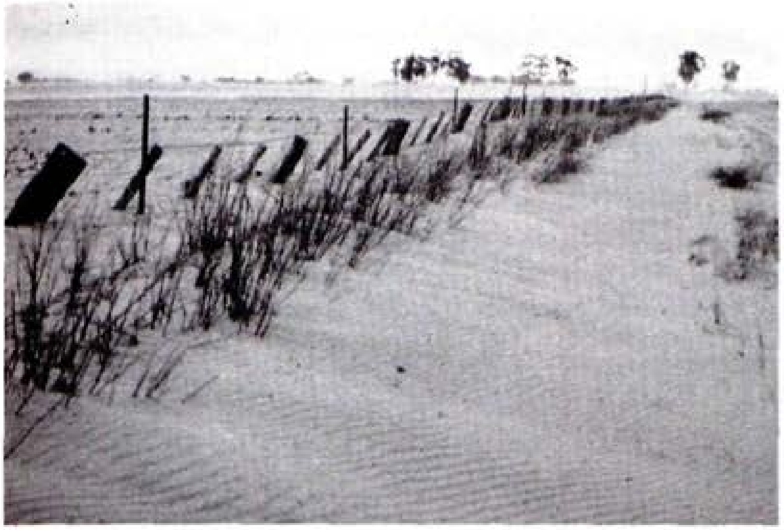
Hydrologic research into dryland salinity in north central Victoria indicates that only small quantities of water enter the groundwater per unit area - and the modification of existing farm practices, or the greater use of deep-rooted pasture plants like lucerne - may reduce the deep percolation sufficiently. The use of trees to take up the rainfall may be the only answer on some specific areas of land that permit high rates of deep percolation to groundwater.

The most severe occurrences of dryland salting mentioned have developed during the last 40 years. Many areas are still expanding, while some may have reached a new equilibrium where additional drainage and evaporation from saline areas balances excess input to the groundwater. In most cases, we do not have sufficient data to determine if or when that point is likely to be reached.

Wind Erosion

The risk of wind erosion generally increases with decreasing rainfall, and with increasing sand content in the topsoil. It is related to the density of vegetation cover, particularly when the soil is dry, and to the ease with which vegetation can be restored after disturbance.

Regular severe wind erosion is usually restricted to land with very sandy topsoils where vegetative protection is reduced, such as cleared parts of the



The results of wind erosion at Dooboob-etic during the 1982/83 drought.

Big Desert and the lunettes of Lake Hindmarsh.

Often, however, it causes considerable damage to other sandy areas, particularly in dry years when overgrazing or poor crops leave the soil sparsely protected. Such areas include the fringes of the Little Desert, the NNW--SSE ridges west of the Wimmera River, the granitic soils around Buckrabanyule and Yowang Hill, and other small sandy rises and dunes throughout the study area.

Even the self-mulching dark clay soils of the Wimmera plains, which have an inherently low susceptibility to wind erosion, are being significantly eroded on many properties in dry periods due to breakdown of surface structure by over-cultivation.

During drought years, damage can extend to the hard-setting duplex soils of the plains and undulating country throughout the area. Stock remove the protective cover of stubble, crops, or pastures and break up the coarse tilth prepared on bare fallows. Their hooves detach soil from the hard surface, leaving it susceptible to removal by the strong dry winds. Soil losses of between 20 and 50 tonnes per hectare were common in the Charlton area in the 1982/83 drought and few farms had sufficient conserved fodder to prevent the need for stock to roam the whole property during that time.

Prevention and control

Areas prone to wind erosion require specialized management techniques. Much of the worst erosion is caused by inappropriate or excessive cultivation of sensitive land, or by overgrazing during the summer months.

Prevention of wind erosion can be achieved by retaining a good protective cover of crop, stubble, or pasture, and by special cultivation techniques such as the preparation of cloddy fallows in cultivated paddocks.

Where wind erosion already occurs, emergency control methods are often employed. Deep cultivation to provide a rough cloddy surface or ridging the paddocks

Gully erosion on the lower slopes of granitic Yowang Hill.

perpendicular to the prevailing winds are the usual methods.

In areas of severe hazard such as the lunettes of Lake Hindmarsh, permanent revegetation programs have been implemented, using pasture species, such as perennial veldt grass and lucerne, or native pérennial species such as cypress pines. Perennial veldt grass, however, has the potential to be a serious weed problem in the future. Concurrent rabbit control measures are also essential for these programs to succeed.

Water Erosion

Any activity that removes protective vegetative ground cover, such as over-cropping or summer cultivation, increases the hazard of water erosion. Summer storms of high intensity on these exposed areas produce overland water flows, causing sheet erosion and the scouring of drainage depressions.

Sheet erosion is a serious problem on most of the sloping land in the study area, particularly on cultivated land. However, the most serious hazards are associated with the hills and slopes of the granitic and sedimentary terrain to the east. The soils here are highly erodible, having weakly structured topsoils with low organic matter contents.

Significant levels of sheet erosion also occur along a strip on the eastern side of the Wimmera River north of Dimboola, on the prominent NNW--SSE ridges west of Dimboola, and on the lunettes near Lake Buloke and Lake Hindmarsh.

The areas at greatest risk from gully erosion are the lower slopes and valleys on, or adjacent to, the steeper granitic or sedimentary hills and ridges in the east. Subsoils in these areas tend to disperse and slake readily, resulting in soil detachment and erosion. Gully erosion also occurs on the prominent NNW --SSE ridges mentioned above and, to a lesser extent, along the strip bordering the eastern side of the Wimmera River.

Dryland salting may also initiate gully erosion by inhibiting the growth of a protective vegetative cover. Gully erosion, although directly affecting only a small proportion of the land, has major detrimental effects such as damage to roads and bridges, restriction of movement of stock and vehicles, and increased flooding and sedimentation downstream.

Control

On cleared land the control of sheet and gully erosion involves the use of management techniques that retain a strong vegetative ground cover (such as minimum tillage) and the careful disposal of run-off along slightly graded banks and grassed waterways. Where severe gully erosion threatens productive lands and public utilities such as roads, concrete structures are built at the head of the gully to prevent further extension upstream. Revegetation of cleared areas with deep-rooted pasture species and native trees reduces run-off and can provide a permanent solution to most erosion problems.

Soil Deterioration

Structure decline

Deterioration in soil structure has been (and remains) one of the most important hazards affecting soils in the area.

Particularly susceptible are the duplex soils of the plains, and the soils derived from Palaeozoic rocks. The compaction and decline in structure of the topsoil result largely from vehicular traffic, trampling by stock, and excessive cultivation. With the loss of structure, the soil surface sets hard, thereby reducing crop or pasture germination and water infiltration. The resultant increase in run-off often leads to soil erosion problems.

Even on the grey self-mulching clays, continuous cropping has resulted in some deterioration in soil structure, rendering them more difficult to work, particularly when wet. However, many of these soils are presently cropped under a three- or four-course rotation, which apparently causes little structural damage. Predicted increases in cropping intensity may increase the hazard, but the tendency towards less mechanical cultivation would offset this.

The red and brown soils of the area have deteriorated structurally under cropping and in many cases can now only be maintained in workable condition through regular applications of gypsum. Other methods of maintaining topsoil structure include stubble mulching and reducing the number of cultivations.

Nutrient decline

Depletion of soil nutrients is not a major problem, except when deep sands of intrinsically low nutrient status are cropped.

Chemical residues

Awareness of the potentially deleterious effects on soil biology of chemical residues has resulted in careful scrutiny of all chemicals used in agriculture and deregistration of some (such as mercury-based seed treatments). Those now registered for broad-acre use in the study area have high specificity and/or rapid breakdown to harmless residues. Thus, despite their increased use, agricultural chemicals are unlikely to become a significant hazard.

Tree Removal

Removal of trees from public and private lands by farmers continues to be a significant hazard in the study area.

Larger agricultural equipment, with greater clearance requirements and less manoeuvrability, requires the removal of trees within cropping paddocks, along old fence lines (now removed to give larger paddocks), and even on public lanes and roadways linking paddocks and farms.

Decreasing economic importance of livestock enterprises has reduced the perceived importance of trees for shelter and shade.

On most of the agricultural land in the study area, cultivation or grazing prevents natural re-establishment of trees. Establishment of trees by man is usually confined to the vicinity of the homestead.

Grazing has also prevented natural regeneration of native species, particularly bull-oak, on many small areas of public land and road reserves. Thus the trees remaining are usually very old and senescent, and as a result the Wimmera plains may soon become an almost treeless landscape.

Flooding

Three main systems drain the Wimmera region: Wimmera, Avoca, and Richardson Rivers. These Wimmera streams, which have effluents and anabranches as a general feature, all flow generally northward, usually terminating in shallow lakes that are frequently dry. Only the

Avoca River overflows to the Murray, and then only in major floods after filling terminal basins.

The extent to which flooding affects particular parts of the region is not known with any certainty except in some of the urban areas. An approximate indication can be obtained from the geological map (Map 5), which shows recent alluvial deposits.

Wimmera River system

The Wimmera River is the largest of all streams in the study area and has the greatest flooding potential. Near its junction with Mount William Creek, a complex network of anabranches has developed on the combined flood-plain of both streams and two important effluents emerge - the Yarriambiack and Dunmunkle Creeks.

Horsham under flood in 1906.

Yarriambiack Creek flows north through Warracknabeal in a well-defined broad valley. A series of weirs built along the creek for recreational purposes can create problems in time of flood by causing water to spread out further than it would under natural conditions. Two main problems result from flooding in this creek - damage to crops and cutting of roads. Flood-waters occasionally threaten part of the town of Warracknabeal, where the frequency and extent of flooding is currently the subject of a study by the Rural Water Commission.

Dunmunkle Creek flows north from Glenorchy through Rupanyup, and for part of its course is used as a domestic and stock water supply channel. Flooding in the creek is rare, and of short duration when it occurs. Damage to crops is the main result. In most cases, excess flood-water can be assimilated into the domestic and stock water supply system.

The Wimmera River itself may flood large areas of farmland, cut a number of arterial roads, and threaten urban areas at Horsham, Dimboola, and Jeparit. The Water Commission has recently completed a detailed study of flooding at Horsham, and has recommended a co-ordinated program of protective works.

Avoca River

The character of the Avoca River changes downstream of Charlton from a reasonably well-defined course, where flooding is confined, to a divergent stream where the main course has a very limited capacity and flood-waters spread out over a wide area, following effluent courses that are often poorly defined. Floods can cause considerable damage to crops and cut arterial roads, including the Calder Highway.

The larger floods threaten part of the township of Charlton. The Water Commission is currently carrying out a study of the Avoca River downstream from there, with the aim of developing a regional strategy for flood-plain management.

Richardson River

Little information is available on the flood characteristics of the Richardson River, which is not seen as having major flooding problems. While damage to crops is always possible in time of flood, the threat to urban development at Donald is minor.

Water Pollution

Water quality in the Wimmera River has caused concern in recent years. The problems experienced include high salinity, colour, and nutrient levels, depressed dissolved oxygen levels, and nuisance aquatic weed growths. Factors contributing to these problems are mostly diffuse inputs such as leaching of saline soils, colour from the decay of plant matter, and nutrients in run-off from both dryland and irrigated agricultural areas.

The major point source of pollutants entering the river is the discharge from the City of Horsham's sewage-treatment

Above: Nuisance growth of Phragmites *on the Wimmera River near Jeparit.*

Opposite: Burnt area of heath in the Little Desert. This vegetation type presents an extreme fire hazard.

works to the McKenzie River prior to its confluence with the Wimmera River 5 km downstream of the city. Components of this discharge causing most concern are the nutrients, in particular phosphorus, which may contribute to the nuisance aquatic plant growths, especially of *Phragmites australis* (common reed) observed along the Wimmera River below Horsham.

A State Environment Protection Policy for the Wimmera River and its catchment is currently in preparation. It will address such issues as beneficial uses and factors affecting water quality. In particular, it will examine methods of reducing the impact of diffuse sources of pollution and the discharge of the City of Horsham's sewage-treatment works.

Fire

Fires are a natural part of the environment here, and their effects are not always deleterious.

In the 15 years from the 1969/70 to 1983/84 fire seasons, Forests Commission personnel attended a total of 71 fires in the study area. During this period, fire burnt a total of approximately 69,000 ha, producing an average fire area of 970 ha. The majority of fires (67%) occur in the Little Desert Crown land block (including the National Park) where logistic and environmental factors result in the burning of relatively large areas.

One-half of all fires have been started by lightning (see Table 20), which may be produced by cold fronts approaching from the west after periods of high temperatures and hot northerly winds. Such conditions often make fire control extremely difficult. The remoteness of some areas and the low speed of access due to deep sands on tracks may result in delays of several hours for first-attack fire suppression. Prior to the 1977/78 fire season, fire-prevention works were largely restricted to chained 60-m fire-breaks. Since then, large-scale fuel-reduction programs involving controlled burning, wide-perimeter-break construction, and track upgrading have reduced fire sizes generally. However, the ecological effects of the present regime of controlled burns may necessitate changes in the frequency and season of burning.

Woodlands dominated by river red gum or the gum--box--bull-oak association present a variable fire hazard, depending on the annual growth of grass. These woodlands, however, cover only a minor portion (5%) of the public land, generally as remnant stands around water reserves, and low-lying areas too wet for cereal production.

The pale infertile sands of the Little Desert area support three vegetation associations, with 65% of the public land dominated by brown stringybark woodlands and open scrub (5--15 m). This vegetation type has a dense heath understorey and occurs predominantly on the low-level dunes. Between the dunes, the flatter sandy plains support low (0--2 m) heaths (20% of the total area). Both these associations present an extreme fire hazard and burn intensely even under mild conditions.

Due to a less continuous vertical fuel distribution and lower fuel quantities, the mallee--broombush association of the Little and Big Deserts presents a lesser fire hazard, since it requires stronger winds to maintain constant forward rates of spread. The mallee associations occupy approximately 10% of the public land within the study area.

Fire suppression is carried out by the Department of Conservation, Forests and Lands personnel on public land and by rural fire brigades on private property. However, co-operative efforts by both organizations are the norm, with the local fire brigade often providing the first-attack crew until Departmental resources arrive to complete the suppression works. Within the Little Desert block, access for two-wheel-drive C.F.A. tankers is limited, forcing them to remain on sealed roads primarily to control fire advances into and from public land.

Little of the public land has water readily available - the few dams are unreliable, especially towards the middle of the fire season. Dry fire fighting techniques involving dozer line construction and follow-up patrols have proved most effective, as the general nature of the bush does not produce excessive mop-up problems requiring large volumes of water. The most common problems encountered involve the sustained short-distance spotting of the fibrous bark from brown stringybark stems and the very high forward rates of spread across the low heath plains.

Several fire-prevention measures are adopted on public lands.

Surrounding the entire Little Desert block is a break 3 chains (60 m) wide, constructed between 1972 and 1975 using Departmental and hired equipment. Prohibitive plant costs make it uneconomic to re-chain these breaks at present. The breaks are being maintained and extended by a controlled burning regime that involves burning the original break and a recently constructed internal 60-m break alternately every 3 years. This has the effect of producing an effective 120-m-wide wildfire barrier at substantially reduced costs. All boundary tracks are disced and internal tracks slashed on a similar rotation.

Fuel-reduction burning is practicable - although not always appropriate - in all vegetation types (except the yellow gum and red gum flats, where the light ground fuels generally will not carry fire) with strategic internal strip and/or block burns being implemented in April and October of each year.

In the public land outside the Little Desert, the initial fire-prevention measures involve boundary break construction (normally 20 m wide) and internal track maintenance by discing or slashing as required. This boundary break construction around previously unprotected blocks is an ongoing program. Emergency crossing points are maintained across the Wimmera River.

Township protection in those towns with significant Crown land areas - Dimboola, Wail, Gerang Gerung, and Kiata - is carried out on an annual basis in conjunction with local C.F.A. brigades. It involves fuel-reduction burning and/or mechanical reduction as required.

Detection of fires throughout the area depends on the fixed lookout tower at Mount Arapiles (jointly funded by the Department of Conservation, Forests and Lands and the C.F.A.) located on the southern boundary of the study area 35 km west of Horsham. Fixed-wind aircraft flights are often undertaken soon after electrical storms have passed over the more remote areas. Both methods are continually supported by additional observation by local landholders, forest workers, and Departmental personnel.

Weeds

The presence of weeds on public land causes concern for various reasons. On recreation areas, they may be aesthetically displeasing, cause discomfort through prickles or thorns, or have poisonous properties. In nature conservation areas they compete with native plants and are aesthetically undesirable. Measures to control them may be incompatible with management aims. Often weeds on public land pose a real danger to adjoining land. Their removal from large areas of public land has been in the past, and will continue to be in the future, a great cost to the taxpayer.

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Table

SUMMARY OF FIRE ORIGIN, CAUSE, AND

Year	Lightning		Deliberate		Escapes from private property		Machinery defects	
	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)
1972/73	3	1,320	1	400	1	320	-	-
1973/74	1	<1	-	-	-	-	-	-
1974/75	1	700	-	-	1	40	1	60
1975/76	1	4,050	1	580	-	-	-	-
1976/77	9	33,600	-	-	-	-	1	10
1977/78	3	2,985	-	-	2	4,375	-	-
1978/79	-	-	-	-	1	27	1	8
1979/80	5	290	-	-	-	-	1	60
1980/81	7	614	1	100	2	265	3	10,050
1981/82	2	2,000	-	-	3	1,280	-	-
1982/83	-	-	1	3,400	2	24	-	-
1983/84	-	-	-	-	-	-	-	-
Totals	32	45,559	4	4,480	12	6,331	7	10,188
Percentages	51	67	6	7	19	9	11	15

* As at 21 February 1984. The table includes all fires attended by Departmental personnel in that part of the Dimboola forest district that was within the Wimmera area (this covers

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AREA BURNT (1972/73 to 1983/84*)

Cigarettes/ matches		Tourists/ campers		Miscellaneous		Unknown		Totals	
No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)
-	-	1	<1	-	-	1	<1	7	2,040
-	-	-	-	-	-	-	-	1	<1
-	-	1	8	1	<1	1	<1	6	809
1	5	-	-	-	-	-	-	3	4,635
-	-	-	-	-	-	1	<1	11	33,610
-	-	-	-	-	-	-	-	5	7,360
-	-	-	-	-	-	-	-	2	35
-	-	-	-	1	2	-	-	7	352
-	-	-	-	-	-	-	-	13	11,029
-	-	-	-	-	-	-	-	5	3,280
-	-	-	-	-	-	-	-	3	3,424
-	-	-	-	1	1,500	-	-	1	1,500
1	5	1	8	3	1,502	3	1	63	68,074
1.5	<1	1.5	<1	5	2	5	<1	100.0	100.0

most of the public land in the study area). It includes fires that started outside the study area.

Although some 41 noxious weeds are recorded as being present here (see Appendix 3) only a relatively small number cause any immediate threat to public land in the study area.

Skeleton weed

The most widespread problem species - skeleton weed - grows on a range of soil types, but predominantly on the lighter sandy soils that have been disturbed. Over the past few years biological control of this weed has been reasonably successful using a group of gall mites, gall midges, and rust fungi. Currently one type of skeleton weed (Type C) has not been attacked by the fungi and is apparently increasing in density.

African love-grass

This recently proclaimed noxious weed is firmly established in places adjacent to the study area and occurs as scattered patches throughout the area. At the moment, its significance as a threat to public land remains unknown.

Horehound

Creating problems throughout the region, horehound is generally found on lighter soils, especially in areas used exclusively for grazing such as horse paddocks and yards. It can be a major problem on undisturbed public land and, if not controlled, leads to the exclusion of all other plant species.

Boneseed

This notorious bushland invader of the Mornington Peninsula and the You Yangs grows over a large area around the edges of Lake Hindmarsh. Although rabbits eat it at the seedling stage of growth, this practice does not appear to be inhibiting its spread in dune and sandy country. The plant can strongly invade areas of native vegetation, whether the habitat is disturbed or not.

Spiny burr-grass

This weed is very hard to distinguish from other grasses until actually flowering and seeding, making early control difficult. Its needle-sharp spines stick to almost anything that brushes against it, ensuring ready spread even by means of native animals, rabbits, foxes, etc.

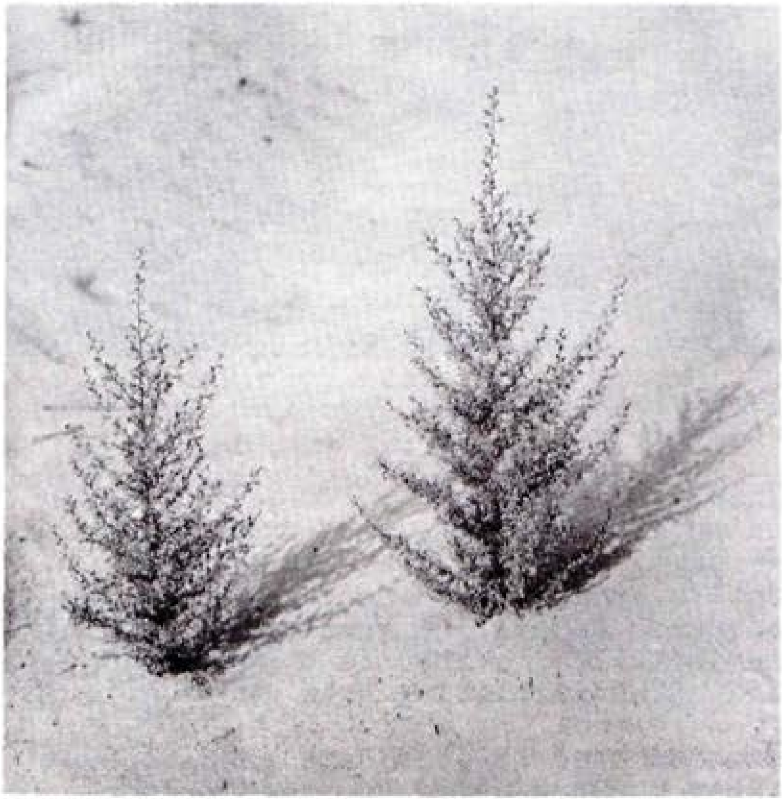
The weed is very prolific in many areas of public land throughout the region.

Stinkwort

Formerly of major concern along roadways and agricultural land, stinkwort will invade areas of public land. The plant has a most unpleasant odour and is generally regarded as undesirable for this reason. It prefers land that is occasionally cultivated, as opposed to undisturbed areas, and therefore is much less common in natural bushland than in places such as wayside rest areas.

Other weeds

Burry and prickly plants form another important group among the noxious weeds - Bathurst burr, caltrop (bindii), spiny emex, Californian burr, noogoora burr, saffron thistle, and stemless onopordum (stemless thistle). These plants are prevalent on much of the public land in the study area, including roadsides, reserves, and land held under grazing leases or licences. Many are characterized by successive germination and the ability to flower and fruit under adverse conditions.



Stinkwort - a noxious weed that invades disturbed sites in the Wimmera.

Other common weeds in the study area include: hoary cress, soursob, bindweed, and cropping knapweed (hardheads). However, these generally cause major problems on agricultural land only.

A plant of particular concern on public land is smilax asparagus: although not a declared noxious weed, it is causing considerable problems on sandy soils at Lake Hindmarsh and along the Wimmera River. Various species of native mistletoe can be a threat to remnant areas of gum--box--bull-oak woodlands. Their effect is particularly evident along roadsides in the Wimmera.

Animal Pests

Pest species of animals present problems in the use and management of public land. For example, rabbits compete with native fauna and feed voraciously on the vegetation, thus leading at times to soil erosion and the elimination of some plant species, while giving many weed species the very conditions they require to establish. Control by poisoning may kill some native animals and this practice may conflict with the aims of management.

Declared vermin found in the Wimmera are rabbits, foxes, hares, and wild dogs.

Predation by foxes may affect Mallee fowl populations.

Good grain harvests may lead to mouse plagues.

In addition, house mice, feral cats, starlings, sparrows, kangaroos, emus, long-billed corellas and locusts are considered to be pests in some circumstances.

Rabbits

Although found throughout the study area, rabbits normally pose a major problem only in areas west of Horsham or on some of the sandier country around Charlton in the east. On public lands, as on grazing land, they compete for herbage, often to the exclusion of native mammals. In doing so they can severely damage the vegetation, depleting wildlife habitats and populations, and often initiating soil erosion.

Methods used to eradicate rabbits when their numbers build up have included poisoning with 1080, infecting with myxoma virus, fumigation, and ripping up warrens. A major concern on public land within the study area is the rabbit damage along the foreshore and adjoining areas of Lake Hindmarsh, including sand dunes to the east of the lake.

Feral cats

These cats are widespread in the study area, but more common on farms than on public land. Feral cats are opportunistic predators and scavengers, and their diet depends on availability of prey species. In undisturbed scrub, small native mammals and reptiles form a great part of their diet, whereas rabbits and house mice are the main animals eaten in farming areas.

Foxes

Also widespread in the study area, foxes mainly live on mice, rabbits, and carrion, although most also eat herbage, birds, and insects. Of particular concern, however, is the effect of their predation on Mallee fowl populations.

Hares

Hares are occasionally found within the area and do not appear to present any problems.

Mice

Occasionally, when conditions are ideal -plentiful supplies of food through good grain harvests, and summer rainfall followed by a mild winter - the mouse population grows to plague proportions and inflicts severe losses on farms and towns. The last plague here was in 1983/84 and predation, trapping, and poisoning failed to control it. Natural causes eventually lead to the reduction in numbers back to normal levels.

Exotic birds

Sparrows and starlings are widespread in the State and compete successfully with native birds for food and nest sites. No official regulatory action has been taken as yet although the birds can also cause damage to crops and carry poultry diseases.

Native animal and bird pests

The Wimmera study area contains a number of native species that can from time to time cause significant economic damage to the rural community.

Western grey kangaroos frequently damage fences, eat crops and pasture, trample crops, and compete with stock for feed and water in drought years. Emus cause similar damage, with the emphasis on fence damage and crop trampling. Brush-tail possums may damage trees or foul stored grain in localized areas if they are in high numbers.

The Fisheries and Wildlife Service, in conjunction with the National Parks Service, has undertaken kangaroo population studies in the Hattah-Kulkyne and Wyperfeld National Parks to the north in an attempt to formulate a management program. Culling may be required on Crown land when numbers become excessive, to prevent damage to the environment.

Long-billed corellas, sulphur-crested cockatoos, and galahs have caused considerable damage to farmland by pulling up germinating crops, eating mature cereal crops, and damaging or cutting off the heads of mature oil-seed crops (particularly corellas on sunflower crops). Other destructive activities include digging holes in grass tennis courts and golf greens or tearing up malthoid cricket pitches. The restricted distri-

Flocks of long-billed corellas may cause considerable damage to farmland.

Table 21

INSECT PESTS

Crop or pasture affected	Insect pests	
	Common name	Scientific name
Cereals	Armyworm	*Mythimna convecta* *Persectania ewingii* *Persectania dyscrita*
	Cereal aphids	**Rhopalosiphum maidis* **Rhopalosiphum padi*
	Cereal cyst nematode	*Heterodera avenae*
	Webworm	*Hednota* sp.
Leguminous pastures	Lucerne flea	*Sminthurus viridis*
	Red-legged earth mite	*Halotydeus destructor*
	Spotted alfalfa aphid	**Therioaphid trifolii*
	Blue-green aphid	**Acryrthosiphum kondoi*
Rye-grass pasture	Anthelid larvae	*Anthelid* sp.
Peas, lupins, and sunflowers	Native budworm	*Heliothis punctiger*
	Cutworms	*Agrostis munda*
Sunflowers and saf-flowers	Rutherglen bug	*Nysius vinitor*
All enterprises during plague years	Australian plague locust	*Chortoicetes termini-fera*

* Exotic species

bution of the long-billed corella has resulted in research into the species so that acceptable control measures can be adopted without placing the species at risk.

The Fisheries and Wildlife Service has been approached to permit the use of poisons, particularly for long-billed corellas and galahs, but has refused because of the risk of destroying large numbers of non-target species.

In municipalities where long-billed corellas and sulphur-crested cockatoos have posed significant problems, the birds have been removed from the protected list - to allow affected land-owners greater control and eliminate the need for a large number of almost continuous permits on their land.

A few other native species may cause minor problems on freehold land. Black swans have eaten, trampled, and fouled crops and pasture, along with Eurasian coots in areas adjacent to swamps. Ravens have been reported to have attacked lambing ewes and new lambs, but it is felt that this only occurs with sick, weak, or dead animals.

In most cases specific permits are issued where economic damage is occurring so that the land-owner can legally shoot a pre-determined number of the offending species. Other tactics such as scare guns, scare cartridges, or scarecrows are frequently used in conjunction with shooting.

Destructive insects

The study area contains many insect pests of cereals and pasture species, some of which are listed in Table 21.

The Australian plague locust, *Chortoicetes terminifera*, is a problem in some years, when suitable conditions for hatching and survival occur in New South Wales and, to a lesser extent, north-western Victoria. While damage to cultivated plants and pastures can be significant, the effect on native vegetation is usually slight.

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15. CONSERVATION

Conservation is concerned with man's relation to his environment. The need for conservation of economic resources is obvious, because society uses them for many of the material comforts of modern life. These aspects are considered in subsequent chapters under such headings as timber production, water utilization, and minerals and stone.

Conservation also embodies the concept of preservation and protection of native species, natural features, and landscapes - and preservation of archaeological and historical features. In recent years, society has placed greater emphasis on the need to protect and preserve these attributes. Management to achieve these aims is important when land is set aside for reference, conservation of species, recreation, and education. None of these uses necessarily monopolizes the land; often conservation uses are compatible with each other or with commercially productive uses.

Use of Conservation Areas

Reference areas

The solution to problems in land use (such as falling productivity) is often helped by reference to an undisturbed example of that land type. Here the soils, vegetation, and fauna, and the processes linking them, can be studied under natural conditions.

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 employed, to breed plants and animals with required 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; access should be restricted, experimental manipulation should not be allowed, and they should be protected by a buffer zone.

Although all land types should be represented in reference areas, the need is most urgent in those that have already been extensively developed for various uses.

Few, if any, areas suitable for reference remain for some land types in the study area. For example, the grassy open woodlands that were once widespread over the area have been extensively altered by agriculture and only small pockets remain in public ownership.

Conservation of species

Each species of plant and animal is a unique assortment of biological characteristics, evolved over millions of years, which makes a contribution to the richness and diversity of the environment. Each is part of man's natural heritage, potentially offering an enrichment of our knowledge; as such, many people feel a moral responsibility to ensure that none should knowingly be lost or endangered.

Chemists, geneticists, physiologists, and scientists in many other disciplines place a special value on each species for its potential - to provide the means of solving research problems or to act as the stock for breeding essential plants or animals.

Conservation of the existing species and their 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 other instances, particular species may be living in unusual habitats or near the limits of their distributions, and this may justify devoting land expressly to their conservation.

Appendix 1 lists significant plant species in the study area. The status of the vertebrate animals recorded in the area is noted in Appendix 2.

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

The range of different ecosystems in a region is often reflected in the vegetation. Plants express the various conditions of soil and climate, and they determine the types of food and shelter available for animals. Conservation of a representative area of each distinctive vegetation formation therefore ensures protection of most of the different ecosystems and most of the individual species.

Special natural values

Particular areas of land are often needed to preserve such natural values as distinctive geological features. Many of these have great scientific interest, while others are valuable for education. The more accessible and spectacular features also attract tourists; but, unlike historical or archaeological sites, the geological features are not protected by specific legislation in Victoria.

Brown stringybark in the Little Desert National Park.

A register of Historic Buildings was established in accordance with the *Historic Buildings Act* 1981. It is administered by the Ministry for Planning and Environment.

The National Trust of Australia (Victoria) also records or classifies all buildings, landscapes, areas, objects, and sites that its expert group consider worthy of preservation.

The study area contains a number of Aboriginal relics and sites, mainly located around the lakes, swamps, and rivers and in woodland areas. Many of these relics and sites have not yet been fully documented, nor have they been set aside in reserves managed for their protection and preservation.

Recreation

Most Australians live in the artificial environment of large cities and towns, and many find that their lives are enriched by contact with the natural world. The need for natural surroundings for certain forms of outdoor recreation is discussed in Chapter 16. Bird-watching, nature study, hunting, and bushwalking all require the conservation of the native plants and animals; picnicking and pleasure driving simply require a background of trees or shrubs in the recreational areas.

These requirements can be filled in the study area.

Few parts of the study area are very far from the obvious hand of man. The Little Desert, however, is a large area of native vegetation in a relatively undisturbed state, and does exhibit many of the characteristics required for wilderness recreation. Smaller, more accessible areas are also valuable in providing some degree of solitude and contact with nature, and in reducing the pressures on places better suited for conservation of particular natural features or species.

Culture

The preservation of the profound beauty and regional diversity of the natural landscape should supplement our concern for the preservation and display of man's own finest creations - art, music, building, and writing. Thus, there is a need to preserve characteristic Australian scenery and wildlife, particularly as our economic system necessarily encourages the use of exotic plants and animals, often as monocultures.

Education

Another important use of land in a natural or near-natural state is education. Woodlands, rivers, and other natural landscapes have many applications in education (from primary to post-graduate levels) giving students opportunities to see natural land forms and observe, interpret, and monitor biological processes, and collect specimens. 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.

Viability

Each natural community has evolved within its particular environment, with all the species forming a stable but slowly changing system. Undisturbed, the com-

Big Bend on the Wimmera River between the Wail Forest Reserve and the Little Desert National Park.

munity represents the best combination and relative abundance of the plant and animal species that can continue to live and compete with each other in the prevailing soil, topographic, hydrological, and climatic conditions.

Different natural systems have different degrees of stability. In some of the most vulnerable, stability depends on a particular facet, such as specialized vegetation; others may have inherent topographic, soil, or hydrological weaknesses.

The viability and effectiveness of conservation areas therefore depend on many factors, including the size of the area, the type of community, ecosystem, or features to be conserved, the degree to which the area can be managed to control influences that upset the natural balance, and usage of surrounding land.

Large reserves have less perimeter relative to their area and so tend to be better buffered against intrusive factors. Generally, the conservation of birds and mammals will require areas larger than those required for the maintenance of plants, insects, or amphibians. Communities that exist in more variable climatic zones - regions prone to drought, floods, or fire - usually require large areas (or more examples set aside) to ensure survival.

Small areas can nevertheless contribute to nature conservation or to the preservation of particular features. These include narrow reserves along streams, roadsides, and railways, and many of those set aside in the past - for instance, 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 contribution to the regional character of the landscape. They are also often the only refuges for populations of the remaining native animals.

Narrow strips of native vegetation are valuable for migratory and nomadic birds and as wildlife 'corridors' for small animals. This applies particularly in those parts of the study area that are predominantly agricultural.

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, eradicating introduced species, and preventing rubbish being dumped in the area.

In the past, many such areas have not been properly administered nor have they been well known to the public. Because of this, they have not been used as they might have been, nor have they been as secure from alienation or despoliation as they should have been.

Types of Reserve

Many of the uses discussed above are complementary, and this is reflected in the types of reserves into which public land may be 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 preservation of important landscapes and historical sites. There are different types of parks, and individual parks are zoned to reduce 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 alterations to the environment for experimental purposes - not permitted in parks or other reserves - can be carried out. Other types of reserves that may be proclaimed include flora, flora and fauna, bushland, streamside, scenic, geological, and historical reserves.

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16. RECREATION

Recreation can be defined as any activity (or planned inactivity) undertaken for pleasure during a person's leisure time. This chapter concerns outdoor recreation, and those activities carried out on public land, and should be read in conjunction with Map 11. It begins with the definition of several environments, then describes the main public land recreational resources, and ends with a description of the major recreational activities that take place in the study area.

Resources for outdoor recreation include both natural and man-modified landscapes such as timbered and cleared lands, water bodies, and air space.

The recreation resource itself is a combination of physical and biological features and the ability and desire of man to appreciate or use them. The attributes that comprise the resource are often the same as those for other forms of land use, such as agriculture, grazing, timber production, and mining. In many cases recreation and other land uses may be complementary, but occasionally they compete, and certain conflicts must be resolved.

The Wimmera area has many fragments and scattered blocks of public land containing a variety of recreational features. In particular, the Little Desert is a very important recreational resource, while the numerous freshwater lakes provide many opportunities for fishing, yabbying, swimming, boating, and duck-hunting.

The Wimmera is traversed by the highway linking Adelaide and Melbourne, and also by the Calder, Sunraysia, and Borung Highways so access for tourists is good. While too far from Melbourne for day trips, it is close enough for comfortable overnight stays or weekend trips.

Many of the recreational activities are closely linked with tourism, and most visitors to the area probably engage in some form of recreation. 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.

Recreation demand

Even if the popularity of various outdoor recreation activities remains constant, it can be expected that demand for recreation resources (much of which will need to be provided on public land) will increase as populations and their discretionary income and leisure time increase.

An organization aiding the dissemination of tourist information is Wimmera Tourism Ltd, a public company funded by the Victorian government, and by local government and private enterprise from both sides of the border.

It appears unlikely that the local population will have a major influence on increasing recreation demand in the short-term future. With a shorter working week and the existing road access to the region, most of the future demand for its recreation resources will probably be generated by residents of metropolitan Melbourne seeking opportunities for nature-based recreation.

Environments

Definition of several environments, and of the various recreational activities and their requirements, will make it easier to understand the potential and types of recreational use.

Urban

Cities and townships in the study area offer facilities for formal activities such as tennis, golf, bowls, rifle- and pistol-shooting, archery, cricket, and football, as well as parks and playgrounds for more passive recreation. These user-oriented resources are located close to the home base, enabling ready access and high frequency of use. Most of them have been developed on public land, usually by municipal councils.

Urban environments also include many tourist-oriented facilities - such as caravan parks, historic parks, museums, galleries, and ornamental gardens.

Agricultural

A large proportion of the study area comprises agricultural land, characterized by extensive clearing or alteration of the natural vegetation. Because of the general lack of features, and problems of access through private land, the open landscape of the broad plains does not have high potential for recreation.

The undulating to hilly agricultural land in the east is more aesthetically attractive, and country roads through this area provide good opportunities for pleasure driving.

Woodland

Woodlands occur on many of the small blocks of public land in the Wimmera and belong to two types: the river red gum and gum--box--bull-oak alliances.

River red gum woodlands grow along the margins of rivers, streams, lakes, and swamps. They usually contain wetland areas and have an abundance of wildlife, especially waterfowl.

The gum--box--bull-oak associations offer less diversity of recreation pursuits, because they generally occupy the drier or unflooded areas. Yellow, grey, and black box eucalypts usually adjoin the river red gum forests on areas that are rarely flooded.

The larger blocks of timbered public land contain a range of recreational resources: floral, faunal, and water-based. Such resources provide opportunities for hunting, horse-riding, nature study, photography, bushwalking, and camping.

Wooded areas form an important part of the landscape here. Local residents use them frequently for activities that include picnicking, nature study, pleasure driving, riding motor-cycles and horses, jogging, shooting, and walking. The same resources provide timber and firewood and support bee-keeping and grazing.

Scrub

Natural scrub areas in the Little and Big Deserts provide large, relatively undisturbed tracts of native vegetation. Vegetation types include low woodlands and open scrub of brown stringybark and mallee scrub (especially the mallee--broombush association), while low treeless heaths cover large areas.

This environment provides excellent opportunities for bushwalking, four-wheel-drive touring, and nature study. In particular, the heaths of the Little Desert are well-known for their colourful wildflower displays in spring.

Rivers, lakes, and swamps

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

Main Public Land Recreational Resources

Little Desert

The Little Desert is by far the largest area of public land in the study area. Stretching from the Wimmera River to the South Australian border, it covers some 132,000 ha and provides for a wide range of recreational activities. These include nature study, bird-watching, four-wheel-drive touring, trail-bike riding, and camping.

Vegetation here varies from low treeless heaths to mallee scrub, low brown stringybark woodland, and tall woodlands of yellow gum. The area is renowned for its diversity of native plants, and its wildflower displays in spring. Its diverse bird fauna is also a major attraction, in particular the fascinating Mallee fowl.

Camping and picnicking - in the Little Desert National Park.

The Little Desert is easily reached from the Western Highway linking Melbourne and Adelaide. Access is good, via several major sealed tourist roads and an extensive system of gravel roads. The Little Desert National Park occupies some 35,300 ha in the east of it, where a number of picnic areas have been established, including one with provisions for camping. Its western and central blocks so far remain undeveloped for recreation, despite their interesting flora and fauna.

Dimboola - the 'gateway to the Little Desert' - offers a range of accommodation, including a motel, hotels, and a caravan park. Nhill, Kaniva and the

Little Desert Lodge on the western boundary of the National Park also offer accommodation and other facilities for tourists. The Little Desert Lodge and Little Desert Tours of Nhill both conduct organized vehicle tours, and the National Parks Service runs an information centre at Kiata.

Most tourist use is concentrated in the National Park, where popular activities include the Sanctuary Nature Walk (south of Kiata) and Stringybark Walk near the Nhill--Gymbowen Road. Other features of interest include Salt Lake, Pomponderoo Hill, and river red gum forests along the Wimmera River.

In 1982/83, more than 12,000 day visitors used the National Park, and camper-nights spent in the park exceeded 3,000. Use has remained at this level for a number of years without any major fluctuations due to the effects of weather or fuel prices.

The most popular time to visit the park is in spring, when the abundance of wildflowers forms the major attraction. The graph shows the seasonal nature of visits to the park and indicates that more than 60% of use is recorded in the 4 months August--November. Easter and the May school holiday period are also popular times for both campers and day visitors.

An extensive system of well-signposted sandy tracks provides access to the rest of the Little Desert, but mainly requires four-wheel-drive. This difficulty of access by conventional vehicle is probably the main reason for the low use of these areas so far. Features here include Broughtons Waterhole, The Crater, and Red Gum Swamp.

Wail Forest Reserve

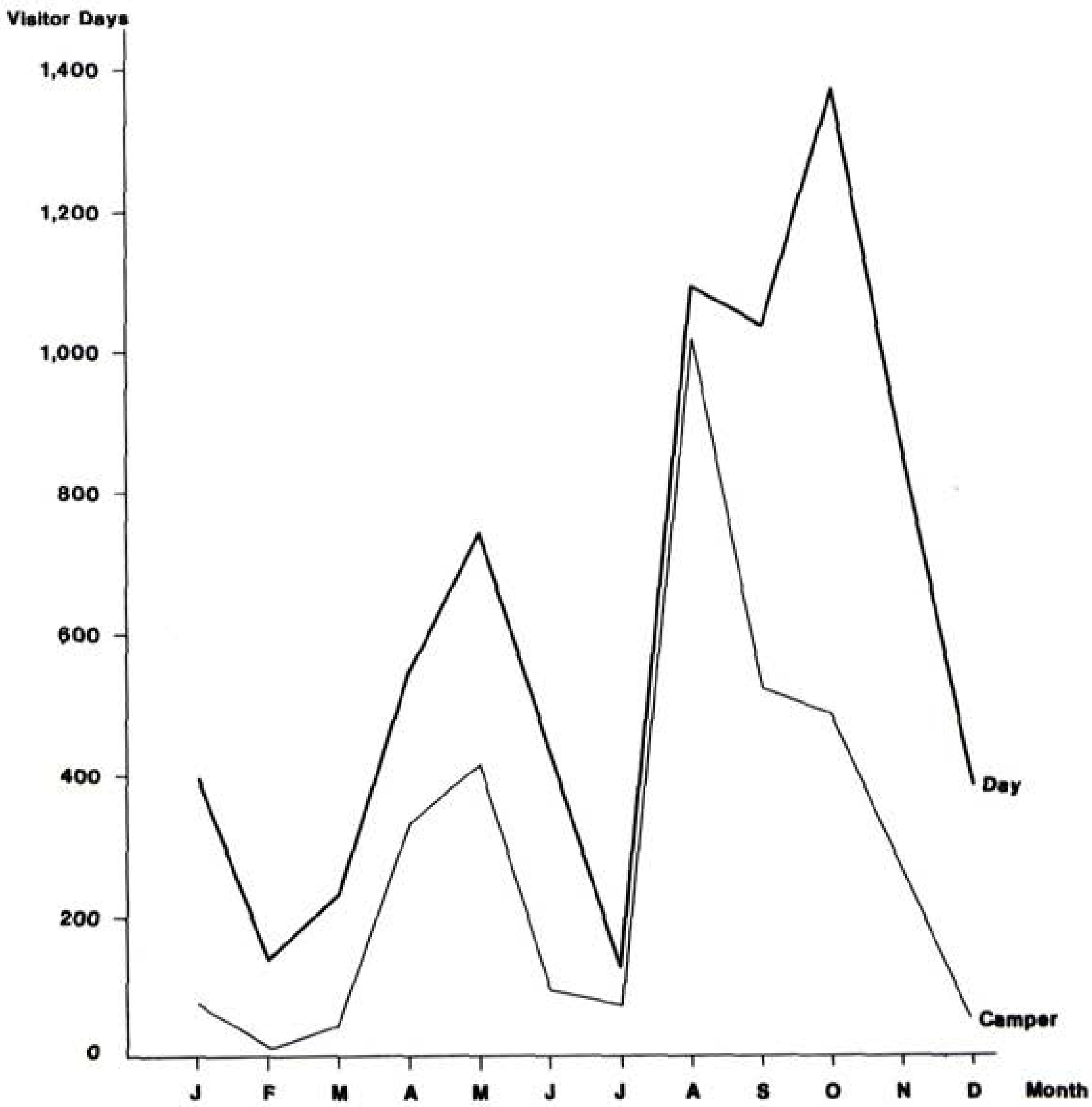
This reserve comprises about 3,250 ha of floristically diverse woodlands and scrub east of the Wimmera River. It also includes the Dimboola Forest Office, depot, and Wail Nursery, three picnic areas, a nature trail, and native and exotic plantations. It is dissected by a number of sandy tracks, which are generally unsuitable for two-wheel-drive vehicles. However, the level of four-wheel-drive usage is high.

The Wail Forest Nursery - managed by the Department of Conservation, Forests and Lands - is the largest State-owned nursery supplying trees for farm use in Victoria. It annually raises some 800,000 plants of 700 different species. The sales season extends from May to September, and many people also visit the nursery at other times of the year, including school groups on educational tours as well as tourists. In 1982 it received a total of 31,204 visits. The nursery has attractive gardens with a picnic area and tables.

Dimboola High School has constructed two nature trails in the Forest Reserve

Figure 5

SEASONAL USE OF THE LITTLE DESERT NATIONAL PARK - 1983



adjacent to the nursery, which visitors and students use for exercise, sight-seeing, and nature study.

Picnic areas at Big Bend, on the Wimmera River, and at Barbers Lake are both accessible by two-wheel-drive from the south. Barbers Lake, an open, flat, and usually dry swamp bed, provides opportunities for picnicking, yabbying, open-space games, and nature study. Big Bend has two picnic sites within black box woodland beside a large pool on the Wimmera River. Access is difficult, especially when wet. During the warmer months it is used for fishing, picnicking, camping, social gatherings, four-wheel-driving, and occasionally trail-bike-riding.

Barbers Lake in the Wail Forest Reserve.

Its proximity to Horsham and Dimboola ensures that the Wail Reserve is popular for recreation. In 1982 it attracted some 3,168 day visitors, and 50 overnight campers, with 130 using the nature trail.

Big Desert

In the north-west, the study area includes public land that is contiguous with the large area in the Mallee known as the Big Desert.

Vegetation here is mallee--broombush scrub with brown stringybark scrub and woodland occurring on the sandy ridges. Apart from the Murrayville Track - an interesting tourist road running further north into the Big Desert - these areas have not had any development for tourism. They provide opportunities for nature observation (particularly birds), camping, four-wheel-drive touring, trail-bike-riding, and bushwalking.

Wimmera River

The Wimmera River bisects the study area from south to north and is skirted on either side by public land frontage for almost all of its journey. The river and its environs are used for picnics, camping, fishing, hiking, natural history, art, and photography, and for boating on stretches that are cleared and maintained as waterways. Access over private land is often difficult. The river environment, having a better tree cover than the largely cleared Wimmera plains, is one of the most pleasant and potentially useful areas of public land in the region.

The scenic 15-km stretch between the Wail Reserve and the Little Desert National Park has many pools and a long section of boatable and skiable water, forested on both sides. Access to the river through the Reserve is by an unformed track, which is very sandy in the north, but an all-weather gravel road runs through the National Park. Water levels are generally higher than at many other places along the Wimmera River because the river is dammed at Dimboola to augment domestic water supplies.

In the warmer months this stretch of the river and its banks provide fishing, four-wheel-driving, camping, yabbying, and swimming, as well as boating and skiing when there is sufficient water. A rowing club has operated in Dimboola for one hundred years and hosts the Dimboola Regatta in November each year.

Lake Hindmarsh

Victoria's largest freshwater lake, Lake Hindmarsh, forms part of the Wimmera River system. It is linked with Lake Albacutya to the north via Outlet Creek. Public land foreshore around it is popular for camping, boating, and fishing.

Camping at Four Mile Beach, Lake Hindmarsh.

The lake itself provides both sport and commercial fishing for English perch (redfin), and is also very popular for yabbying.

The tourism that Lake Hindmarsh attracts is important to the economy of the nearby town of Jeparit. Visitor interest in the lake will almost certainly increase with the increasing promotion of public land areas to the north, particularly Wyperfeld National Park and Lake Albacutya Regional Park.

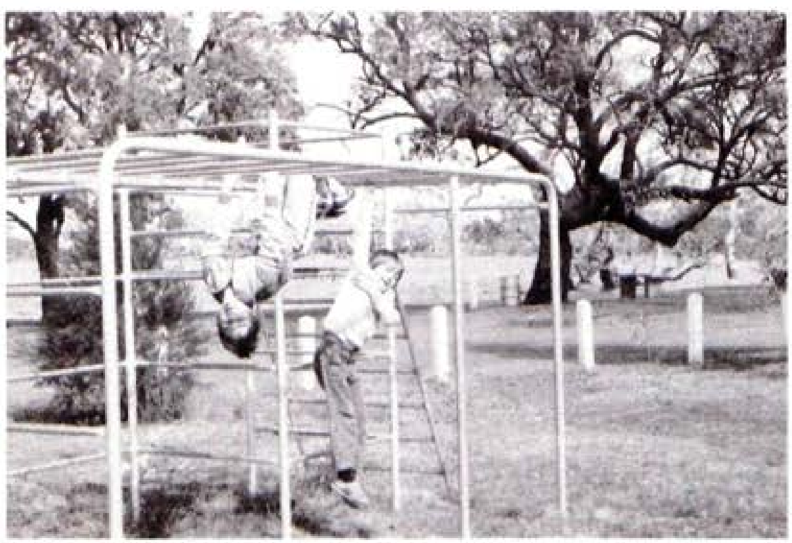
Lake Buloke

The second-largest body of water in the study area is Lake Buloke. A large plain to the north of it is also public land.

Lake Buloke is one of Victoria's major duck waters, and the nearby town of Donald relies heavily on the additional money it brings here each duck season. The increase in commercial activity covers a broad range of items, including accommodation, fuel, camping and sporting goods, food, clothing, and a big boost to the hotel trade. The lake also has potential for bird-watching.

South-western Wimmera plains

Lakes and swamps are the main features of recreational interest in the areas of public land scattered across the south-western Wimmera plains.



Playground at Wooroonook Lakes.

Six major ones are permanent or hold water for most of the year - three of these are saline. Another 11 lakes and swamps dry out each year or fill occasionally.

Access to them is often difficult, and sign-posting is usually non-existent. Only Lake Natimuk has facilities for picnicking and camping, and is also used for water sports such as power-boating, skiing, and windsurfing, as well as for fishing, yabbying, and duck-shooting.

Duck-shooting is a widespread activity on the other lakes and swamps of the plains - in a good season almost all of them would be shot over. Other popular activities are fishing, yabbying, swimming, and nature study.

No figures are available for the numbers of people taking part in these activities. Most users would be local people, although duck-shooters would be drawn from a wider area.

Mitre Rock, 30 km west of Horsham, is a rocky outlier of Mount Arapiles. It affords opportunities for rock-climbing, picnicking, and sightseeing, as it commands a good view of Mitre Lake and the surrounding plains.

Another feature of the south-western Wimmera plains is the Jane Duff Highway Park at Duffholme on the Natimuk--Goroke road. It contains the area in which a young girl, Jane Duff, cared for her two brothers when the three were lost in the bush for eight days in the 1860s. There is a memorial cairn on the roadside, and facilities for picnicking and camping have been provided.

Other public land resources

North of the Little Desert, a broad band of farming country extends from the State border to the Wimmera River. This contains scattered reserves and swamps, but few unusual geographic or natural features. Public land areas have value as resting places for travellers on major roads.

Swamps in the area north of Nhill and Kaniva are of interest to natural historians as well as shooters and campers, particularly Boyeo, Red Gum, Peechember, and Yanac Swamps.

Approximately 30 km north-east of Dimboola the Glenlee Timber Reserve incorporates 54 ha of mixed eucalypt plantation with 600 ha of mixed woodlands comprising some fine stands of yellow gum, black box, bull-oak, and belah, with small pockets of open dumosa mallee scrub. No recreational facilities are provided but access tracks throughout are maintained annually.

Local groups and residents make some use of the reserve for recreation, as it constitutes the only substantial area of woodland between the Wimmera River and South Australian border, and between the Little Desert to the south and Big Desert to the north.

Between the Wimmera River and Yarriambiack Creek lies the Barrett Forest Reserve, consisting of 170 ha of mixed eucalypt plantation and 200 ha of gum--box--bull-oak woodland. No facilities are provided for recreation; however, it is the only substantial timbered block within a large area of generally treeless agricultural land.

Immediately to the east of Horsham are Dooen and Darlot Swamps - two wetland areas of natural interest. A pistol range and trail-bike and go-kart tracks have been developed on the western side of the Dooen Swamp adjacent to the Henty Highway. These cater mainly for users from nearby Horsham, but are of official competition standard and attract visitors from further afield for competitive meetings.

Further east, three large forest reserves - Marma, Barrabool, and Brynterion (Rupanyup South) - receive low levels of use. People from Murtoa use the Wimmera River frontage of the Marma Forest for picnicking, fishing, and yabbying. No facilities have been provided.

Apart from the reserves mentioned, little public land remains on the Wimmera plains. Public reserves along waterways, such as the Yarriambiack and Dunmunkle Creeks, are generally water frontages, many leased to adjoining land-owners. As with the Wimmera River, access is often difficult or impossible for visitors, but there is very little demand for such access in any case.

In the far east, lakes, rivers, and small mountain outcrops are significant features that make this region more visually interesting than the rest of the Wimmera. Lake Buloke (previously described) and Wooroonook Lakes are freshwater inland lakes suitable for water-based recreation. Both the Richardson and Avoca Rivers cross the region, providing opportunities for fishing, yabbying, and camping. Mount Wycheproof (promoted as the smallest mountain in Victoria) and Mount Jeffcott offer excellent views of the surrounding areas from their peaks.

Recreational Activities

Recreation driving

Recreational driving in the study area may take the form of touring along highways and main roads or using four-wheel-drive vehicles along unmade tracks. For many people pleasure driving and sight-seeing are major activities, while for others driving provides access to areas where some other recreational activity will be enjoyed.

Pleasure driving is usually associated with picnicking. Public land reserves on roadsides such as Wooroonook Lakes and the Jane Duff Highway Park have well-developed picnic areas that cater for this activity.

Recreationists in four-wheel-drive vehicles mainly use the Little Desert - both the National Park and the unreserved public land to the west. The special requirements of these people are challenging tracks that give access to remote areas.

They usually travel to interesting features such as Salt Lake, Broughtons Waterhole, and The Crater. High points such as The Sisters and Mount Moffat afford broad views of the surrounding scrub and low woodlands.

Few hazards and conflicts are associated with pleasure driving throughout most of the Little Desert. As with many recreational activities, the major factor detracting from people's enjoyment is overcrowding. In the Little Desert this may be a problem only on the most popular roads during holiday periods. The road system can cope with recreational use without undue deterioration.

Motor-cycling

Trail-bike-riding is popular. This form of recreational riding may present certain problems to the land manager, in terms of road damage and off-road activities and also of unlicensed riders and unregistered vehicles. Under the *Land Conservation (Vehicle Control) Act* 1973, no vehicle (four- or two-wheeled) may

Stringybark Walk in the Little Desert National Park.

leave a formed road except with permission, and only registered drivers may use roads on public land. The Horsham Motorcycle Club leases an area of public land on the Henty Highway adjacent to Dooen Swamp for a scramble track, while next to this the Horsham Go-Kart Club runs a go-kart track.

Walking

Two types of activity fall under this heading: short walks on prepared signposted tracks, and longer ones, often taking 2 days, through remote country away from tracks (bushwalking).

Walking on tracks is a popular activity in the Little Desert and the Wail Forest Reserve. In the former, the most popular walks are Sanctuary Nature Walk, Stringybark Walk, and the Pomponderoo Hill Fire Walk, while the Wail Trail is located next to the nursery in the Wail Forest Reserve. The walking tracks have signposts, which also give the length or duration of the walk. No bushcraft or map-reading expertise is required. Explanatory leaflets to accompany the Pomponderoo Hill Fire Walk and the Wail Trail are available from the Department of Conservation, Forests and Lands.

The Little Desert has limited value for extended bushwalking, because of the lack of variety in the terrain and the absence of reliable water sources.

Camping

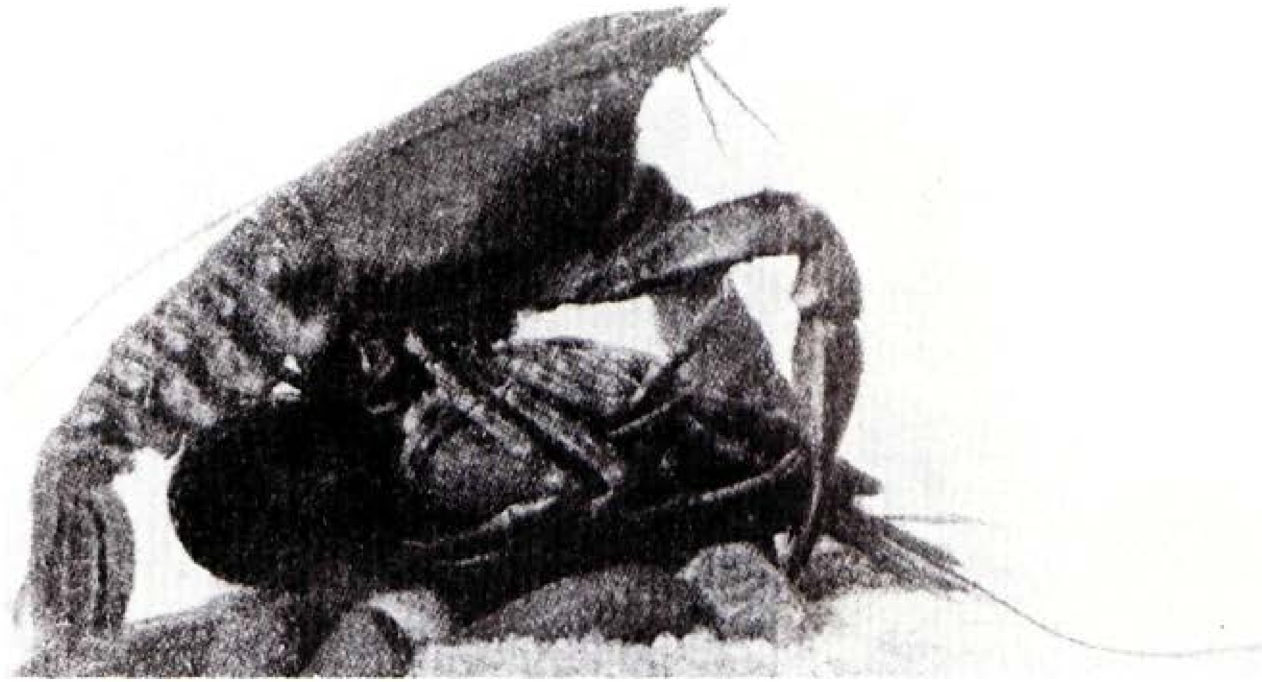
Although informal camping takes place on public land throughout the study area, it is concentrated in established camping grounds, with facilities such as fireplaces, tables, and often toilets and water supply. These are present at Lake Hindmarsh, at Lake Natimuk, in the Little Desert National Park south of Kiata, at Wooroonook Lakes, and especially at the more popular tourist centres.

Four-wheel-drivers and people fishing along the Wimmera River are the main groups camping away from such grounds. Camping creates problems of fire protection and litter disposal, and overcrowding may occur in peak periods at Christmas, Easter, and school holidays.

Water sports

Many people swim in the lakes and rivers during the hot summers experienced here, particularly in Lake Hindmarsh, with its

This stretch of the Wimmera River up-stream of Dimboola is popular for water-skiing.



Yabbies are found widely in the Wimmera lakes and streams.

sandy beaches. Boating flourishes on Lake Hindmarsh, Lake Natimuk, and Wooroonook Lakes, where activities include power-boating, water-skiing, and windsurfing. Lake Hindmarsh is also used for sailing.

Weirs on the Wimmera River at Dimboola and Horsham, and on Yarriambiack Creek at Warracknabeal and Brim, provide suitable stretches of water much used for boating and fishing.

Fishing

Areas for fishing in the Wimmera are excellent and widespread. English perch, goldern perch, Murray cod, catfish, rainbow trout, and brown trout can be caught in large numbers. Yabbying is also extremely popular and widespread.

The most favoured sites are Lakes Hindmarsh, Natimuk, and Marma, Wooroonook Lakes, and the Wimmera and Avoca Rivers. An annual fishing contest on the Wimmera River organized by the Apex Clubs of Horsham is advertised as the largest in Australia, and attracts large numbers of entrants each Labour Day weekend.

To ensure continued good fishing, the Fisheries and Wildlife Service regularly stocks many waters with trout, golden perch, and Murray cod. For example, 6,000 brown trout and 6,000 rainbow trout were liberated in Lake Natimuk in 1982, followed by 15,000 brown trout and 15,000 rainbow trout in 1983.

Hunting

Duck-hunting during the open season is very popular throughout the Wimmera with both local and Melbourne-based shooters. Open season for wild duck is generally declared between March and May, when both public lands and freehold lands are shot over. Local concentrations of game birds occur on lakes, swamps, and rivers throughout the study area, and duck-shooters hold Lake Buloke in particularly high regard.

Quail-shooting also draws many visitors, while foxes and rabbits are hunted for sport, for income, and for vermin control.

Organized sports

Throughout the study area, small blocks of public land are used for golf-courses, rifle ranges, football and cricket grounds, racecourses, tennis courts, and the like.

Horse-riding

A number of residents (especially children) enjoy horse-riding as a hobby. From time to time many of these people take rides into nearby bushland.

Duck-shooting is very popular throughout the Wimmera.

Nature study

The Little Desert attracts many people who have specialized interests in studying some aspect of nature - mainly the vegetation, or the birds. Its diverse habitats contain large numbers of plant and bird species. Of particular interest are the wildflower displays in spring, and the presence of the unusual Mallee fowl.

Lake Wyn Wyn and other lakes south of the Little Desert National Park also hold great interest for naturalists because of the numerous waterfowl they attract.

While many people would visit public land specifically for nature study purposes, far more combine nature study with other activities, such as picnicking, camping, and recreational driving.

Future demand

Several factors are expected to markedly increase recreation pressures on public land in the study area, primarily the significant population growth in Melbourne and regional centres such as Horsham.

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

17. TIMBER PRODUCTION

Hardwood timber production is not a major form of land use in the study area. Much of the vegetative cover on public land consists of open scrub and heaths, with the only tree species being stunted eucalypts such as mallee or brown stringybark. However, scattered areas of other eucalypts capable of yielding timber provide an important source of farm timbers for local use. River red gum, yellow gum, black box, and grey box constitute the major species used for this purpose.

In addition, a small sugar gum plantation at Wail is used for intermittent production of sawlogs, fencing timbers, and firewood. Brown stringybark, a less-suitable species because of its poor form in this area and lack of natural durability, is not actively sought. Bull-oak and slender cypress pine also grow in the central parts of the area, but are not utilized.

While the timbers from the durable species described above are well-suited for use as railway sleepers, posts and other farm timbers, and fuel, sawlog-size timber is found only in the river red gum and yellow gum stands in the south-western section of the Little Desert, near Goroke, on public land along the Wimmera River east of Horsham, and at Wail.

History of timber use

Since the early days of settlement, woodlands capable of yielding timber have been cleared to make way for agriculture - especially cereal-growing. Much of the timber removed has been used for farm buildings, poles, fencing materials, and firewood. In more recent times small areas of freehold land have been cut over for railway sleepers, a limited amount of sawn timber, and fencing timbers.

On public land, relatively heavy cutting for fencing materials took place during the periods immediately following World Wars I and II. The main areas cut were in the Wail, West Wail, Barrett, and Glenlee Timber Reserves and the Crown lands adjoining the Wimmera River. These areas are again capable of yielding this material.

The principal eucalypt used in plantings in the study area, sugar gum, is endemic to South Australia. It probably first came to Victoria with the influx of settlers of German descent into the Wimmera from various localities in that State.

Sugar gum plantings at Wail began in 1911 and continued until 1928; since then only small additions have been made to the plantation. Elsewhere, beginning in the 1950s, plantations of mixed eucalypts including yellow gum, black box, and swamp yate were progressively established at Barrett Forest Reserve (142 ha) and Glenlee Forest Reserve (54 ha), to forestall alienation of the reserves for agriculture.

Commercial timber production in the area has never been well established because of the limited areas of productive forest that could be retained. The relatively small area of commercial species remaining will not permit the establishment of a permanent industry and can only sustain intermittent cutting to meet part of local demand.

Forest types and products

Historically the main tree species cut for sawlogs and sleepers have been river red gum, yellow gum, and grey box, while more recently the sugar gum plantation at Wail has become the sole source of

The sugar gum plantation at Wail.

sawlogs. These, and black box, are also the main species utilized for posts, farm timbers, and firewood. Table 22 summarizes current production.

Table 22

TIMBER PRODUCTION FROM PUBLIC LAND

	1981	1982	1983
Sawlogs (cu. m)	-	-	66
Sleepers (number)	-	-	525
Poles (number)	103	-	-
Posts (number)	678	111	961
Firewood (cu. m)	153	229	521
Stepping blocks (number)	-	211	-
Rails (number)	72	-	12
Stays (number)	-	-	216

Source: Department of Conservation, Forests and Lands

The sugar gum plantation at Wail provides sawlogs, poles of various sizes, posts, and firewood. A privately owned chemical preservation plant, established in the Wail plantation in the late 1960s, treats much of the timber produced here for sale to the public. Utilization of the plantations at Barrett and Glenlee has not yet commenced. Preparation takes place at stump in the forest, with the exception of sawlogs, which are converted at a sawmill in Horsham.

The demand for firewood has accelerated in the past few years after a period of decline. Output figures for the area underline this trend. The major production of firewood locally has come from timber-clearing operations on farmland. It is considered, however, that supply from this source is diminishing and that - unless extensive wood-lot plantings are made - public land will become the principal source of firewood.

A chemical preservation plant in the Wail Forest Reserve treats timber from the nearby plantation, for sale.

A section of the very extensive Wimmera Forest Nursery at Wail.

Other products

Apart from fencing timbers, some saw-logs, and firewood, the area does not yield much in the way of forest produce. The mallee species occurring in the Little Desert are not suitable for the production of eucalyptus oil, and the production of mallee roots for firewood is not permitted on public land. Honey production is dealt with in Chapter 19.

Broombush *(Melaleuca uncinata)* is harvested and used for garden fencing. The demand for broombush is strong and about half the production comes from public land. No broombush utilization is permitted in the Little Desert, but dispersed operations take place in the Big Desert to the north (including the small portion in this study area). No operations on public land within the study area took place in 1983/84.

Wail nursery

In 1946, the Wimmera Forest Nursery was established at Wail, with a view to propagating both native and introduced varieties of trees and shrubs that would be suitable for shade, shelter, and aesthetic plantings on the farmlands of the Wimmera and Mallee. It is the largest State-owned nursery supplying plants for farm use in Victoria.

It incorporates an extensive arboretum, to determine the suitability of species to the area and provide a source of seed, as well as assisting visitors in the selection of species for planting.

The nursery and arboretum have both become very widely known. Plants purchased from here can be seen throughout much of western and northern Victoria. Annual production totals some 800,000 plants, including hundreds of different species of native plants. The current trend is to raise seedlings of different provenances of native plants, to enable the most suitable forms to be available for farm and other plantings.

18. AGRICULTURE

Agriculture is by far the dominant land use in the Wimmera. About 89% of the land in the area is privately owned and most of this is cleared. In addition, grazing licences cover many small areas of public land and much of the public land is used intermittently for honey production.

In 1983/84, agricultural production in the study area had a gross value of about $200 million. Almost one-third of the population depends directly upon agriculture, and the economic well-being of the towns is directly related to the incomes that the primary producers receive. The townships are largely based on service industries, which supply farm inputs and also transport, market, and process agricultural products.

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

Most farmers still rely on the traditional forms of agriculture that began more than 100 years ago. Virtually all farms in the study area operate both cropping and livestock enterprises, with much greater emphasis on cropping in the central part. Cereals - wheat, barley, and oats - are the main crops, and sheep are raised for both wool and meat production.

Two small irrigation areas near Horsham and Murtoa support mixed farming - mainly sheep and dairy cattle.

Pig- and poultry-raising are also practised in various parts of the Wimmera. Map 12 indicates the locations of the major agricultural pursuits, and Table 23 lists the areas involved and stock numbers.

Crop Production

Cereal crops

Cereal-growing is the dominant agricultural industry, with wheat (300,000 ha) being the most important crop throughout the study area. Barley is now widely grown in the Wimmera with a dramatic increase in area from less than 10,000 ha to 70,000 ha over the last 20 years. Oats are grown mainly on the south-western Wimmera plains, which have higher rainfall than the rest of the study area. The area sown to oats has fallen significantly during the last 20 years, and is now about 20,000 ha.

Table 23

AGRICULTURAL LAND USE 1982/83

Item	Study area total		Percentage of State total
	Number	Area (ha)	
No. of holdings	2,450		5
Crops		440,000	20
Sown pasture including lucerne		340,000	6
Native pastures		220,000	7
Balance		370,000	11
Total area used for agriculture		1,370,000	10
Livestock numbers			
Sheep	1,300,000		6
Beef cattle	25,000		1
Dairy cattle	3,000		0.2
Pigs	24,000		6

Data are estimates from Australia Bureau of Statistics information, based on local government areas.

Wheat - the most important crop here - before and during harvesting.

In areas receiving less than 450 mm of annual rainfall, a rotational system of farming is used in which wheat is produced following a 10-month bare fallow, usually in rotation with pastures and other cereal, grain legume, and oil-seed crops.

In higher-rainfall areas and on light soils, cultivation usually begins less than 2 months before sowing.

Nearly 800,000 tonnes of grain was produced from cereal crops grown in the study area in 1981/82, having a total value of nearly $120 million. That year the study area produced about 27% of the State's wheat, 21% of the barley, and 6% of the oats. The following one (1982/83) was a drought year, which saw a dramatic reduction in yields to less than 120,000 tonnes of grain, with a total value of only $20 million.

Oil-seed crops

Safflower, rapeseed, and sunflower sowings are small, but the amount of rapeseed sown is increasing. Cultural practices differ from those used for cereals, and successful oil-seed cropping requires skilful management.

Rapeseed is an oil-seed crop of increasing importance.

Oil-seed crops can be very useful in preventing a carry-over of cereal disease from one cereal crop to the next.

Grain legume crops

The grain legume crops, including field peas and lupins, are grown for both human and livestock consumption. Successful lupin crops are confined to the acid soils, while the area of field peas on alkaline soils has increased rapidly in recent years. A wide range of grain legume varieties should be available in the future, including chick-peas and tick beans.

A most important feature of grain legume crops is that they can restore soil nitrogen levels in the same way as a medic or subterranean clover pasture.

Livestock Industries

Practically all grazing in the study area is based on improved pastures. The major legume base of these pastures is either an annual medic (on lower-rainfall alkaline soils) or subterranean clover (on high-rainfall non-alkaline soils). The major grasses are the annual Wimmera rye-grass and barley-grass.

Sheep

These animals dominate the grazing in the study area, which carries about 6% of the State's sheep population.

In the pioneering days, the squatters raised sheep on the extensive runs they had adopted, making sheep production one of the earliest agricultural pursuits in the area. Today, the industry is much more intensive. It forms an important part of the rural environment, and produces both wool and prime lambs in association with cropping.

The higher-rainfall areas of the west carry self-replacing Merino flocks, run principally for wool production. Additional income is derived from production of prime lambs or cross-bred ewes.

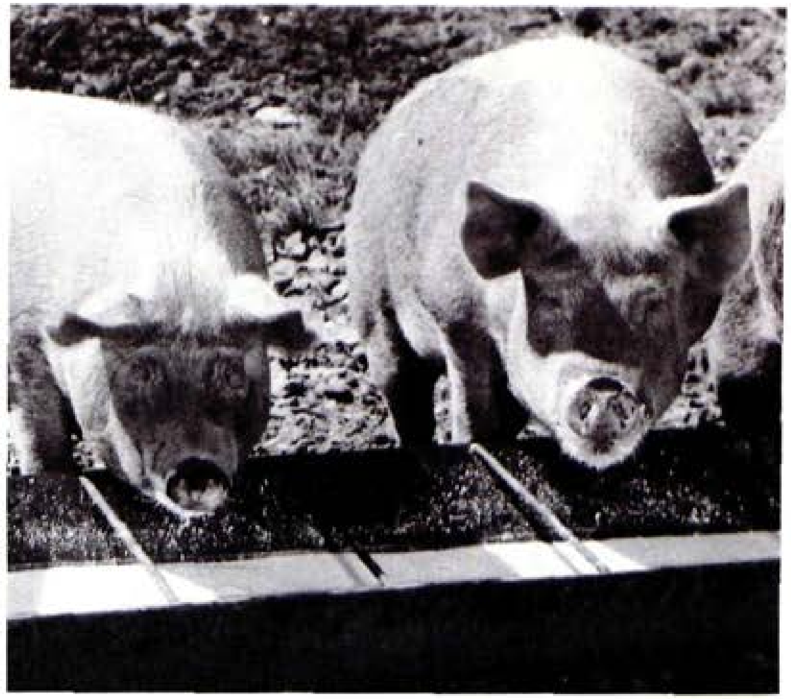
In central and eastern parts where cropping intensity rises, more emphasis is placed on production of prime lambs from cross-bred or Merino ewes bought in from other areas. Merino wethers may be run purely for wool production.

Stud breeders of Merino and British-breed rams (Dorset or Border Leicester) are well represented in the Wimmera. Most producers mate their ewes in spring for an autumn lambing.

Cattle

The short growing season makes the Wimmera less suitable for cattle. Numbers are low and beef production is generally restricted to the west and north-west of the study area.

Dairy cattle only occupy small irrigation areas near Horsham and Murtoa. The number of dairy farms and quantity of milk produced have fallen rapidly in recent years.



Pig enterprises are scattered throughout the Wimmera.

Pigs

Small pig enterprises are scattered throughout the study area, usually run in conjunction with cereal production. They have an important role in providing additional employment and farm income. Also, a number of larger pig enterprises are run as individual businesses and do not form part of wheat farms.

Other animal industries

Angora goats are bred for fibre production on a few farms, usually on a non-commercial basis.

A small number of poultry farms may be found in various parts of the Wimmera.

Longerenong

Prior to March 1983, the Longerenong campus of the Victorian College of Agriculture and Horticulture was called the Longerenong Agricultural College, which was established under the *Agricultural Colleges Act* 1884 and opened in 1889.

Trickle irrigation in the orchard at Longerenong.

Aerial view of the Longerenong campus.

It originally occupied 966 ha of land at Dooen, 13 km north-east of Horsham, that had been reserved for 'Forest and Experimental Purposes'.

Its main role has been the training of young men, and since 1971 young women, for careers in farming and more recently in the agricultural service industry.

Training at the College has traditionally been farm-based; its farm has been extensively developed for teaching purposes, incorporating a number of enterprises - broad-acre cropping, orchard and vegetable production, dairying, extensive pig and poultry production, and grazing of cattle for beef and of sheep for wool and prime lambs. About 60 ha of the farm supports pasture and crop production under irrigation.

Longerenong College has always been a centre of advice for farmers. As well, it has provided support for farming industries through the production and sale of pedigree seed wheat, stud pigs, and Poll Dorset rams, although these activities have been reduced in recent years as the educational role of the campus has expanded.

The Department of Agriculture, which controlled the College from 1944 to 1983, has for many years based its cereal experiments in the Wimmera at Longerenong. The work of the Cereal Experimental Centre has covered all aspects of cereal production, including varietal evaluation, fertilizers, rotations, alternative crops, pasture legumes, disease control, cultivation, and other agronomic practices.

Longerenong is also the venue for the Wimmera Machinery Field Days held over 3 days in the first week of March every year.

Potential of Private Land

Most farms in the study area have very little scope to bring additional land into production. Thus, efforts to increase income to keep pace with rising costs will concentrate on changes to more profitable enterprises, and/or increases in productivity per hectare and per labour unit.

Consequently, cropping intensity is expected to increase, with greater investment in agricultural machinery and a possible decline in the importance of livestock production. This decline could be averted if livestock enterprises based on legume fodder crops prove to be as profitable as grain legume crops.

Agricultural Use of Public Land

Rapid expansion of pastoral occupation during the 1840s resulted in the movement of domestic stock into nearly all parts of the study area by the 1850s. Grazing dry sheep for wool production has been the major form of pastoral land use since this time.

After the gold rushes, land was made available as freehold around the mining centres during the 1860s. This process extended into the study area in the decades following the passage of various *Lands Acts* designed to encourage settlement. Grazing licences continued to be issued over much of the remaining Crown land, and as areas were dedicated as forest reserves the control of grazing in them passed to the Forests Department.

Almost all of the Little Desert was covered by grazing licences for many years, but grazing is now confined to margins bordering private land.

Areas grazed

The gum--box--bull-oak woodlands with grassy ground cover have the highest capability for grazing. As the tree and scrub layers become thicker, less grass grows beneath them, and this capability falls.

Map 12 shows the major areas currently held under grazing licences or agistment rights. They consist mainly of these woodlands. Although some brown stringybark woodland patches occur within the licensed areas, this vegetation type produces relatively little forage.

Grazing on public land is controlled by issuing licences or agistment rights. Nearly all the grazing in the study area depends on annual licences of which some

Sheep grazing near Mount Jeffcott.

275 are current, covering about 19,700 ha. Rentals are based on the carrying capacity of the land, and the licensed areas vary from 5 ha to 4,600 ha - many being about 50 ha.

Under agistment, the authorities regulate the number of sheep permitted to graze a given area according to the condition of the ground vegetation, charging on a per-head, per-week basis. For instance, the northern part of the Glenlee Timber Reserve has been grazed only occasionally in the past 20 years, on an agistment basis, to prevent damage to regeneration of bull-oak and other native tree species.

Most parts of Lake Buloke and the floodplain to its north remain dry for much of the year, and are held under perpetual leases and swamp leases, which allow grazing and cropping. These cover a total area of nearly 8,000 ha.

Impact of grazing

Relatively little is known of the impact that grazing has on natural ecosystems. It does affect the vegetation, because sheep graze selectively, choosing species that contain little fibre and lack a strong taste. These tend to become rare and disappear, and are replaced by other less-palatable ones, including exotic species. The degree to which this happens depends on the grazing pressure, or stocking rate.

Once degeneration of the natural vegetation has reached a certain stage, removal of stock will not result in return to the original, as the unpalatable species - often exotics - become dominant. In many parts of the public land, this selective grazing has probably initiated a permanent change in the understorey community - from one dominated by perennial summer-growing indigenous species to one dominated by annual aliens.

Sheep may compete with native herbivores for food. Although in some cases the two groups prefer different species of plants, in dry seasons when food is scarce they are thrown into direct competition. Ground-feeding birds may also be affected.

Some conflict may arise between grazing and recreation. For some people the presence of sheep in the forests would detract from the naturalness of the bush. On many areas of woodland, grazing is an aid to fire protection because it reduces the build-up of fine fuels in the understorey.

In some cases, the impact of grazing on the vegetation, soil, native wildlife, and recreation may be reduced by maintaining a light stocking rate, or through strategic grazing at times of abundant feed. In other cases, grazing may need to cease altogether to permit revegetation.

Cropping

A few small areas of public land adjacent to private land are used for growing cereal crops. In suitable years, the public land held under perpetual leases and swamp leases at Lake Buloke is also cropped.

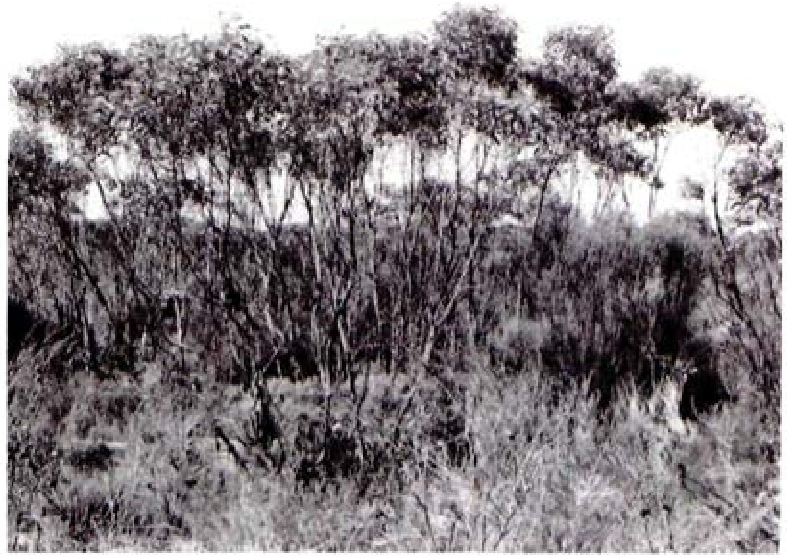
Fishing

Up to 16 professional fishermen operate on Lake Hindmarsh, catching mainly English perch (redfin) and sometimes yabbies. Some of them also employ a crewman, resulting in employment of a further 8 or 9 men. These people come from Jeparit, Horsham, and Dimboola, and the towns of Rainbow and Hopetoun to the north of the study area. Professional fishermen are allowed to use an unlimited amount of mesh net, and a fisherman with a crewman may use about a mile of net.

Development Potential of Public Land

Public land is generally of poor agricultural quality. The early settlers occupied the better tracts, with the result that the public land remaining is confined mainly to the sands of the Little and Big Deserts. Most of the small blocks of it in the rest of the study area are either swamps (and poorly drained sites) or have soil of poor quality. Steep rocky outcrops occur on most of the small areas of public land in the far east.

The sands of the Little and Big Deserts have limited agricultural potential because of their low natural fertility, low water storage capacity, and high wind erosion hazard. They have some potential for establishment of perennial pasture species such as lucerne and perennial veldt grass, and good-quality groundwater is available from the Duddo Limestone aquifer. It is unlikely, however, that returns would match the high costs of clearing the brown stringybark and mallee scrub, and of the large fertilizer inputs that would be required.



The costs of clearing the mallee scrub of the Little Desert are high.

Scrub regrowth and accelerated soil deterioration can be major problems.

Considering the current state of agricultural markets (in particular sheep and beef markets) and the factors listed above, investment in the development of public land would probably be less profitable than other forms of investment.

19. APICULTURE

The apiculture industry depends on the introduced honey bee, *Apis mellifera*. This insect collects and stores quantities of plant nectar as a carbohydrate food source. The excess is harvested as honey. In the process, the bees also collect pollen, on specially adapted hairs on their rear legs; and they store this protein food, along with nectar, for feeding. Their pollination activity - especially in relation to agricultural and horticultural crops - is probably more important than their commercial value as producers of honey.

Products

Bee-keepers harvest honey, beeswax, and some other minor products. Honey is used for table consumption, for confectionery manufacture, as a stock food, and in the preparation of meat products, of vinegar, and of some pharmaceutical and cosmetic products. Beeswax has many uses, including candle, cosmetic, and polish manufacture and other industrial purposes.

The minor products - pollen, royal jelly, and propolis - are used as health foods.

Approximately half the honey crop is sold overseas, making Australia one of the main exporters of honey. Exports go to the United Kingdom, West Germany, Africa, Asia, and the Middle East.

One of Australia's largest honey processing and packing plants is located at Maryborough, in central Victoria. Other packing plants are located in Melbourne, Broadford, and Bairnsdale.

Bee-keeping in the study area

Victoria has 2,500 registered bee-keepers, the majority of whom operate part-time. A number of the commercial operators live in or close to the study area.

Commercial bee-keeping is a migratory industry. Operators truck their hives to areas of high nectar yield, following the honey flows of different eucalypts. They also travel to overwintering sites where bees can build up their stocks of pollen and honey.

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.

Higher water contents of the nectar can cause hive fermentation and a consequent loss of bees with alimentary upsets. Carrying of hives through the 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.

Desert banksia

The Little Desert has special significance for apiarists as an overwintering refuge for thousands of colonies of bees. This is because of the abundance on the sand plains of desert banksia (*Banksia ornata*), which flowers more or less every year from April through until spring. It grows on public land (including the Little Desert National Park) and on private property.

To work desert banksia the hives are usually stripped of their honey stores, which can pay for transport costs.

The strong-flavoured banksia honey is either exported or used for manufacturing, and can be harvested through winter as a saleable crop.

With the approach of spring, hives are in a productive condition ready to be moved on to prospective honey flows. The Little Desert therefore provides a vital link for bee-keepers in their seasonal migration and manipulation of colonies.

Other important plant species

The main eucalypt honey flora are listed below in order of importance.

Yellow gum (*Eucalyptus leucoxylon*) is a good yielder of premium-grade honey, but produces little pollen. Its honey is a clear pale straw colour with medium density and a mild flavour.

River red gum (*E. camaldulensis*), a valuable tree for the bee-keeper, often secretes nectar very profusely and is one of the heaviest yielders. It yields a straw-coloured honey, not quite so dense as that from yellow box, and with a very good flavour. It produces pollen in great quantities, which makes it extremely valuable when grown in pollen-deficient areas. Average honey yields of 27 kg per hive per year are obtained.

Yellow box (*E. melliodora*) regularly yields nectar to produce one of the best-quality honeys available. Bees do not collect its pollen, however, and would soon deteriorate without access to an alternative pollen source.

Black box (*E. largiflorens*) produces a good-quality honey with a medium flavour and medium amounts of cream-coloured pollen. Honey yields average 27 kg per hive per year.

Long-leaf box (*E. goniocalyx*) produces a medium- to dark-coloured honey of reasonable flavour and is a prolific yielder of pollen. Bees winter well on it. Average honey yields are 2 kg per hive per year.

Grey box (*E. microcarpa*) produces honey of excellent flavour, amber-colour when pure. It also produces large amounts of cream-coloured pollen, which is important to the industry as this is the only available source at the season's end - that is, around autumn. Annual honey yields average about 14 kg per hive.

Brown stringybark (*E. baxteri*) yields good crops of dark-coloured strong-flavoured honey, and is also a good pollen-yielder.

Bull mallee (*E. behriana*) is a good yielder of dark-coloured, strong-flavoured honey and a good pollen-yielder.

Other native species that are useful as nectar-yielders or pollen-producers or both include silver banksia, casuarinas, tea-trees, grass-trees, melaleucas, green mallee, slender-leaf mallee, yellow mallee, boronias, wax-flowers, scarlet bottlebrush, heaths, hop-bushes, and plantations of sugar gum.

On agricultural and horticultural land, lucerne, seed crops, and various clovers provide important sources of nectar and pollen. Declared noxious weeds (such as Paterson's curse, thistles, and blackberries) are also important sources, as are other weeds like capeweed, cat's-

Beehives - on desert banksia in the Little Desert (above) and on woodland in the Wail Forest Reserve.

ear, and onion-grass. A potential disadvantage of these plants lies in the application of pesticides - to protect pastures and crops and kill weeds - that can rapidly deplete a whole apiary.

Licensed bee-keeping on public land

On private timbered and agricultural land, siting of hives is by arrangement with the land-ownder.

Licensing of bee sites on public land is carried out by the Department of Conservation, Forests and Lands. A licence allows a bee-keeper to use a small area to set up his hives and equipment, and he has the exclusive right to work his bees within a radius of about 1.6 km.

Permanent sites occupy the best areas; that is, the bee-keepers pay the licence fees whether or not they use them that year. Temporary sites may be taken up when nectar flows.

The Wimmera study area contains some 69 bee sites on public land (including up to 20 in the Little Desert National Park) and some 183 on private property. Many of the latter are sited immediately adjacent to public land and hence use public land from private property without paying a licence fee.

This study area is a vital link for the bee-keeping industry of Victoria, which places much importance on retaining access to it.

20. MINERALS AND STONE

As most of the study area consists of private land, the bulk of mineral and stone extraction occurs from private land. The only mineral (as defined in the *Mines Act* 1983) mined in the Wimmera is gypsum, while minor amounts of salt are extracted through licences granted under the *Land Act* 1958. Stone and gravel are more widely extracted, primarily for use in road maintenance and construction.

All current mineral and stone extraction sites on public land in the study area are listed in Table 24 and marked on Map 5. Mineral exploration is current over parts of the Wimmera.

Minerals

Mineral exploration

As at October 1984, 13 exploration licences were current in the study area, all held by C.R.A. Exploration and most containing some public land. Map 13 shows their location.

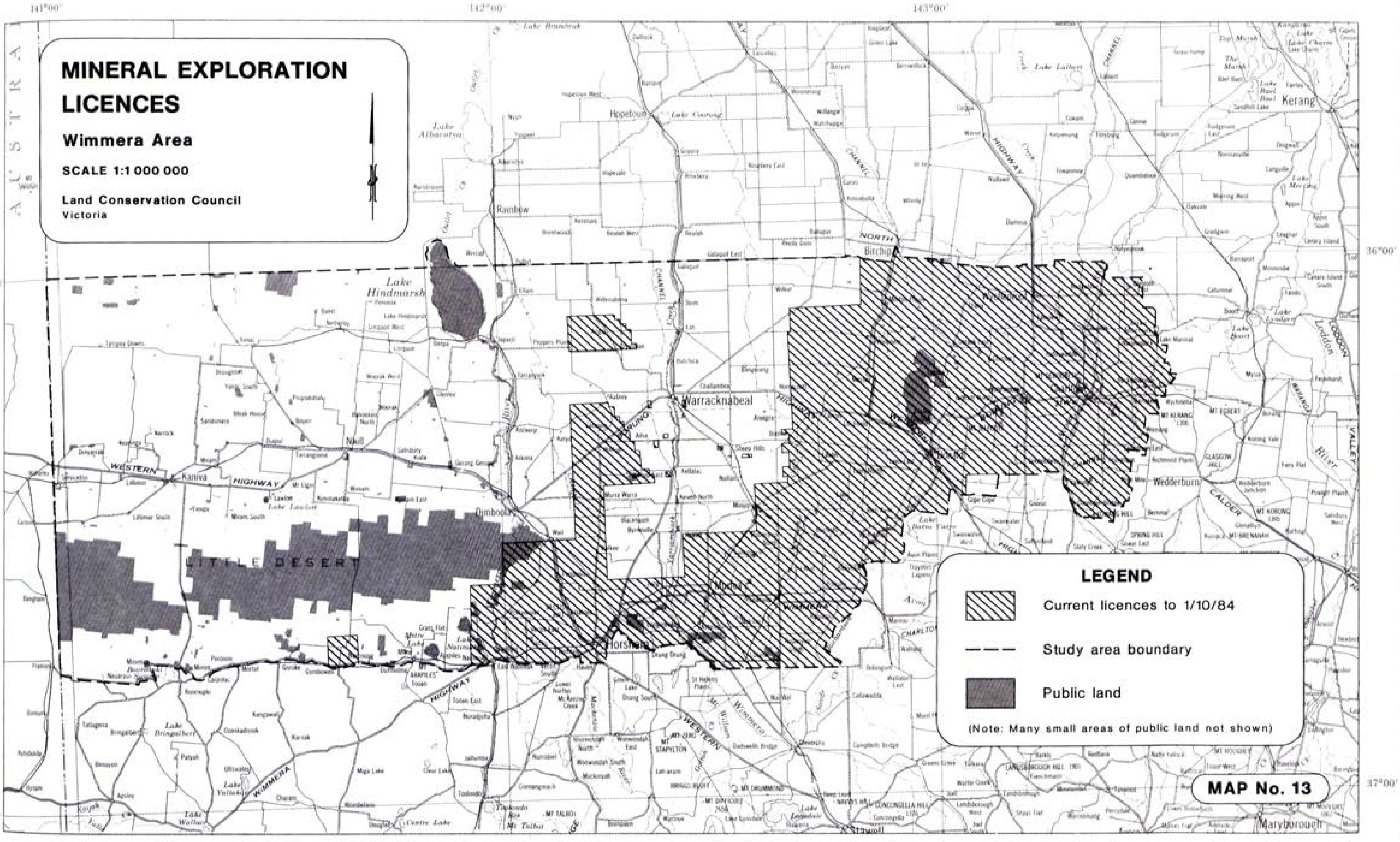
Since 1980 considerable effort - using extensive regional aeromagnetic surveys, airborne radiometric surveys, and drilling - has been directed towards investigating potential brown coal basins within the Tertiary sequence of the Murray Basin.

Using the same techniques, exploration has also been conducted for heavy minerals associated with coastal strandlines developed in the Parilla Sand, ancient river channels (deep leads) that have the potential to contain gold and diamonds, and diamond-bearing pipes and metallic mineral prospects within the basement rocks lying beneath the Murray Basin.

The amount spent on these investigations over the 4 years up to January 1984 was approximately $1,700,000.

The search for coal so far has been unsuccessful in the Wimmera, yielding only thin bands of brown coal located at uneconomic depths. More recently it has been concentrated on the heavy mineral potential of the Parilla Sand.

In one significant aspect of this exploration effort, the magnetic and radiometric data have generated contour maps that yield an enormous amount of


MINERAL EXPLORATION LICENCES
Wimmera Area
SCALE 1:1 000 000
Land Conservation Council
Victoria
LEGEND
Current licences to 1/10/84
Study area boundary
Public land
(Note: Many small areas of public land not shown)
MAP No. 13
141°00'
142°00'
143°00'
36°00'
37°00'
Lake Hindmarsh
LITTLE DESERT
Hopetoun
Rainbow
Birchip
Warracknabeal
Kaniva
Nhill
Dimboola
Horsham
Wedderburn
Kerang
Maryborough
WESTERN HIGHWAY
CALDER HIGHWAY
WIMMERA HIGHWAY

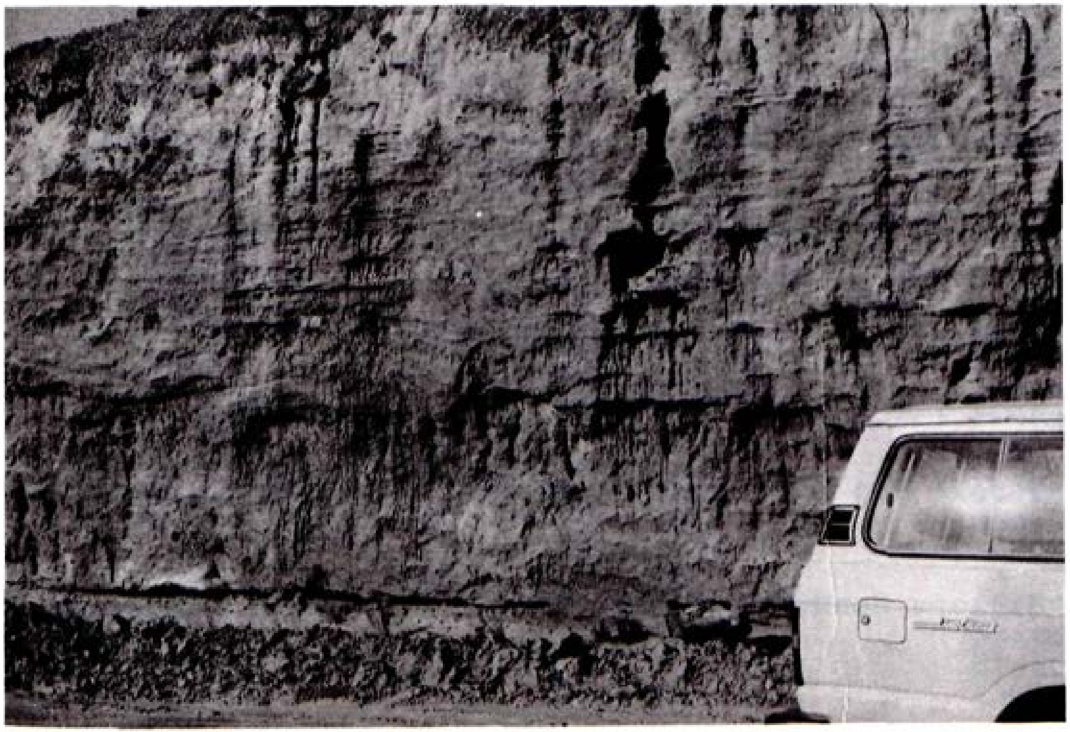
information about the deeply buried basement rocks beneath the study area.

Gypsum

Numerous gypsum deposits occur throughout the north-west of the State, and the mining of gypsum for agricultural use occurs in a zone running south from Lake Hindmarsh. This zone contains saline groundwater within a metre or so of the surface, which, when drawn to the surface in hot weather by capillary action, leads to fractional crystallization of gypsum ($CaSO_4$) at or close to the surface. Gypsum is mined by shallow stripping of the floors of depressions, or of the adjoining dunes where it has accumulated due to wind deflation of the depression floors.

Most gypsum mined in the Wimmera is used within the area on soils containing dispersive clays. Such soils develop surface crusting and, unless treated with gypsum, decrease in productivity when subjected to cultivation.

Total gypsum production in the study area in 1982 was 81,000 tonnes (44% of State production for agricultural purposes), a drop of 18% on 1981.



Parilla Sand - Aubrey Pit. The Shire of Warracknabeal extracts sandstone for road maintenance and construction from this public land site.

Table

MINERAL AND STONE EXTRACTION

Authority	No. or name	Mineral or stone
Mines Act (1983)	Mining lease 209-1	Gypsum
Extractive Industries Act (1966)	Extractive industry leases 115, 243	Crushed rock
Land Act (1958)	5002/138	Salt
	5109/138	Salt
	5140/138	Salt
	5163/138	Salt
Forests Act (1958)	Wail Pit	Sand
Various	Goroke Tip	Sand
	Millers Road No. 1 Pit	Gravel, sandstone

24

FROM THE PUBLIC LAND

Quantity removed in last recorded year of extraction (t = tonnes)	Location	Comments
120 t (1979)	West Wail Timber Reserve	
59,765 t (1981/82)	Parish of Charlton East	Large current hard-rock quarry; the operation also includes extractive licence 742, which covers adjacent freehold land
9 t (1978)	Salt Lake Parish of Duchembegarra	16 t removed 1972--81
320 t (1981)	Loch Iel (Pink Lake)	1,230 t removed 1972--81
5 t (1981)	Parish of Arapiles	29 t removed 1972--81
25 t (1980)	Lake Wyn Wyn	37 t removed 1972--81
200 cu.m (1983)	Wail Forest Reserve	Small pit of about 0.05 ha
200 cu.m (1983)	Parish of Goroke	Large pit 2--3 m deep operated for many years
8,000 cu.m (1983)	Parish of Dahwedarre	Large quarry currently used by Shire of Lowan; sandstone has high plasticity but is suitable for sealing

Table 24 (continued)

Authority	No. or name	Mineral or stone
	Nhill-Gymbowen No. 1 Pit	Gravel, sandstone
	Nottles Reserve	Limestone
	Boundary Pit	Gravel, sandstone
	Boundary North Pit	Gravel, sandstone
	Sanders Pit	Gravel, sandstone
	Murrawong North Pit	Gravel, sandstone
	Woollen Rises Quarry	Gravel, sandstone
	Aubrey Pit	Gravel, sandstone

Sources: Gypsum and crushed rock - Department of Minerals and Energy; Salt - Departme Conservation, Forests and Lands, and Shires; Gravel, sandstone - Shires.

Quantity removed in last recorded year of extraction (t = tonnes)	Location	Comments
2,000 cu.m (1983)	Little Desert (Parish) of Catiabrim)	Used intermittently by Shire of Lowan
3,000 cu.m (1983)	Parish of Warraquil	Used on a regular basis by Shire of Lowan
2,951 cu.m (1974)	Parish of Dahwedarre	Quarry used intermittently by Shire of Kaniva
2,848 cu.m (1977)	Parish of Mahrong	Used intermittently by Shire of Kaniva
3,320 cu.m (1979)	Parish of Mahrong	Used intermittently by Shire of Kaniva
2,009 cu., (1979)	Parish of Mahrong	Used intermittently by Shire of Kaniva
51,000 cu.m (1982/83)	Parish of Glenloth	Large quarry 6--7 m deep; Shires of Charlton and Wycheproof and R.C.A. cart from this quarry regularly; intermittent use by Shire of Gordon
7,000 cu.m (1982/83)	Parish of Cannum	Quarry 5--6 m deep used by Shire of Warracknabeal

nt of Conservation, Forests and Lands; Sand - Department of

Table 25 gives the annual production figures. All the gypsum came from private land in 1982, with 11 of the 20 mining leases current in the study area recording production that year. Only one mining lease occupies public land (see Table 24) and no production has been recorded at this site since 1979.

Salt

Halite or common salt (sodium chloride - NaCl) is mined under licence at a number of localities on the public land. Production is small and intermittent (see Table 25) depending very much on how wet the preceding winter has been and, to a lesser extent, on the demand for salt during the hotter months.

Table 25

PRODUCTION OF GYPSUM FOR AGRICULTURAL PURPOSES AND OF SALT (tonnes)

Year	Gypsum[A]	Salt[B]
1978	10,015 (9% of State total)	22 (1978–1979)
1979	51,885 (45% " " ")	
1980	110,702 (55% " " ")	275
1981	99,213 (49% " " ")	325
1982	81,098 (44% " " ")	0

Sources: A. Department of Minerals and Energy, *Annual Reports*

B. Department of Conservation, Forests and Lands

Salt is harvested at Loch Iel near Dimboola.

The salt deposits are associated with the same groundwater discharge zone responsible for the gypsum deposits described above. Upward leakage of groundwater partially fills a number of lakes in the area during winter. As the lakes evaporate in summer, salt is precipitated around the edges, or on the lake floors if drying is complete. The salt is scraped up, air-dried, bagged, and used as a salt lick for stock. Some salt from Loch Iel near Dimboola is used in brickmaking at Stawell.

Production from 1972 to 1981 under the four current licences was 1,300 tonnes, of which 325 tonnes were extracted during 1981.

Stone

'Stone' as defined in the *Extractive Industries Act* 1966 is a general term for sand, gravel, limestone, sandstone, slate, basalt, granite, clay, soil, etc.

Extractive industries fall into two main categories for the purpose of licensing and regulation - commercial and non-commercial operations.

Extraction for commercial purposes on both public and freehold land is subject to the provisions of the *Soil Conservation and Land Utilization Act* 1958 for excavations less than 2 m deep and more than 0.2 ha in extent, and to the *Extractive Industries Act* 1966 for excavations deeper than 2 m. Operations less than 2 m deep on unreserved Crown land are also subject to the provisions of the *Land Act* 1958, while extractions of any depth on reserved forest are subject to the *Forests Act* 1958.

When municipal bodies or the Road Construction Authority (R.C.A.) make non-commercial extractions they are not subject to leasing or licensing under the *Extractive Industries Act* 1966. They must, however, comply with the health and safety provisions of this *Act*.

Non-commercial extraction may take place under a range of *Acts*, including the *Land Act* 1958, *Local Government Act* 1958, *Forests Act* 1958, and *Country Roads Act* 1958. Such operations are subject to the *Soil Conservation and Land Utilization Act* 1958 where a risk of soil erosion is involved or where municipal power of entry to private land has been used.

In the Wimmera, the Shires and the R.C.A. use stone and gravel extensively for the maintenance and construction of roads. However, the regional geology is such that much of the area is generally unsuited to yield such material. Low-cost roadmaking materials of reasonable quality do occur, but are scarce and often difficult to locate.

One of the most extensive rock units in the Wimmera is the Parilla Sand, and the R.C.A. and many of the Shires have developed pits and quarries in this material. Its suitability for roadmaking material depends on clay content, hardness, and useful depth. It varies in quality, and generally the R.C.A. classifies it as suitable only for base course, although occasionally higher-quality material has been located. The Shires use the Parilla Sand widely for unsealed roads, and in some cases it can be used as a base for sealed surfaces.

Extraction of stone and gravel, for road maintenance and construction, represents the largest extractive activity in the study area. The R.C.A. and the 12 local Shires used about 663,000 cu.m of gravel during 1982/83. Of this total, they extracted some 71,000 cu.m from public land within the area.

Table 26

STONE REQUIREMENTS OF SHIRES 1982/83

Shire	Quantity used (cu.m)	Percentage supplied from public land in the study area	Comments on extraction from public land
Arapiles	17,000	0	
Birchip	40,000	0	
Charlton	36,000	69	Large quarry at Woollen Rises
Dimboola	20,000	0	
Donald	20,000	0	Mostly supplied from public land in the Shire of Kara Kara (outside the study area)
Dunmunkle	48,500	0	
Kaniva	49,500	0	Three pits in the north of the Shire are used intermittently
Kowree	12,500	2	One sand pit adjacent to Goroke Tip
Lowan	39,000	33	Mostly from two pits in the north of the Shire
Warracknabeal	60,000	12	Currently supplied from one pit at Aubrey
Wimmera	71,000	0	
Wycheproof	30,000	33	Carted from Woollen Rises quarry
Total	443,500	12.4	

Source: Shires

Table 26 shows the use of stone by Shires for the year ending June 1983. In total, about 12% of Shire gravel requirements come from public land within the study area, with more than 60% of the public land extraction coming from one quarry at Woollen Rises near Narrewillock.

Four of the 12 Shires obtain part of their gravel and stone requirements from public land within the study area. The remaining Shires obtain all their gravel and stone requirements either from outside it or from private land (see Table 26). In particular, Birchip, Charlton, Dunmunkle, and Donald Shires all cart from the Shire of Kara Kara in the North Central study area. The Shires of Wimmera, Arapiles, and Kowree obtain gravel from the adjoining South-western study area.

The only hard-rock quarry in the area is near Charlton. It operates on private and public land and supplies crushed rock for roads and the construction industry in the east of the area. Due to lack of suitable rock, hard-rock needs for the central and western parts of the Wimmera are obtained from quarries outside the study area, such as those at Stawell and Nigretta.

Demand for sand for construction, mortar, filling, concrete, etc. is fairly constant in most parts of Victoria. In the Wimmera such sand is usually obtained from the dunes (lunettes, source-bordering dunes) that dot the area. The largest operations are in lunettes on private land at Lake Hindmarsh and at Dooen. Two small operations on public land occur in the Wail Forest Reserve and north of Goroke (see Table 24), and account for about 1% of total sand production in the area.

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21. WATER UTILIZATION

Due to the absence of any significant independent surface water supplies and the unreliability of the streams that flow into the study area from the south, most of the Wimmera relies heavily on the Wimmera--Mallee Domestic and Stock Water Supply System. This System - an extensive network of dams, channels, and storages - harvests the water resources to the south of the study area and distributes them to the central and eastern parts of the Wimmera and Mallee.

Channel construction using horses.

As well as providing water for domestic and agricultural uses, the surface waters of the study area also provide faunal habitats and have recreational uses. These aspects of water utilization are described in the Fauna and Recreation chapters.

The western part of the study area has large reserves of good-quality groundwater associated with the aquifer known as the Duddo Limestone. Bores here supply water for domestic, stock, and irrigation purposes.

The Wimmera--Mallee Domestic and Stock Water Supply System

History

In the 1840s, pastoralists began to settle in the region between the Wimmera River and the Murray. However, with only the unreliable Wimmera River system and low run-off, lack of water for both domestic and stock use became a serious problem in the region.

The Wilsons of Longerenong dammed the Wimmera River at Ashens and Longerenong around 1856, to divert water into the Ashens and Yarriambiack Creeks. These creeks were in turn dammed, and by the late 1860s water was distributed through a series of pipes and channels to form the foundation of the Wimmera--Mallee system as we know it today. Other settlers soon followed their example.

The droughts of 1865 and 1869 caused the government to consider the question of water supply, but no action was taken until the droughts of 1877 and 1881, when finance was made available to Shire Councils for water supply works. Tanks, weirs, and other works were constructed in an attempt to provide accessible water for farmers.

In 1878, the Shire of Wimmera constructed a timber weir at Longerenong to divert water to the Yarriambiack Creek. This weir was similar to one built by the Shires of Dunmunkle and St Arnaud, above Glenorchy.

The Wimmera United Waterworks Trust was formed in 1882 under the provisions of the *Water Conservation Act* of 1881. This Trust built the first irrigation storage, Wartook Reservoir, on the headwaters of the Mackenzie River in the Grampians between 1882 and 1887.

Between 1882 and 1895 many channels, weirs, and tanks were constructed and irrigation development around Horsham intensified with the establishment of orchards, vineyards, market-gardens, and dairy-farms. The 7-year dry period that culminated in the 1902 drought, together with the difficulties farmers faced in obtaining water outside the Trust districts, saw the commencement of construction of the dam on Mount William Creek to form Lake Lonsdale near Stawell.

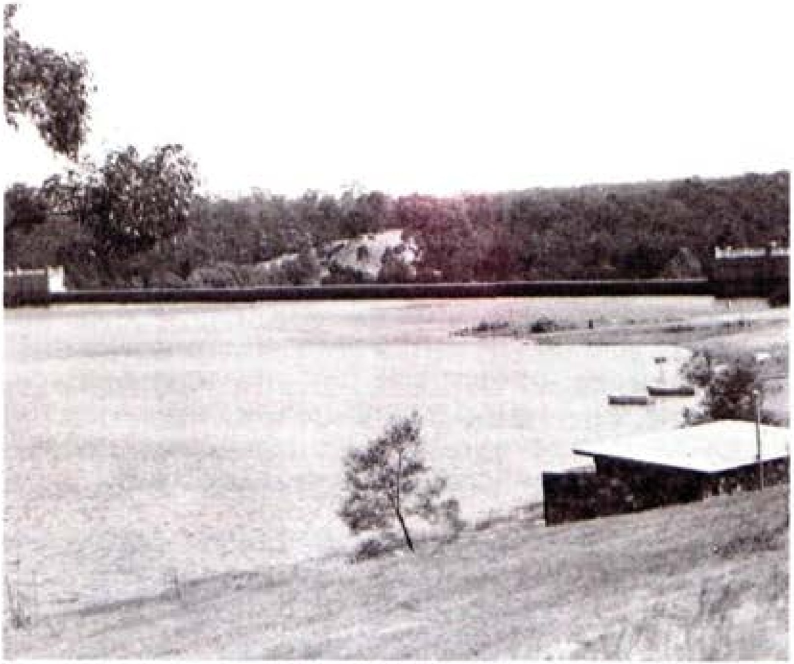
By this time, seven rural Waterworks Trusts were operating in the Wimmera. Divided control of the headwaters caused endless disagreement and problems relating to finance and rate collection.

The *Water Act* 1905 was passed in an endeavour to co-ordinate distribution and utilization of available supplies. All natural streams and waters in Victoria were declared as property of the Crown.

Under the provisions of the *Act*, the State Rivers and Water Supply Commission was established in 1906 and by 1909 it had taken over the functions and responsibilities of the Trusts.

In 1907 construction of the main channel commenced. It was designed to replace distribution via natural watercourses and reduce excessive water losses. Although incomplete by the 1914 drought, the system proved effective for conveying water.

The 1914 drought saw the start of construction of Lake Fyans reservoir, which was completed in 1916. Lake Taylor and



Rocklands Reservoir.

Pine Lake were finished in 1920 and 1923 respectively, and Green Lake and Dock Lake in 1933. These storages, located just south of the study area, were formerly natural swamps or lakes. Rocklands Reservoir, located 15 km upstream of Balmoral on the Glenelg River, was completed in 1953 and is the major storage for the Wimmera--Mallee supply system. Water from the southward-flowing Glenelg River is diverted north through a tunnel.

This collection of storages around the Grampians area combines with a network of distribution channels to make up the Wimmera--Mallee Domestic and Stock Water Supply System, one the world's most extensive gravitational supply systems.

Importance to Victoria

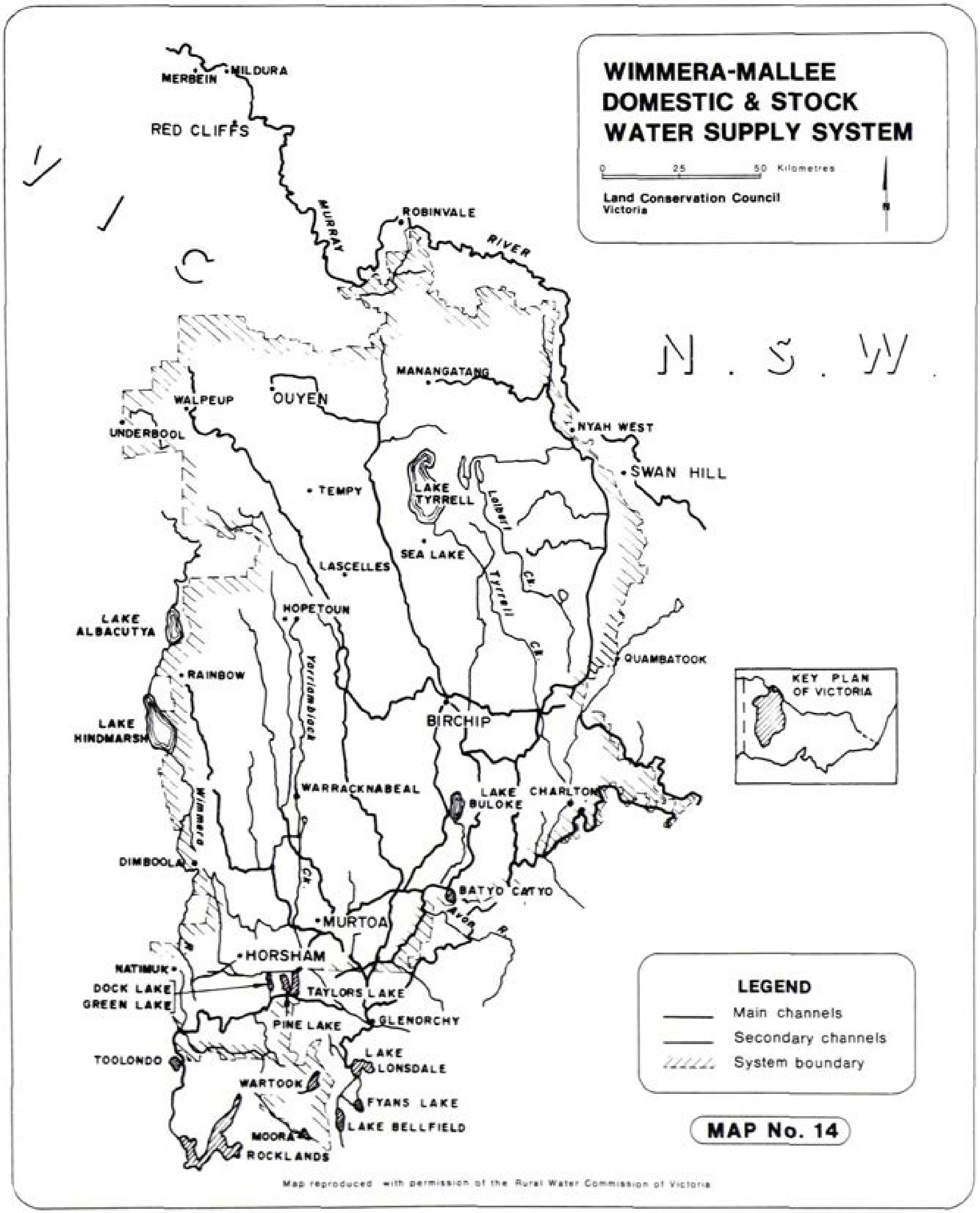
The Wimmera--Mallee system serves 28,500 sq. km of farmland in western and north-western Victoria. Farms here produce mainly sheep and cereals, including most of the State's wheat and barley. About 70,000 people live in the area, two-thirds of them in the towns. The system also supplies water for 3,055 ha of irrigated farms near Horsham and Murtoa.

The extensive distribution system, which takes water from the Grampians and mid-lands storages to where it will be used, includes some 9,600 km of Rural Water Commission (formerly State Rivers and Water Supply Commission) channels and some 6,500 km of farmers' channels. It fills about 20,500 farm dams and the storage basins of 48 towns each year.

Without this water, life in most parts of the Victorian Mallee and Wimmera would be difficult and the agriculture of these two regions would be much less productive.

Operation

Map 14 shows the area served by the Wimmera--Mallee system and the headworks storages. The plains of the central and northern Wimmera and the southern Mallee slope away from the Grampians. Six main channels take water by gravitation from


WIMMERA-MALLEE
DOMESTIC & STOCK
WATER SUPPLY SYSTEM
0 25 50 Kilometres
Land Conservation Council
Victoria
VIC
N.S.W.
MERBEIN
MILDURA
RED CLIFFS
MURRAY
RIVER
ROBINVALE
MANANGATANG
WALPEUP
OUYEN
UNDERBOOL
NYAH WEST
SWAN HILL
TEMPY
LAKE TYRRELL
Lalbert
SEA LAKE
LASCELLES
Tyrrell
Ck.
Ck.
HOPETOUN
LAKE ALBACUTYA
Yarriambiack
RAINBOW
QUAMBATOOK
KEY PLAN OF VICTORIA
LAKE HINDMARSH
BIRCHIP
Wimmera
WARRACKNABEAL
LAKE BULOKE
CHARLTON
DIMBOOLA
Ck.
BATYO CATYO
Avon
R.
MURTOA
R.
HORSHAM
NATIMUK
DOCK LAKE
GREEN LAKE
TAYLORS LAKE
PINE LAKE
GLENORCHY
TOOLONDO
LAKE LONSDALE
WARTOOK
FYANS LAKE
LAKE BELLFIELD
MOORA
ROCKLANDS
LEGEND
Main channels
Secondary channels
System boundary
MAP No. 14
Map reproduced with permission of the Rural Water Commission of Victoria

any of the storages to anywhere in the system, except for a few elevated localities. Some of these localities, however, can be served from particular storages; in other instances pumping stations are required. Water is also diverted from the Wimmera River into channels at Glenorchy and at Huddlestons Weir, a further 15 km downstream.

To minimize evaporation and seepage losses, the channels are run once a year in winter. The northernmost points are watered first, and those nearest the headworks storages last. Most towns pump from a holding reservoir into elevated tanks for distribution. Most Wimmera--Mallee residents collect rainwater in tanks for domestic use.

The total volume of water used annually in the system varies greatly, but averages about 118,000 ML a year for domestic and stock supplies, and 27,000 ML for irrigation. The annual diversions from the Wimmera River vary widely depending on the water available. In a 5-year period during the early 1970s they varied from 2,500 ML to 43,000 ML.

New waterworks

Development of the water resources of the Grampians appears to be approaching its economic limit. However, the Rural Water Commission is currently investigating the adequacy of supply and possible means of augmentation of the Wimmera--Mallee system.

Improved efficiency

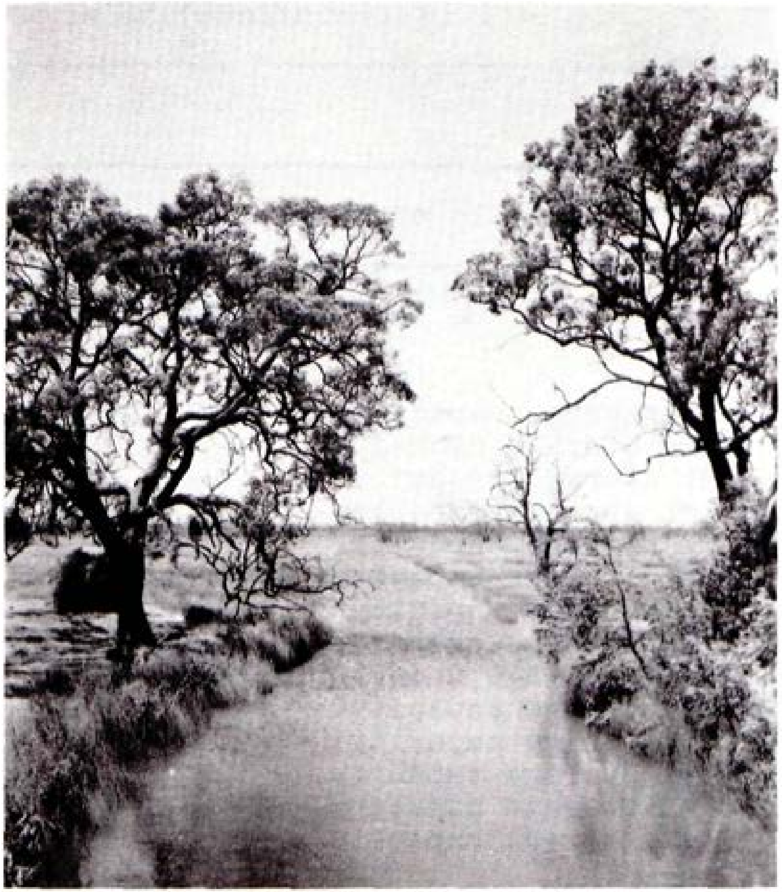
Although few opportunities to conserve more water exist at the head of the system, considerable water can be saved by improving methods of distribution in the Wimmera and Mallee.

The earthen channels used at present are inefficient. Water losses from them are very high, particularly north of Hopetoun in the Mallee, because of seepage into sandy soils and evaporation. This results in an average of only 26% of the water released from storage being delivered to the users. Efficiencies vary from 65% in the southern Wimmera to 20% in the northern Mallee. A small piped system west of Rainbow has been very successful - it supplies an area of 10,000 ha of farmland by gravity from the town storages; use of pipelines here has saved a large quantity of water.

Pipeline installation also results in improved quality of the water delivered, as the water in open channels is unprotected and bank wash causes turbidity. It is expected that, wherever practicable, pipelines will ultimately replace the earthen channels.

Urban Water Supply

Ten Water Boards or municipal bodies provide water services for towns within the Wimmera area. The Rural Water Commission administers the water supplies of another 13 towns in the area, while



Typical Wimmera water supply channel.

V/Line (formerly Victorian Railways) controls supplies to the town of Serviceton.

Details of the town water supplies are set out in Table 27. The majority of these towns use excavated earthen storages and pump into standpipes to supply the reticulation system. The exceptions to this are Antwerp, Dimboola, Dooen, and Jeparit, which have storages filled by gravity, although Dimboola has a split-level system, with the high-level storage being supplied by pumping from the low-level storage.

The western part of the study area is not served by the Wimmera--Mallee system and has no natural watercourses. Hence all towns here depend on groundwater for domestic supplies. Some schools have also needed to develop their own bores. Fortunately, this western region overlies a large resource of good-quality groundwater associated with the Duddo Limestone. The towns of Nhill, Kaniva, Lillimur, Miram, Serviceton, and Goroke all have reticulated water supplies that use groundwater.

As well as reticulated supplies, most residents use rainwater collected in tanks as a supplementary supply for domestic uses such as drinking, cooking, and washing. Some of the small settlements, such as Tarranyurk, Corack East, and Lubeck, draw water from public or council tanks by permit. In the west, small settlements - including Gerang Gerung, Lorquon, Minimay, Netherby, and Yanac - draw water from bores maintained by the local community, to supplement water collected in private tanks.

Treatment

The water supplied to Horsham, Donald, and Murtoa is chlorinated prior to de-

Table 27

TOWN WATER SUPPLIES

Town	Approximate population[1]	Details of supply[2]
A. Administered by Rural Water Commission - all supplied from the Commission's Wimmera--Mallee domestic and stock system		
Antwerp	34	33 ML storage capacity
Birchip	895	387 ML storage capacity
Brim	94	66 ML storage capacity
Dimboola	1,675	427 ML storage capacity
Dooen	50	18 ML storage capacity
Jeparit	538	226 ML storage capacity
Jung	87	22 ML storage capacity
Minyip	567	114 ML storage capacity (230-ML storage under construction)
Natimuk	482	95 ML storage capacity
Pimpinio	86	35 ML storage capacity
Rupanyup	406	173 ML storage capacity
Watchem	195	108 ML storage capacity
Wycheproof	938	531 ML storage capacity
B. Administered by local water authorities		
Charlton (Charlton Water Board)	1,300	Water gravitated from Water Commission channel to 753-ML storage and then to pump station and 730-kL service basin
Donald (Donald Water Board)	1,600	Water gravitated from Commission channel to 550-ML storage, pumped to 2.95-ML standpipe and 182-kL high-level tank, and chlorinated prior to distribution

Table 27 (continued..)

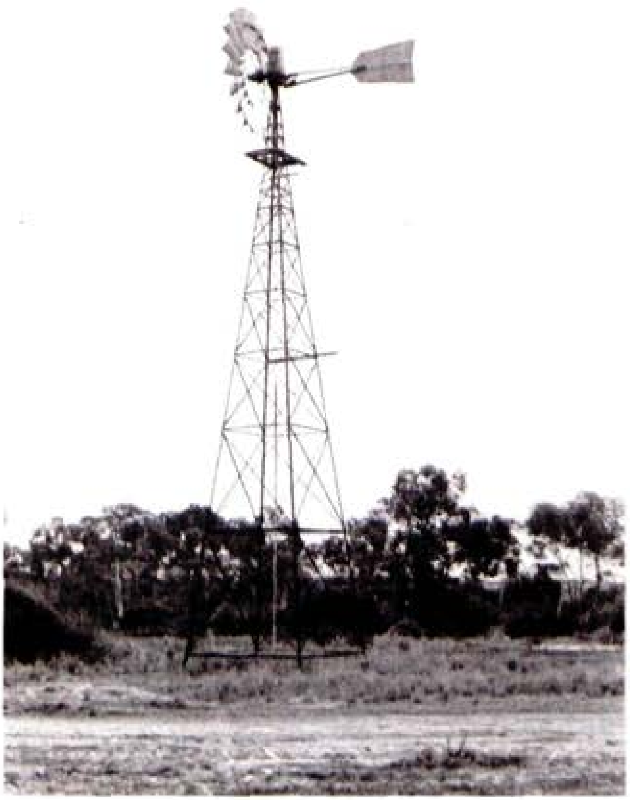
Town	Approximate population[1]	Details of supply[2]
Goroke (Kowree Water Board)	370	Supply from local bores
Horsham (City of Horsham)	12,580	Water gravitated from Commission channel to 206-ML storage, two service storages, and then pumped to 1-ML roofed elevated storage; water supply is chlorinated
Kaniva Lillimur Miram (Shire of Kaniva)	1,100	Supply from bores
Kiata (Shire of Dimboola)	25	Supply from local bore
Murtoa (Murtoa Water Board)	1,025	Supply is taken from Commission channel to Lake Marma and pumped to town stand-pipe; water is chlorinated prior to distribution
Nhill (Nhill Water Board)	2,150	Water supply from several bores within township to ground-level and elevated storages
Serviceton (V/Line)	85	Supply from local bores
Warracknabeal (Warracknabeal Water Board)	2,880	Supply drawn from Commission's Lake Whitton storage and fully treated, including sedimentation and chlorination, prior to distribution through reticulation system

1. *Source:* Part A - Census 1981 and Rural Water Commission
Part B - Local water authorities
2. *Source:* Rural Water Commission and Department of Water Resources

livery. Warracknabeal's water supply is treated by sedimentation prior to chlorination and distribution. All other supplies are untreated.

Future demand

Urban consumption of water has risen slowly over the past decade. This rise is due to greater use for watering sports-grounds and gardens, and to greater usage within homes.



Groundwater is the major source of stock supplies in the west of the study area.

Farm Supplies

Surface water

Farms in the central and eastern parts of the study area are served by the channels of the Wimmera--Mallee domestic and stock system.

Farm dams are also an important source of supply in the study area. Most dams have about 1 ML capacity, but a few go up to 30 ML. Household supplies are drawn from tanks. River flow and supplies in lakes and swamps are also used where quality is suitable. Water is pumped from the river into storages, and then used for stock and domestic supply or irrigation.

Groundwater

In addition to the use of surface water, farmers make considerable use of groundwater for both stock and domestic supplies, especially in the western part.

Under the *Groundwater Act* 1969, any person who wishes to use groundwater is required to either register or license the bore. If intending to drill a bore for any purpose, the landholder is required to apply to the Department of Minerals and Energy for permission to drill. Any proposal to drill a bore for

Early bore construction in the Wimmera.

irrigation use is then referred to the Rural Water Commission for comment on the possibility of interference with any other known bore. The Commission also advises the Department of Minerals and Energy of the conditions under which it would issue a licence to authorize extraction from the bore. As at October 1983, the study area contained about 280 licensed bores (see Map 15). Appendix 4 lists all authorized bores in the study area, and indicates their use.

Irrigation

Surface water

A number of small irrigation permit areas in the study area are supplied from the Wimmera--Mallee domestic and stock system. Several are located near Coromby, north of Murtoa, while others are centred around Horsham to the south (see Map 7).

Estimated surface water utilization for irrigation on the permit areas totalled 5,169 ML during 1982/83, a drought year (see Table 28). This volume, which required the release of some 7,400 ML from the Wimmera--Mallee storages, was a record figure.

Table 28

WATER DELIVERED IN IRRIGATION AREAS (1982/83)

Centre	Water delivered (ML)
Horsham	878*
Murtoa	4,291
Total	5,169

* Because some of the irrigation permit areas lie outside the study area, the figure given is for the amount of water known to have been delivered in the study area.

Source: Rural Water Commission

In addition to this, private diversion for irrigation in the study area uses some 1,600 ML annually, as indicated in Table 29. These schemes are mostly operated by individual land-owners under licences or permits issued by the Rural Water Commission. Many of the land-owners also have licences to site their pumps, pipelines, and channels on public land.

Table 29

DIVERSION PERMITS FROM SURFACE WATERS

Stream/Lake	Domestic (No.)	Domestic and stock (No.)	Dairy and domestic (No.)	Irrigation			Miscell. (No.)
				No.	Area (ha)	Vol. (ML)	
Lake Natimuk	-	-	-	1	20	120	-
Richardson River	1	1	-	4	32	200	-
Wimmera River	16	14	1	47	215	1,280	1
Yarriambiack Creek	2	2	-	-	-	-	-
Yanac Swamp	1	-	-	-	-	-	-
Total	20	17	1	52	268	1,600	1

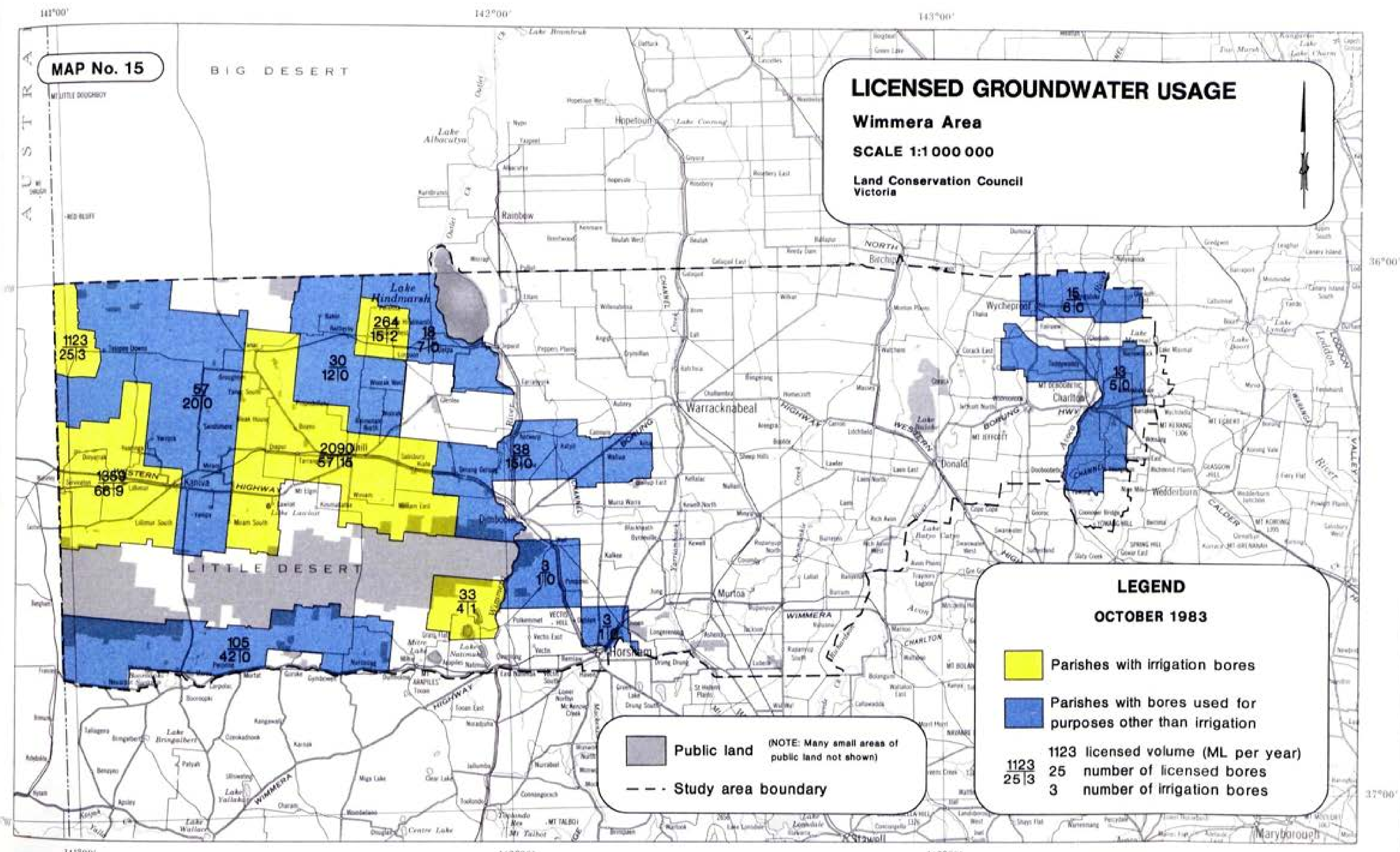
Source: Rural Water Commission (1983)

Due to the intensity of use of the water resources in the area at present, and to the salting hazard in many of the streams, any expansion of irrigated agriculture using surface supplies in unlikely.

Groundwater

Currently, a limited amount of groundwater is used for irrigation in the western part of the study area. As at October 1983, 30 irrigation bores had a total licensed volume of 2,670 ML per year. Appendix 4 and Map 15 may be consulted for details.

Adjoining the study area in South Australia, high-yielding central pivot irrigation systems in operation utilize groundwater from the Duddo Limestone. There is interest in developing similar


MAP No. 15
LICENSED GROUNDWATER USAGE
Wimmera Area
SCALE 1:1 000 000
Land Conservation Council
Victoria
BIG DESERT
LITTLE DESERT
LEGEND
OCTOBER 1983
Parishes with irrigation bores
Parishes with bores used for purposes other than irrigation
1123 licensed volume (ML per year)
25 number of licensed bores
3 number of irrigation bores
Public land
(NOTE: Many small areas of public land not shown)
Study area boundary

schemes, using the same aquifer system, on the Victorian side of the border.

Recreational Lakes

The Rural Water Commission provides water for ten recreational lakes from the Wimmera--Mallee system, depending on available supplies. Five of these lakes are within the Wimmera study area.

A total of 1,380 ML may be made available to these lakes if the total volume of water stored equals or exceeds 350,000 ML, coincident with supply being available to a particular lake from the channel system.

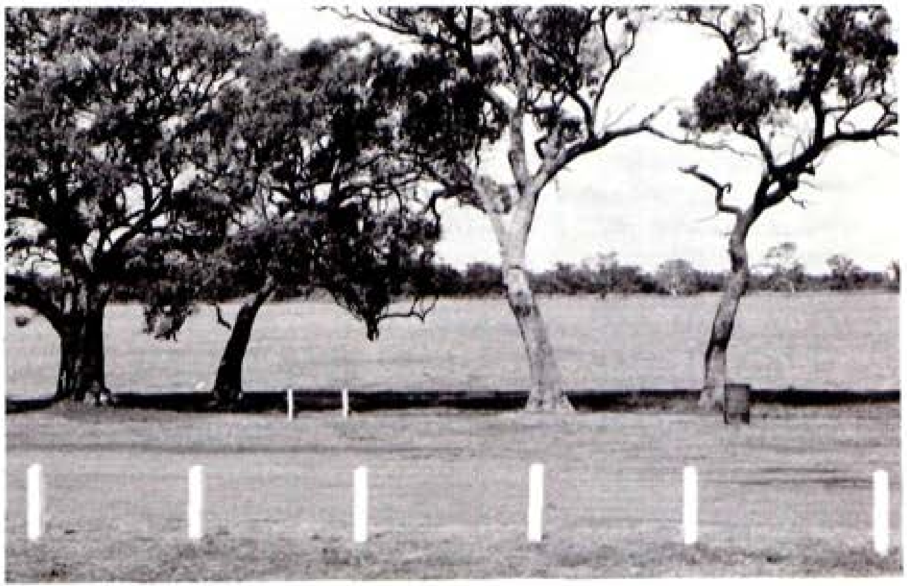
The approved lakes are Wooroonook Lakes, Donald Park, Lake Watchem, Lake Corack, and the Yarriambiack Creek at Warracknabeal.

River Improvement

The *River Improvement Act* 1958 provides for river improvement and maintenance works to be carried out, and enables the constitution of river improvement districts under the control of a single authority.

Apart from such works, the *Act* also makes provision for carrying out drainage works and for rating lands within the district that such works benefit.

Works include the use of structures to reduce flooding and erosion, the removal of weeds and silt, and re-grading of the



Wooroonook Lakes - recreational lakes supplied from the Wimmera--Mallee system.

river-bed. Fallen timber may be removed from rivers or alternatively placed against their banks to control erosion.

Only one River Improvement Trust operates in the Wimmera: the Avoca River Improvement Trust in the far north-east of the study area.

The principal aim of river management is to achieve a reasonable balance between the stable carrying capacity of a stream and the protection or enhancement of its associated wetlands and frontages.

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22. UTILITIES

Often the utilities and services essential to modern community living are located on public land. They may include facilities for transport, communications, navigation, power supply, waste disposal, or airstrips. This chapter describes the major utilities in the study area and attempts to assess future requirements in certain fields.

Waste disposal

Disposal of the waste produced by urban communities can be a problem for municipal authorities. The selection of new disposal sites can be difficult; in many cases, little suitable land remains near towns, and conflict may arise between waste disposal and the recreational and conservation pressures for the same areas.

The illegal dumping of rubbish on public land is of widespread concern, and even the licensed tips have caused problems with fire risk, windblown material, and unsightliness.

Throughout the study area, the authorities mainly dispose of solid waste by the landfill method - using natural depressions or old excavations. Generally, the tips serving the towns occupy either freehold land or public land specifically reserved or licensed for waste disposal.

Sewage-treatment works processing both domestic and industrial waste operate for 12 of the major population centres of the study area; two further sewerage systems have been proposed. Effluent from these systems is generally disposed of via irrigation works. Further details on the sewerage authorities are set out in Table 30.

Electricity supply

The State Electricity Commission of Victoria supplies electricity from the State high-tension grid network. A single-circuit 220-kV line crosses the study area from south to north connecting the Horsham and Red Cliffs terminal stations. The easement for this transmission line mainly occupies private land, but does pass through the Longerenong campus of the Victorian College of Agriculture and Horticulture.

There are no Commission power stations in the area and no other major transmission lines are planned at present.

Table 30

SEWERAGE AUTHORITIES

Town	Controlling body	Population sewered	Method of treatment	Disposal of effluent
Birchip	Shire of Birchip	900	Stabilization lagoons located 1.5 km east of Birchip	Grass irrigation
Charlton	Charlton Water Board	1,300	Biological oxidation in stabilization lagoons south-west of Charlton	Irrigation
Dimboola	Hindmarsh Water Board	1,800	Preliminary sedimentation tank, separate tank for the digestion of the sewage solids, trickling filter and sludge drying beds; works located to the south-west of Dimboola	Irrigation on 12 ha of adjacent land
Donald	Donald Water Board	1,600	Oxidation lagoons located 1.5 km to the south of the town	Irrigation
Horsham	City of Horsham	12,600	9.9 ha of lagoons, an oxidation ditch, clarifier and sludge drying beds located 3 km south-west of Horsham (outside study area)	Estimated 30--35% by irrigation of 40 ha of land adjacent to treatment works, remainder to McKenzie River immediately upstream of confluence with Wimmera River
Jeparit	Hindmarsh Water Board	550	Lagoons north-east of Jeparit	6 ha of land irrigation

Table 30 continued

Town	Controlling body	Population sewered	Method of treatment	Disposal of effluent
Kaniva	Shire of Kaniva	1,000	Kaniva is divided into two drainage basins by a low ridge crossing the northern portion of the town; therefore there are two separate treatment works situated 2.5 km north and 2 km south of the town; treatment is by anaerobic settling and digesting lagoons and aerobic oxidizing pools	Confined seepage and evaporation areas
Murtoa	Murtoa Water Board	1,000	Sedimentation and sludge digestion at treatment works located 1 km north-west of the town	12 ha of land irrigation
Nhill	Nhill Water Board	2,000	Trickling filter at treatment works located to the south-west of Nhill	15 ha of pasture irrigation
Serviceton	Shire of Kaniva	85	Lagoons located to the north of Serviceton	1 ha of pasture
Warracknabeal	Warracknabeal Water Board	2,700	Trickling filters at treatment works located 1 km south of the town	65 ha of pasture irrigation
Wycheproof	Wycheproof Water Board	940	Primary and secondary lagoons located to the west of Wycheproof	Land irrigation

Table 30 continued

Town	Controlling body	Population sewered	Method of treatment	Disposal of effluent
Proposed works				
Minyip	Shire of Dunmunkle		On a 20-ha treatment site to be located 1.2 km north of the town, treatment will be by stabilization lagoons	Land irrigation
Rupanyup	Shire of Dunmunkle		On a 16-ha treatment works site to be located 2.5 km north of the town, treatment will be by stabilization lagoons	Land irrigation

From the Horsham terminal a medium-voltage 66-kV transmission line runs to the Nhill sub-station, and a 22-kV line runs to Warracknabeal. This will become a 66-kV line in a few years, following construction of a sub-station at Warracknabeal. A 66-kV line runs to the Charlton sub-station from the Bendigo terminal station. Further distribution of electricity throughout the area, and to the consumers, occurs via a substantial network of 22-kV and 12.7-kV distribution lines.

Most of these sub-transmission and distribution lines run in road reserves, although some of them occupy easements - usually on private land.

Construction of power lines along the easements of existing road reserves ensures ready access for maintenance vehicles. In some cases, however, it may require the destruction of some roadside vegetation to meet the easement widths that the Commission desires for maintenance of power-line safety and security and minimizing of fire risk.

Road transport

The Road Construction Authority (R.C.A.) has the responsibility for constructing and maintaining the State's major road systems. In the Wimmera, these include the Western (which forms part of the national highway system and is funded by the Commonwealth government), Calder, Sunraysia, Borung, Henty, and Wimmera Highways.

Some routes, defined as 'roads' by the R.C.A., form further links between settlements and come under the control of the relevant municipalities. Others are the sole responsibility of the municipalities or the Department of Conservation, Forests and Lands - within their respective areas of control.

Road reserves often contain significant remnants of the original vegetation, particularly where they pass through agricultural country, and often make an important contribution to the local landscape.

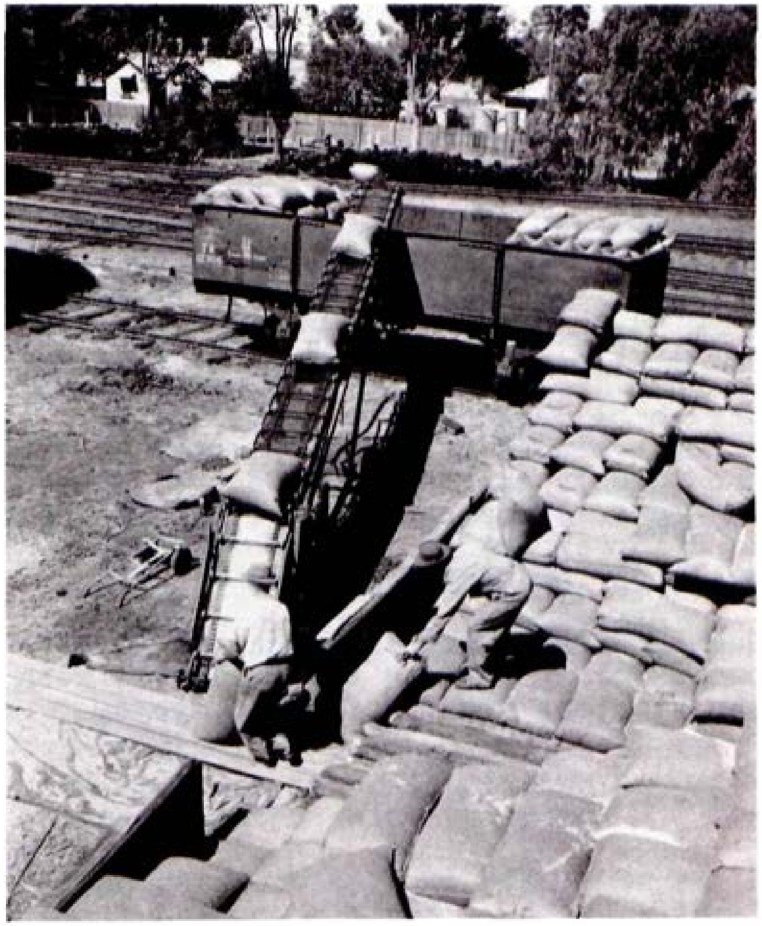
The R.C.A. is currently planning a deviation of the Western Highway to bypass the township of Dimboola. This proposal will affect a small area of public land adjacent to the Dimboola Cemetery. Apart from some improvements to existing alignments, the Authority has no other plans for major highway construction in the study area.

Airports

Five major aerodromes owned by the respective municipalities and licensed by the Commonwealth Department of Aviation are located at Horsham, Warracknabeal, Nhill, Wycheproof, and Birchip. In addition, a number of authorized landing strips are scattered throughout.

Rail transport

The only passenger rail services run by V/Line (formerly Victorian Railways) in the study area are those along the main lines from Melbourne to Adelaide and Mildura. The Melbourne--Adelaide line



Loading wheat at Wycheproof railway siding.

passes through Murtoa, Horsham, Dimboola, and Nhill to the border at Serviceton, while the Melbourne--Mildura line passes through Donald and Birchip. V/Line also provides passenger bus services over several routes in the Wimmera.

V/Line operates a number of freight lines and has regional freight centres at Horsham, Warracknabeal, Nhill, and Donald. Several small feeder lines run to these centres.

Cartage of wheat makes up by far the largest part of V/Line's freight traffic in the area. The busiest time of the year for the railways thus comes in December and January, when the wheat harvest is filling the silos at every siding on the lines through the Wimmera. Grain has to be moved to the large inland storage depots at Marmalake near Murtoa and Dunolly in the North Central area, and on to the ports of Geelong and Portland for export or to Melbourne and Ballarat for domestic use.

Bumper wheat crops like that of 1983/84 can severely tax the capacities of both the storages and the freight system.

Military use

The Australian Army has no recognized or proclaimed training areas here, although the Big Desert Training Area abuts the northern boundary of the study area. This has been used infrequently in the past, and the Army does not expect to increase the usage rate in the future.

Other uses

Public utilities and institutions occupy land for schools, cemeteries, trigonometrical stations, public buildings, and municipal depots. Small parcels of public land are continually required for such uses.

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23. LAND USE RELATIONS

Preceding chapters of this report have described the natural resources of the study area and discussed the existing and potential utilization of resources on public land. Hazards associated with these uses have also been considered.

Groups with a wide range of interests are making growing demands for resources on public land. In such a situation the interaction of various uses becomes an important issue that must be considered before decisions can be made on the allocation of that land. This chapter examines the nature of the interactions.

Land use compatibility

Each type of land use requires a certain set of resources for its operation, and these have been discussed in relevant chapters. In many cases the resources required overlap in both time and space, thus providing a source of potential conflict. Moreover, the operation of each will have a series of direct and indirect effects on most other uses. These effects may be considered as:

* beneficial - resulting in an increase in another activity or activities (complementary uses)

* harmful - resulting in a decrease in another activity or activities (competitive uses)

* negligible - having no effect in either direction (supplementary uses)

The nature of these effects will determine the degree of compatibility between two or more land uses, and hence their ability to be combined in order to obtain the best combination of uses on a land management unit. In practice, several ameliorating factors operate, which include the following:

* Activities occur at different levels of intensity. (Incompatibility between two activities at a high intensity may be reduced if the operations of one become less intensive.)

* Some activities occur for a short period, thus restricting their effects and allowing other activities to continue in intervening periods.

* Often an activity only occurs in a small part of a wider area, thus localizing its effect. (This enables other activities to continue in the general area.)

* Compatibility between uses in an area changes over time as the once-harmful effects of one activity are lessened.

* Prevailing social attitudes towards the tolerance of harmful intereffects may change. (In some cases improved technology helps change these attitudes.)

* Skilful management techniques can reduce possible competitive effects of an activity on others.

Land use flexibility refers to the degree to which any one activity precludes (by its operation) other activities' utilization of a given resource. Flexible uses include those having either negligible or beneficial effects on others.

The following sections give a general outline of relations between broad land use categories in the study area. This report does not deal with relations between various activities or aspects within each major category of use, although the same principles would apply. Those between various forms of recreation, however, are briefly considered.

Agriculture

Clearing of land for agricultural production has benefited some native animals by increasing the area of grassland and forest margins, while farm dams and irrigation works may have extended the range of some amphibians, reptiles, and birds. Nevertheless, agriculture is normally incompatible with most aspects of nature conservation, since most species are severely reduced in number or even eliminated by the removal of their habitat and the introduction of alien plants and animals.

On the other hand, agricultural activities often form a dominant feature of the rural landscape.

Agriculture can affect water production, as the conversion from forest to grassland can alter the volume and timing of run-off, which in turn may lead to increases in total water yield, turbidity, and salinity, as well as a reduction in summer stream flow. Pollution may also result from injudicious use of fertilizers and pesticides or from the concentration of stock near watercourses.

Forest grazing can conflict with nature conservation because of the disturbance to the environment caused by stock grazing and watering, and the introduction of alien plants. It is also competitive with some forms of recreation that require natural environments and, by reducing native ground flora that provide nectar and pollen for honey bees, it can compete with apiculture.

Apiculture

Since the bees serve the useful function of cross-pollination, apiculture may complement agriculture. It relies largely on native flora and so 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 largely unknown.

Timber production

This is a relatively flexible land use, particularly when carried out at a low intensity. It is compatible with forest grazing, honey production, and all but the strictest forms of nature conservation. It can benefit some forms of outdoor recreation by providing access tracks for walking and pleasure driving.

Harvesting operations can immediately degrade vegetation, fauna, and landscape values. Most effects are temporary, but some could be long-term. Tree-felling becomes more noticeable as the size of the area increases and when most or all of the trees in the stand are cut.

Increasing the levels of hardwood production decreases its compatibility with other uses, such as nature conservation, apiculture, and many forms of recreation.

Intensive practices may favour certain commercially valuable species, remove trees containing sites for animal nesting, limit the size to which trees are allowed to grow, intensify harvesting activities, and require the increased use of fire.

Hardwood timber production in certain parts of the study area competes with recreational activities requiring solitude. It could also be considered to be in competition with agricultural production on those areas of forested public land that have potential for agricultural development.

Water conservation

The production and utilization of water is an important use of public land. To some extent it is competitive with agriculture, timber production, mining, and recreation (depending on the intensity of these uses, the management techniques employed, and the intended use of the water).

The hydrology of the surface drainage system in most of the study area has been significantly altered by use of water within and outside the area. While this management of water is a necessary part of land management for food and fibre production, it can affect the value of wetlands for wildlife habitat and the health and vigour of some of the river red gum woodlands to the north of the study area.

Activities such as logging, road-making, quarrying, clearing, and grazing can cause soil disturbance and reduce absorption by the soil, leading to increases in surface run-off, stream turbidity, peak flows, siltation, and erosion.

As well as contributing to the quality and quantity of stream flows, public land also contributes to the quality and quantity of the groundwater, a valuable resource in the western part of the study area. Recharge of underground water supplies can be decreased if run-off is increased by clearing vegetation.

In many cases, activities using parts of catchments away from storage areas do not pose a substantial threat to either water quality or yield. The use of land as a catchment is therefore normally complementary with nature conservation and, to varying degrees, with other activities.

Water storages increase the opportunities for some forms of recreation, such as lakeside picnicking and water-based activities.

Storages, however, can adversely affect nature conservation. Inundation by water obviously destroys the original habitat, and the storage may alter flow regimes, affect water temperature and oxygen content, and consequently affect aquatic and riparian vegetation and wildlife habitats downstream.

On the other hand, storages also create an aquatic habitat, supporting fish and waterfowl.

Compatibility between water utilization and nature conservation can be enhanced by the design of structures and operation procedures.

Nature conservation

This is generally compatible with a wide range of uses, such as water production, apiculture, and low-intensity recreation. It tends to compete with any activity that radically changes the natural vegetation, such as mining, agriculture, urban development, or intensive timber production.

Excessive use for recreation is a problem in some areas of value for nature conservation, because these areas are often used primarily as leisure resources. The other aims of parks and reserves (biological conservation, landscape preservation, and research opportunities) can therefore be threatened.

Areas set aside specifically for reference must be managed to exclude activities other than particular forms of scientific study. This use is complementary with nature conservation and water production only.

Outdoor recreation

Outdoor recreation encompasses a wide range of activities. Their relations with other uses vary according to their type and intensity. Some sports such as golf, horse-racing, and range shooting require their own specialized areas and are therefore incompatible with most other uses. Most recreational activities are relatively flexible, however, and can be accommodated in areas managed primarily for other uses.

A single land use in a particular area may conflict with one type of recreation and yet complement another. For example an abandoned quarry may mar a panoramic view yet provide an ideal site for gem fossicking or riding trail-bikes. Similarly, forestry tracks may reduce the value of an area for bushwalkers seeking natural surroundings, but make it more accessible for picnicking.

Some pursuits such as adventure driving, fishing, and bushwalking can become self-competitive, especially at high usage rates.

Certain water-based activities such as water-skiing may be incompatible with nature conservation. Such conflict can sometimes be alleviated by zoning certain sections of the water body for specific activities.

Urban and industrial uses

Urban areas contain a multitude of different activities that collectively are competitive in space with most non-urban uses, including agriculture, timber production, apiculture, water conservation, mining, and many forms of outdoor recreation. Moreover, the presence of urban areas - by intensifying the utilization of, or requirement for, most resources - undoubtedly compounds the competition between many activities in adjacent areas of public land.

Extractive industries

Mining, quarrying, and shallow gravel extraction can be competitive with most forms of land use through site disturbance, roading, and pollution. Competition is usually localized, however, and its degree depends on the type and scale of operation. Underground mining does not usually involve as much site disturbance as open-cut mining or surface stripping, but dumping of waste material such as mine tailings may still conflict with other uses.

Many conflicts between extractive industries and landscape are localized, but they may be serious where values are high or the operations obvious. On the other hand, some quarries provide the opportunity to study the local natural history, and open sites for the collection of fossils and gemstones.

Exhausted quarries and open-cut mines are often useful for water supply or rubbish disposal, or as sites for such recreation as trail-bike-riding.

Public utilities and transport

Generally the provision of these services requires allocation of small areas of land only, but in most cases this represents an inflexible use. Due to growing recreational pressures and more interest in nature conservation at a local level, waste-disposal problems are increasing. 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 compete with vegetation and some wildlife habitats, and may be unattractive. Likewise, the measures taken to reduce the risk of fire along transmission lines may conflict with other uses. Again, telecommunication facilities on peaks or ridges can conflict with scenic and other values, especially when constructed in attractive or remote landscape.

These services and most others are generally considered essential. However, a measure of compatibility with other uses can be achieved by careful siting, location, and design to minimize conflicts.

PART IV

BLOCK DESCRIPTIONS

BLOCK DESCRIPTIONS

In this part of the report, the study area has been divided into six blocks. For each block, the location and land tenure, the nature of the land, present uses, capability for various uses, the present condition of the land, and likely land-use hazards are described.

A consistent format of headings and sub-headings has been used, to help the reader compare specific information for various blocks. Some sections deal only with the public land. These include vegetation, recreation, and timber production. A key diagram at the beginning of each description gives the approximate location of that block in the study area, while Map 2 shows greater detail for all blocks.

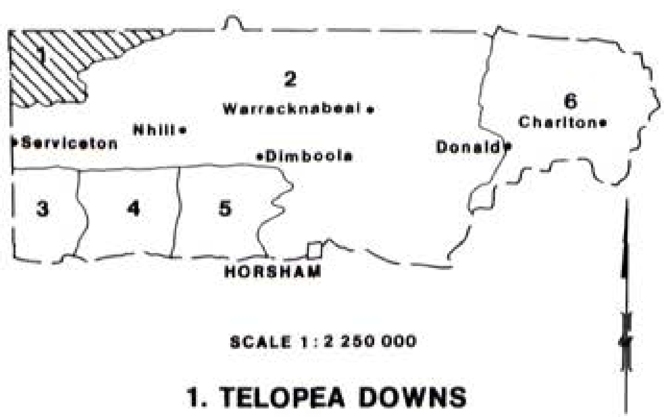
'Capability' refers to the suitability of public land for various uses. Its assessment is based on a number of considerations, including the inherent characteristics of the land, its proximity to centres of population, the level of accessibility within it, the relative scarcity of the type of land, and the hazards associated with the various uses.

Capabilities are given in general terms only, because the amount of information available has varied from block to block and because some of the values have been difficult to quantify. In assessing capability, comparisons have been made with other blocks and with other parts of the State.

1. TELOPEA DOWNS

A. General

Telopea Downs block occupies some 104,000 ha in the far north-west of the area. Approximately 4,900 ha is public land, mainly unreserved Crown land that forms southern extensions of the large Big Desert Crown land block to the north. The remainder comprises a number of Crown land reserves, including several stone reserves. In addition, the Murrayville Track and the Murrawong North Road lie within 5-chain (100-m) reservations.



1. TELOPEA DOWNS

B. Nature of the Land

1. Climate

Average annual rainfall decreases from 450 mm in the south-west to 375 mm in the north-east. Telopea Downs, the only township within the block, receives 437 mm.

2. Geology and geomorphology

The Big Desert consists of irregular sub-parabolic dunes and sandplains of Quaternary Lowan Sand. The encroachment of sands into western Victoria from South Australia took place during the last major arid period, which peaked between 18,000 and 16,000 years ago. The sands are contiguous with those of the Little Desert further south. Although irregular, the dunes show some degree of order that reflects the influence of the prevailing winds that formed them.

Also, occasional exposures of the underlying Parilla Sand occur as isolated ironstone-rich outcrops and ridges extending as remnant coastlines of the retreating Pliocene sea; they consist of marine sand, sandstone, and silt.

3. Soils

Deep pale uniform sand soils with darker brownish B horizons predominate on the sandy dunes and rises. Sandy mottled yellow duplex soils occur on the poorer-drained inter-dune plains.

4. Vegetation

Mallee--broombush is the main vegetation type on most of the public land areas in this block. Yellow mallee is the most common species of the upper stratum, with green mallee and slender-leaf mallee also present in many areas. Broom honey-myrtle and broom baeckea dominate the scrub layer.

On the sandier ridges the mallee--broombush association grades into woodlands or open scrub of brown stringybark with a heathy understorey, and occasionally into treeless heath. These are the northernmost occurrences of brown stringybark in Victoria.

Some areas of mallee--broombush in this block contain patches of yellow mallee open scrub without a broombush understorey. These often have an understorey dominated by porcupine grass.

5. Fauna

The low mallee--broombush and brown stringybark vegetation found here supports relatively few species of mammals, but a wide variety of birds. The western grey kangaroo and silky mouse are common, as are a number of bats. Within the study area Mitchell's hopping-mouse is restricted to the heaths of this block.

Within the study area, Mitchell's hopping mouse is restricted to the heaths of this block.

Characteristic bird species include the emu, Mallee fowl, spotted nightjar, southern scrub-robin, red-lored whistler, crested bellbird, splendid fairy-wren, shy hylacola, and tawny-crowned honeyeater. The inland thornbill is restricted to this part of the study area, as is the Australian bustard.

A number of large reptiles are adapted to the open ground beneath the broombush communities, and dragons, *Ctenotus uber*,

The Big Desert is an important refuge for the Australian bustard.

and shingle-backs are abundant. Other characteristic species include common scaly-foot and *Morethia obscura*. Within the study area the mallee dragon and the rare snake *Drysdalia marstersi* are only found in the mallee and mallee--broom-bush open scrub of this block.

C. Present Use and Capabilities

1. Nature conservation

No conservation reserves exist at present in the Telopea Downs block. Only relatively small areas of public land with natural vegetation still occur and these have a high conservation value.

The public land of the Big Desert, which extends into the study area north of Telopea Downs and Yanac, is an important refuge for Victoria's last remaining population of Australian bustards. The bustards feed mainly on private grazing land, but usually close to scrub to which they can retreat when danger threatens.

These blocks also represent the southernmost limits of distribution for several Mallee species such as Mitchell's hopping-mouse, emu-wren, splendid fairy-wren, and the restricted and rare red-lored whistler.

The largest block north of Yanac has extensive stands of broombush that may provide significant habitats for the red-lored whistler and the western whip-

Mallee--broombush along the Murrayville Track - the main tourist road into the Big Desert.

bird, which is also rare and restricted in Victoria.

2. Recreation

The northern areas of public land adjoin the larger areas of the Big Desert north of the study area. While no development for tourism has occurred, these parcels offer opportunities for nature observation, camping, bushwalking, and the use of recreation vehicles.

3. Timber production

Capability is low. Broombush (*Melaleuca uncinata*) is harvested periodically from the 2,800-ha section of the Big Desert to the north of Yanac.

4. Agriculture and apiculture

The public land has low to moderate agricultural capability. Sandy soils and high clearing costs are the major limiting factors. Some 133,000 ha granted to the AMP *Society* was developed in the 1950s and 1960s, with varying degrees of success. Supplies of good-quality groundwater from the Duddo Limestone are available.

There is very little grazing on the public land areas, most of which are covered by thick scrub.

The Big Desert has a high capability for honey production and for over-wintering of bees.

5. Water

The low rainfall, high evaporation rates, and highly permeable sandy soils of the Big Desert result in very little, if any, run-off and therefore no potential for surface water production.

Groundwater associated with the Duddo Limestone aquifer underlies the whole area and bores yield water with a moderately low salt content of 1,000--3,000 mg per L. This is suitable for stock and for salt-tolerant plants. There is, however, an area north of Broughton with higher salt content.

Parilla Sand from the Murrawong North Pit is used for road-making by the Shire of Kaniva.

6. Minerals and stone

Sandstone of the Parilla Sand occurring as outcrops among the Big Desert dunes can be used for road-making. Several shire-operated pits occupy Crown land.

D. Hazards and Conflicts

The dunes and rises are highly susceptible to wind erosion if the sandy topsoil is left in an exposed condition by the removal of the protective native vegetation or by the overgrazing of pastures.

In dry years when marginal crops fail and pastures are heavily grazed, the dunes can mobilize and the sand in the wind blast or sedimentation can damage or destroy foliage on areas still protected by vegetation.

The grazing and digging activities of rabbits pose a constant threat to soil stability and agricultural production. The numbers of these vermin fluctuate considerably, but can periodically reach high levels in some areas.

Large wildfires also pose a serious hazard to farmland and any that occur within the extensive area of native vegetation to the north of the study area can readily be driven towards the block by the summer northerlies. Fire control is often difficult, due to the lack of surface water and access problems in the sandy loose soils.

Extraction of road-making materials and four-wheel-driving may conflict with nature conservation.

2. WARRACKNABEAL

A. General

Although in total area this is by far the largest block, covering some 1,007,000 ha, it contains only about 31,600 ha of public land. It stretches from the South Australian border to Donald and includes most of the vast Wimmera plains, nearly all of which have been alienated and cleared for agriculture.

The largest area of public land is Lake Hindmarsh (14,800 ha). Seven blocks of reserved forest have a total area of some 3,400 ha. Five of these reserves are found on the alluvial plain of the Wimmera River east of Horsham - Brynterion (600 ha), Barrabool (1,330 ha), part of Marma (350 ha), Saw Pit Swamp (33 ha), and a section of Yarriambiack Creek (53 ha). The other two areas of reserved forest - Glenlee (620 ha) and Barrett (370 ha) - are the only substantial timbered blocks remaining on the extensively cleared Wimmera plains.

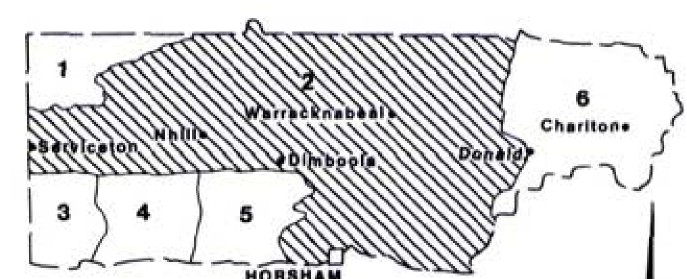
Other substantial areas of public land include Longerenong Agricultural College (950 ha), Darlot Swamp (270 ha), and Dooen Swamp (200 ha). There is a small flora and fauna reserve at Dimboola.

The rest of the public land comprises various stream frontages and reserved and unreserved Crown lands.

B. Nature of the Land

1. Climate

Average annual rainfall ranges from 500 mm in the south-west - near the South Australian border - to 350 mm at Brim in the north-east. Annual evaporation varies, from about 1,450 mm near Horsham to 1,750 mm at Birchip in the north.



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2. WARRACKNABEAL

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Temperature, frost, and rainfall statistics are listed in the climate chapter for Horsham, Nhill, and Warracknabeal, together with rainfall data for several other stations.

2. Geology and geomorphology

The Quaternary sands and clays of the Woorinen Formation cover most of the block. While further north in the Mallee the dunes have relatively straight east--west regular forms, here they have a subdued to sheet-like form, becoming indistinct and patchy towards the east.

Cliffs developed in Parilla Sand on the western side of Lake Hindmarsh.

West of the Yarriambiack Creek the dune field is relatively continuous, and north of the Little Desert the pronounced NNW--SSE ridges of underlying Parilla Sand exert a strong influence on the surface topography. The occasional outcrops of the Parilla Sand ridges, of which the largest occur at Lawloit, are often surrounded by deposits of Lowan Sand. Swamps, commonly with associated lunettes, occur in the lowlands between the ridges.

The major drainage system, the Wimmera River, flows northward and feeds into Lake Hindmarsh, a freshwater lake with an extensive lunette system on the eastern side. To the west of the river, a series of salt lakes and swamps follow the course of an ancient river.

East of Horsham, in the south of the block, lies an extensive Quaternary alluvial plain, bordered to the north by low-lying deposits of the Parilla Sand. North of the Minyip to Banyena area, the undulating plain consists of a complex of broad low dunes and sheets of the Woorinen Formation with extensive exposures of the alluvium of the underlying Pleistocene Shepparton Formation between them.

Where the Shepparton material is absent, low-lying deposits of the Parilla Sand may be exposed.

3. Soils

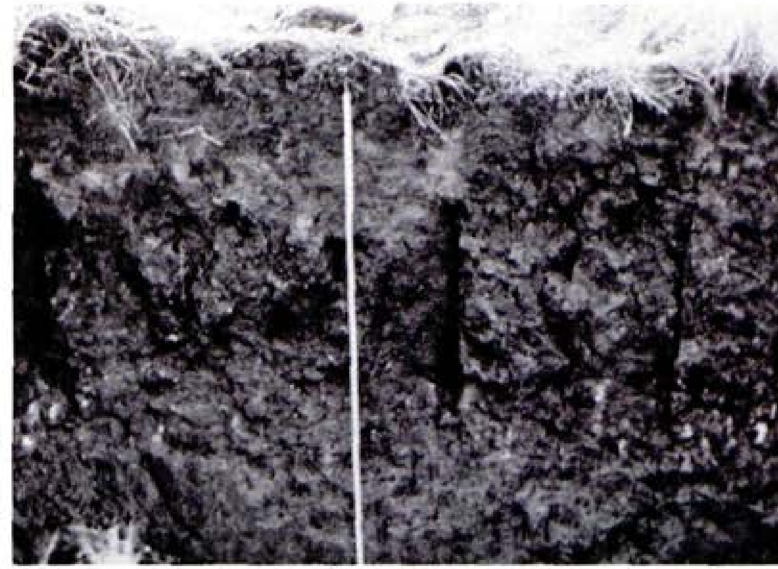
Grey self-mulching cracking clays are widespread throughout this block, occupying the poorer-drained, lower-lying areas. They are frequently found in the depressions between ridges or dunes and, along with reddish-brown self-mulching cracking clays, predominate on the Wimmera plains from Dimboola through to Lake Buloke.

Red duplex soils predominate on the gentle slopes and low crests west of the Wimmera River, but become sub-dominant to the east of the Wimmera River on gentle rises and dunes or better-drained areas of the plain. Yellow mottled duplex soils occur on the poorer-drained parts of the plain west of the Wimmera River. Yellow mottled duplex soils with sandy topsoils occur on the prominent NNW--SSE ridges north of the Little Desert.

Brown calcareous gradational soils are found on the undulating plain of the Wilkur area north-east of Warracknabeal, and on some of the lunettes of Lake Hindmarsh, but deep uniform sandy soils are common on the major lunettes.

4. Vegetation

Almost all the vegetation on public land throughout the block is gum--box--bull-oak woodland, although remnants of mallee open scrub do occur on some public land on the northern Wimmera plains. River red gum woodland II is found along the Wimmera River, around Lake Hindmarsh, at Dooen Swamp, and around many of the lakes and swamps in the west. Black box woodland I replaces river red gum in less frequently flooded parts, with tangled lignum as a frequent component of the understorey.



Grey self-mulching cracking clays are widespread throughout this block. Most support wheat.

Barrabool, Marma, and Brynterion Forest Reserves in the south contain the largest remnants of the gum--box--bull-oak alliance, with yellow gum, grey box, black box, yellow box, and bull-oak as the major overstorey species. The Barrett Forest Reserve is the only sizeable block of native woodland remaining

An interesting remnant of dumosa mallee open scrub in the Dimboola Flora and Fauna Reserve.

on the grey clays of the central Wimmera plains and carries woodland II of yellow gum with bull-oak and black box.

The sandier soils of the Glenlee Timber Reserve and the public land south of Lake Hindmarsh carry woodland II of yellow gum, slender cypress pine, black box, bull-oak, and belah.

A particularly interesting and sizeable remnant of yellow mallee open scrub occurs west of Ellam on a sandy lunette of Lake Hindmarsh. Here yellow mallee grows with slender cypress pine, scrub cypress pine, and a series of understorey species more typical of country further to the north.

An interesting remnant of dumosa mallee open scrub can be found in the Dimboola Flora and Fauna Reserve immediately adjacent to the town. Smaller patches of mallee scrub remain on many of the small blocks of public land and road reserve of the northern and western Wimmera plains.

5. Fauna

Although most of this block has been cleared, the many small areas of remnant woodland do provide habitat for a significant number of native species, especially birds.

Mammals requiring hollows are found in these areas, including the common brushtail possum and yellow-footed antechinus. Western grey kangaroos are common, as are the introduced European rabbit, brown hare, and fox.

Birds are diverse and abundant; common species include white-plumed honeyeater, brown treecreeper, striated pardalote, red-rumped parrot, sulphur-crested cockatoo, peaceful dove, sacred kingfisher, buff-rumped thornbill, red-capped robin, hooded robin, white-browed babbler, white-winged triller, rufous songlark, rufous whistler, and white-winged chough.

Lace monitors live in hollows in river red gums along the Wimmera River, while the marbled gecko and snake-eyed skink inhabit leaf and bark litter at the tree bases. Other common reptiles include the bearded dragon and shingle-back.

C. Present Use and Capabilities

1. Nature conservation

Because of the high ratio of cleared land to natural vegetation, the remnant public land blocks here often have high conservation significance.

The Glenlee Timber Reserve contains the largest remnant of bull-oak--yellow gum --black box woodland in the study area. It supports a typical dry woodland bird community, including the threatened bush thick-knee, red-capped robin, and Gilbert's whistler. The yellow gum woodland alliances of the Wimmera are at present poorly reserved in Victoria's conservation system.

The Barrett Timber Reserve also includes a sizeable remnant of yellow gum--black box--bull-oak woodland, and contains a number of interesting plant species.

Public land at Kiata carries a remnant stand of mature yellow gum--slender cypress pine woodland, and it supports a very diverse bird fauna.

The Wimmera River and Lake Hindmarsh both have high conservation significance. The river red gum and black box woodlands that line the waterways act as habitat corridors through the study area, allowing the movement of migrant and nomadic species as well as dispersal of the young of many species. The river red gum woodland community is becoming rare within the study area and also the State, which has a detrimental effect on

Common brushtail possums are found in the remnant woodlands of this block.

hollow-dwelling species such as parrots, cockatoos, owls, owlet-nightjars, kingfishers, tree martins, and pardalotes. These areas are also havens for many rare and endangered plant species.

Lake Hindmarsh itself is important for waterfowl and wading birds, particularly as a drought refuge. One of only three Victorian breeding colonies of Australian pelicans occupies a spit near the north-western corner of the lake. One of the few breeding colonies of pied cormorants in Victoria also occurs nearby.

The Marma Forest Reserve contains remnant river red gum and grey box woodlands, which are both uncommon in the study area. It is possible the squirrel glider occurs here and also in the Brynterion Forest Reserve.

Most road reserves contain remnants of the natural vegetation and act as corridors for dispersal of birds across the extensive, largely treeless farmlands. Reserves along minor roads and farm tracks can be particularly significant because they often carry more extensive vegetation and are less disturbed.

Many of the swamps and lakes in this block have significance as waterfowl habitat. In particular, Lake Lawloit, and Merwyn, Peechember, Red Gum, Yanac, Boyeo, Tarranginnie, Nhill, Dooen, and Darlot Swamps at times support high populations of waterfowl and wading birds.

2. Recreation

Although the land consists mainly of plains cleared for farming, the block contains many interesting reserves.

The Wimmera River, with its public land frontages, supports fishing, camping, picnics, and boating in some sections. Lake Hindmarsh, Victoria's largest freshwater lake, is also popular for fishing, camping, and boating.

Many small pockets of public land - some near townships - are popular for picnics and nature observation. Because of the lack of unusual geographic or natural features to otherwise attract visitors, those areas near major roads have potential as resting places for travellers.

3. Timber production

Capability is low in the north of the block. In the south, stands of river red gum, yellow gum, grey box, and black box occur along the Wimmera River east of Horsham. They are managed to yield posts and other farm timbers and, less frequently, sleepers and sawlogs. In the Barrett and Glenlee Timber Reserves, plantations of various eucalypt species and remnant woodlands of yellow gum and black box are capable of yielding small quantities of fencing materials.

Although yields are low compared with those in the rest of the State, these remnant woodlands are often significant

Yarriambiack Creek at Warracknabeal.

as a source of farm timbers for local use.

4. Agriculture and apiculture

Much of the public land has low capability for agriculture, but some of the areas in the south carrying gum--box woodland have moderate capacity. Most of the public land is held under grazing licences.

The public land has moderate to high capability for apiculture, but most of the block is cleared freehold land.

Up to 16 professional fishermen operate on Lake Hindmarsh, catching mainly English perch (redfin), and sometimes yabbies. Some of them also employ a crewman, resulting in employment of a further 8 or 9 men.

5. Water

Despite the size of the block, the combination of low rainfall and lack of significant slopes means that run-off is minimal. The major contribution to watercourses such as the Wimmera River, Dunmunkle Creek, and Yarriambiack Creek comes from run-off from the Grampians and Pyrenees Ranges outside the area. In fact, east of the Wimmera River, the dams and storages of many towns and properties are supplemented from the channels of the Wimmera--Mallee Domestic and Stock Water Supply System. The Grampians to the south provide the bulk of this water.

Several small irrigation permit areas, supplied from the Wimmera--Mallee domestic and stock system, are located near Murtoa and Horsham.

The groundwater underlying the block from just west of the Wimmera River to the eastern boundary is highly saline and low-yielding. It is associated with the Parilla Sand and Renmark Group aquifers and, where it reaches the surface, results in salt lakes or saline areas.

West of this zone and through to the South Australian border, groundwater yields and quality improve considerably, particularly in the south. Bores drawing from the Duddo Limestone aquifer provide much of the stock and domestic requirements of the area.

6. Minerals and stone

Despite the size of the block, gypsum and common salt are the only minerals commercially extracted. There are also quarries for obtaining road-making materials from Parilla Sand outcrops in the west, a small limestone pit north of Netherby, and sand extraction sites on lunettes on Lake Hindmarsh and at Dooen.

Gypsum is mined mainly from private land in a zone running south from Lake Hindmarsh, where the saline groundwater is close to the surface. Mining takes the form of shallow stripping within depressions or on secondary wind-blown deposits on adjoining dunes. Most of the gypsum is used in agriculture on soils containing dispersive clays, many of which occur within the block.

Common salt is harvested under licence at Lock Iel, a salt lake north-west of Dimboola. Production is on a small scale and intermittent.

D. Hazards and Conflicts

Wind erosion is a severe hazard on all areas with sandy topsoils, and often occurs on the lunettes of Lake Hindmarsh and the NNW--SSE ridges west of the Wimmera River as well as any other sand rises throughout the block.

Also, some wind, sheet, and gully erosion problems affect many areas used for agricultural production. The destruction of topsoil structure by excessive cultivation and grazing is of major concern.

Sheet erosion by water is a significant hazard on any sloping areas that have soils of low permeability. Most of the block is flat and has a low hazard.

Saline groundwater discharge occurs on the low-lying areas adjacent to the western bank of the Wimmera River and to the west of Lake Hindmarsh. It is likely that the extensive clearing of the native vegetation for agricultural production has been responsible for the reactivation of ancient groundwater discharge sites.

Further south, near Horsham, the regional saline water table has risen to the surface in many places, causing extensive saline areas. Other salt patches occur sporadically across the eastern portion of the block. The cause is thought to be the reduction in plant water use - current agricultural crops and pastures use less than the original vegetation.

In recent years considerable concern has arisen about water quality in the Wimmera. High salinity, colour, and nutrient concentrations and depressed dissolved oxygen levels result from diffuse run-off from the catchment, while the major point source of waste in the catchment - the City of Horsham's effluent discharge - adds to nutrient and dissolved oxygen problems in the lower river.

A steady deterioration in landscape values has taken place, due to the loss of many trees from farmland, fencelines, and road reserves. This has been caused by grazing pressure, the requirements of larger machinery, and natural death. There is little replacement by regeneration, and those trees remaining are often old (and senescent).

The small areas of public land are prone to fires and invasion by weeds and vermin. They can also act as harbours from which farmland can be re-infected. Rabbits and boneseed infestations are particular problems of the Lake Hindmarsh lunettes and dunes.

Grazing by domestic stock conflicts with conservation of ground flora and of animals that feed or breed on the ground. Sand and gravel extraction also conflicts with nature conservation.

3. MINIMAY

A. General

Minimay block comprises some 78,000 ha in the far south-west. Approximately 39,000 ha is public land, most of which forms the western block of the Little Desert (38,500 ha). The remainder consists of Minimay Swamp (150 ha), Yarrackigarra Swamp (93 ha), and Waurn Swamp (77 ha), and a number of small areas of reserved and unreserved Crown land.

B. Nature of the Land

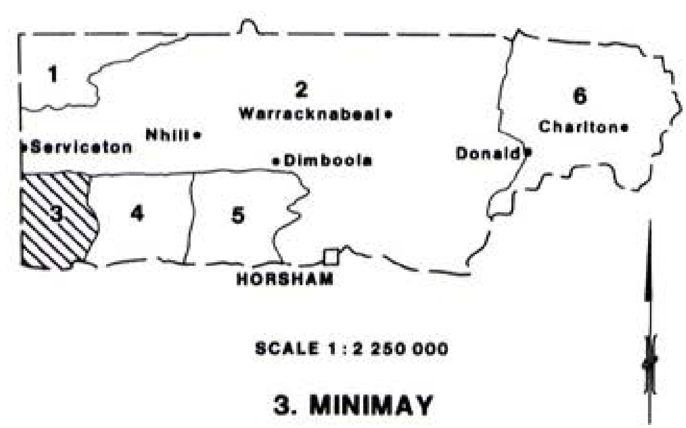
1. Climate

Average annual rainfall exceeds 550 mm in the south-west near the South Australian border, declining to about 475 mm in the north-east. As the regional topography is flat, this decline occurs quite evenly. No weather-recording stations are located within this block.

2. Geology and geomorphology

The Quaternary Lowan Sands of the Little Desert dominate the northern two-thirds of the block as aeolian dunes and sand-sheets. Although apparently irregular, the dunes do reflect the influence of the westerlies that formed them. Occasionally, the underlying NNW--SSE ridges of the Parilla Sand outcrop as iron-rich sandstone crests, which represent coastline positions resulting from the retreat of the Pliocene sea.

The southern portion consists of a flat to undulating Quaternary alluvial plain with many swamps, particularly in the east. Again the underlying Parilla Sand ridges influence the surface topography, as shown by the alignment of swamps in a NNW--SSE direction. These swamps are



3. MINIMAY

groundwater recharge sites and are not saline.

Wind reworking the alluvial sand and the sandstone of ridges has resulted in a thin capping of dune material over most of the length of the ridges.

3. Soils

In the northern portion, the sand sheet of the Little Desert has a dominant influence, with uniform sandy soils predominant on the dunes, ridges, and undulating parts of the sandplain. Sandy mottled yellow duplex soils often occur on the flatter and poorer-drained parts. In the south, the lower-lying flat areas have mainly grey cracking clays or mottled yellow duplex soils, although better-drained areas and the lunettes have red duplex soils. Sandy mottled yellow duplex or uniform sandy soils are found on the major ridges.

4. Vegetation

Brown stringybark woodland I and open scrub, with heathy understoreys, dominate on the sandy soils of the Little Desert. Oyster Bay pine is a frequent co-dominant here, and occasionally other eucalypts. Principal understorey species include heath tea-tree, banksias, guinea-flowers, bitter-peas, myrtles, she-oaks, and hakeas.

These brown stringybark communities grade into mallee--broombush communities

Brown stringybark woodland is the main vegetation type on the public land here.

on shallower soils over a hardpan that causes seasonal waterlogging. Thus mallee--broombush is found on the laterized sandstone ridges of the former shorelines, in swales between dunes, or around claypans.

Yellow gum woodland II grows on sandy clay loams in interdune depressions in the Little Desert. The duration of waterlogging controls the occurrence of yellow gum, which often forms pure stands or occurs with black box. These woodlands can become quite tall in the wetter south-west adjacent to the South Australian border. Shrubby species common in this part of the Little Desert include muntries, dwarf hakea, and holly grevillea.

On sandier soils along the southern edge of the Little Desert yellow gum grows in mixture with slender cypress pine. Scarlet bottlebrush is a colourful feature of the understorey in these and other yellow gum woodlands here.

In the south, Minimay, Yarrackigarra, and Waurn Swamps carry river red gum woodland I surrounding grassy swamp communities where inundation is more frequent.

5. Fauna

While relatively few mammal and bird species are found here, common mammal species include the western-pygmy possum, western grey kangaroo, silky mouse, and a number of bats. Within the study area, the red-necked wallaby is only found here and in Spinifex block.

Characteristic birds include painted button-quail, variegated fairy-wren, crested bellbird, Mallee fowl, spotted nightjar, southern scrub-robin, and shy hylacola.

Reptiles are better represented and include sand monitor, common scaly-foot, bearded dragon, painted dragon, jacky lizard, *Ctenotus uber*, *Morethia obscura*, shingle-back, and bardick.

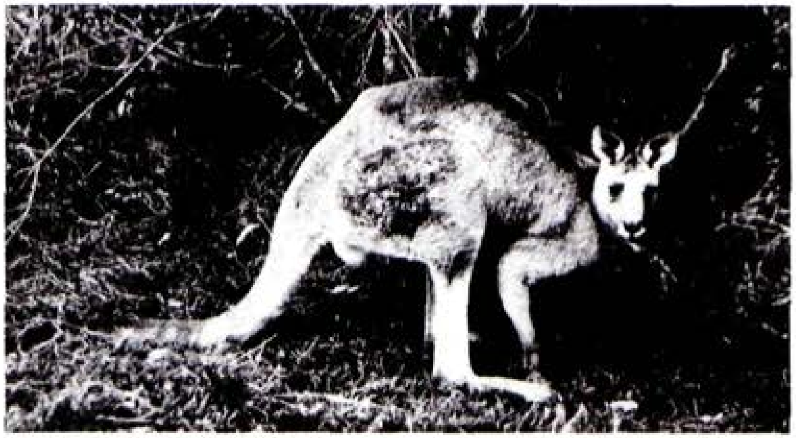
C. Present Use and Capabilities

1. Nature conservation

No public land is currently reserved for conservation, but the western block of the Little Desert has a high capability for such a purpose.

This large parcel of public land has a very wide diversity of vegetation types. In particular, it has sizeable areas of yellow gum woodland - a community that has been greatly reduced over its former range. Also, the examples here are some of the least degraded remaining in Victoria.

Several animal and bird species reach their north-western limits in the State in these woodlands - for example, the red-necked wallaby, sugar glider, little wattlebird, and the rainbow lorikeet.



The western grey kangaroo is common.

Among several rare plants present, the wedge-leaf pomaderris (*Pomaderris obcordata*) is extremely so in Victoria, being known only at the western edge of this block. Pipewort (*Eriocaulon australasicum*), a very restricted and endangered species of swampy areas, also occurs here. Other rare plants include the thorny bitter-pea (*Daviesia pectinata*), *Grevillea glabella*, hairy tails (*Ptilotus erubescens*), and floating bog-rush (*Schoenus fluitans*). These also occur in the two other Little Desert blocks.

Several wetlands to the south - Yarrackigarra, Minimay, and Waurn Swamps - provide valuable waterfowl habitat.

2. Recreation

Minimay block contains the westernmost section of the Little Desert, which, at present, has not been developed for recreation. However, this section of relatively higher rainfall has potential because of its diversity of interesting flora and fauna.

The south-western Wimmera plains contain many swamps and lakes that are popular for duck-shooting.

3. Timber production

Capability for timber production is generally low. However, yellow gum stands in the south and west of the Little Desert are capable of yielding posts and other farm timbers and, less frequently, sleepers and sawlogs. Brown stringybark is not actively sought for farm timbers, because of its poor form and lack of natural durability.

4. Agriculture and apiculture

Capability is low in the sandy parts of the Little Desert, but moderate in the small areas of yellow gum woodland in the wetter south-western part. Most of the small areas of public land south of the Little Desert are held under grazing licences.

The Little Desert has a high capability for honey production and for overwintering of bees.

5. Water

The dunes and sandsheets in the north provide little, if any, run-off; even in the south there are no perennial or significant non-perennial streams. Some of the swamps in the Minimay area may have some potential for stock and domestic use, but most water for this purpose comes from bores.

Groundwater associated with the Duddo Limestone underlies the whole block and high-yielding bores in the area produce good-quality water suitable for domestic and agricultural uses.

6. Minerals and stone

Outcrops of sandstone, where the Parilla Sand ridges protrude through the dunes of the Little Desert and alluvium to the south, have potential for use in roadmaking. Pits are not common in this block, with none currently operating on Crown land. No minerals are commercially mined.

D. Hazards and Conflicts

Wind erosion is the major land deterioration hazard, due to the prevalence of sandy topsoils. Areas exposed to the wind, such as ridge crests, are at greatest risk. A moderate hazard of sheet erosion applies on the ridges and lunettes to the south of the Little Desert, and a low hazard of gully erosion on the slopes of the more prominent ridges.

Large wildfires in the Little Desert may be a major hazard if they escape into the surrounding freehold land. The predominant vegetation species of the Little Desert are highly flammable, and control measures are often difficult due to the problems of access on the loose sandy country.

Rabbit populations can occasionally reach high numbers, causing damage to both native and agricultural environments. Foxes and feral cats pose a threat to some species of wildlife in the public land areas.

Invasion by weeds is a problem, particularly on public land margins and on disturbed sites.

Grazing by domestic stock conflicts with conservation of ground flora and of animals that feed or breed on the ground. Sand and gravel extraction also conflicts with nature conservation.

4. SPINIFEX

A. General

Spinifex block occupies about 103,000 ha in the south-west, of which approximately 47,800 ha is public land - mainly the central block of the Little Desert (45,500 ha). Four blocks of reserved forest on the south-western Wimmera plains total about 770 ha, while a flora and fauna reserve in the north-west covers some 150 ha. The rest of the public land comprises various reserved and unreserved Crown lands.

B. Nature of the Land

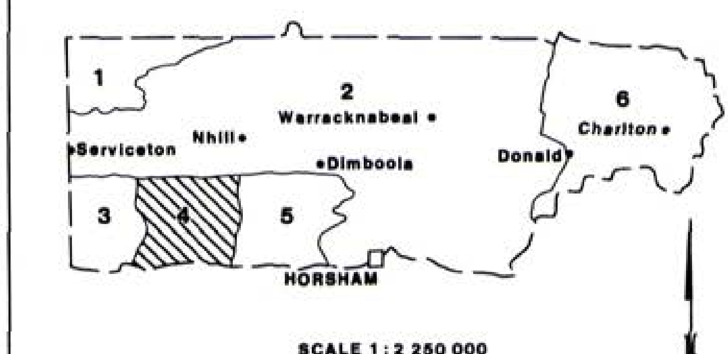
1. Climate

Average annual rainfall varies from more than 500 mm at Goroke in the south-west to about 425 mm in the north-east. As the regional topography is almost flat, this decline occurs quite evenly.

2. Geology and geomorphology

The irregular dunes and sand sheets of the Little Desert (Lowan Sands of the Quaternary period) dominate the northern two-thirds of the block. The form of the natural surface has resulted largely from the influence of the prevailing westerly winds and, in some areas, reflects the major undulations of the underlying NNW--SSE Parilla Sand ridge system. Occasionally, the iron-rich sandstone of the Parilla Sand is exposed on these ridges, which, in the east, can have a local relief of up to 80 m. They represent successive coastline positions resulting from the retreat of the Pliocene sea.

The southern portion consists of a Quaternary alluvial plain superimposed on the ridge system of the Parilla Sand.



4. SPINIFEX

Lowan Sand is often found around the taller ridges, while parallel sequences of swamps and lakes, some with associated lunettes, occur between the ridges. These are groundwater recharge sites and are not salty.

3. Soils

As in Minimay block, the northern (Little Desert) portion is dominated by uniform sandy soils, with sandy mottled yellow duplex soils in the poorer-drained parts. The southern portion also has the same variety of soils as in Minimay.

4. Vegetation

Because of the similarity in the soils, the dominant vegetation type is the brown stringybark woodland I and open scrub found in Minimay block. In the drier conditions here, however, these communities grade into more open woodlands and often into large areas of heath, with no emergent eucalypts.

These heaths, and the understoreys of the brown stringybark communities, are dominated by members of the families Proteaceae, Fabaceae, Epacridaceae, Casuarinaceae, Xanthorrhoeaceae, and Myrtaceae. Heath tea-tree and desert banksia are almost universal dominant or co-dominant species in heaths.

The block also contains larger areas of mallee-broombush, as it is crossed by

Large patches of mallee--broombush occur on areas of laterized sandstone here.

several large laterized sandstone ridges.

It has smaller (and less frequent) areas of yellow gum woodland II than Minimay block, again due to the lower rainfall. At Red Gum Swamp in the east, a sizeable area of river red gum woodland II ringed by yellow gum occupies a depression among the brown stringybark and mallee--broombush communities of the surrounding sands.

South of the Little Desert a number of swamps carry river red gum woodland II with associated grassy wetland communities. A large area of public land north of Goroke carries woodland of yellow gum, slender cypress pine, brown stringybark, and black box. Yellow gum --black box woodland I is present on a number of smaller areas of public land.

5. Fauna

Relatively few mammal and bird species occur in this block. Mammal species include the western pygmy-possum, western grey kangaroo, silky mouse, and a number of bats.

Characteristic birds here include painted button-quail, variegated fairy-wren, crested bellbird, Mallee fowl, spotted nightjar, southern scrub-robin, shy hylacola, slender-billed thornbill, and rufous calamanthus.

Reptiles are better represented and include sand monitor, common scaly-foot, bearded dragon, jacky lizard, *Ctenotus uber*, *Morethia obscura*, shingle-back, and bardick.

C. Present Use and Capabilities

1. Nature conservation

The central Little Desert block has a high conservation value, with no areas being currently reserved except a small flora and fauna reserve on the Kaniva--Edenhope Road to the north of the main public land block.

Shingle-backs are common among the relatively large reptile fauna in the Little Desert.

Broughtons Waterhole and the surrounding public land have high value for fauna conservation.

Broughtons Waterhole (on private property) and the public land surrounding it have a high value for fauna conservation due to the diversity of habitats, which results in a high density and diversity of fauna. Red-necked wallabies, western pygmy-possums, and sugar gliders are notable species occurring here. Whipstick westringia (*Westringia crassifolia*) is a very rare shrub known only at this locality and near Bendigo.

Other rare plant species occurring in the block include small darwinia (*Darwinia micropetala*), thought to have been extinct until recently; a bush-pea (*Pultenaea vestita*) known only in this area in Victoria; thorny bitter-pea (*Daviesia pectinata*), a spider-orchid (*Caladenia bicalliata*), and peppermint box (*Eucalyptus odorata*).

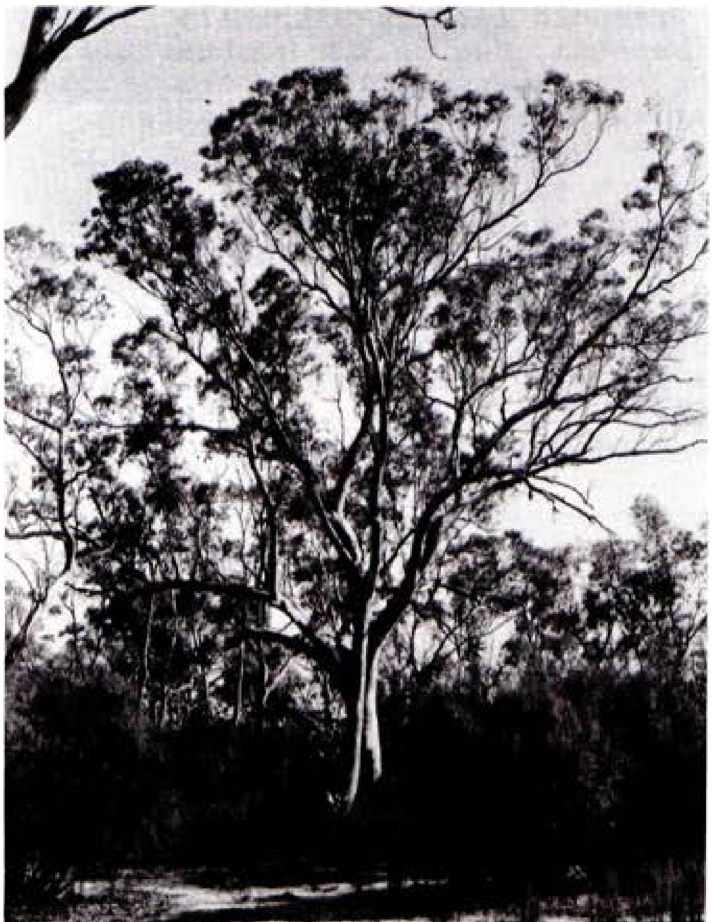
In the north-east, two notable landscape features - 'The Crater' and 'Red Gum Swamp' - occur in an area of high plant diversity and landscape value.

The swamps to the south of the Little Desert provide important habitat for many waterfowl.

2. Recreation

The central section of the Little Desert, located in the north of this block, is as yet undeveloped for recreation, but is used for four-wheel-driving by individuals and organized tours. The diverse and interesting flora and fauna to be seen in the area are potential attractions.

Many of the lakes and swamps to the south are popular for duck-shooting.



A sizeable area of river red gum woodland II, found at Red Gum Swamp, adds to the diversity of vegetation types.

3. Timber production

Capability is low, with the exception of an isolated block of public land north of Goroke, which carries yellow gum and black box, and is important as a source of farm timbers for local use. Brown stringybark also occurs, but is not actively sought for timber.

4. Agriculture and apiculture

Capability is low on the sandy soils of the Little Desert, which are infertile and erosion-prone. Some of the smaller areas of public land south of the Little Desert are held under grazing licences.

The Little Desert has a high capability for honey production and for over-wintering of bees.

5. Water

The Little Desert to the north has no potential for significant run-off. In the south, while there are no perennial streams, the many swamps and occasional shallow lakes may provide some potential for stock water supplies. However, most of the stock and domestic water in the block comes from bores.

The aquifer associated with the Duddo Limestone underlies the whole block, and groundwater from bores is generally high in quality and yield, particularly in the west. In the south-east around Gymbowen, yields are lower and salt content is higher, restricting the use of groundwater to stock supplies.

6. Minerals and stone

The sandstone in outcrops of the Parilla Sand is often suitable for use in road-making. One shire-operated pit lies south of Winiam in the Little Desert, and a few others, including one for sand extraction, occupy Crown land further south. No other commercial deposits of minerals are known on the public land.

D. Hazards and Conflicts

Wind erosion is the major land deterioration hazard, due to the prevalence of sandy topsoils. Areas exposed to the wind, such as ridge crests, are at greatest risk. A moderate hazard of sheet erosion applies on the ridges and lunettes to the south of the Little Desert, and a low hazard of gully erosion on the slopes of the more prominent ridges.

The risk of large wildfires escaping into freehold land is extremely high in some seasons, due to the combustibility of the native vegetation in the Little Desert and the difficulty of access on the loose sandy soils.

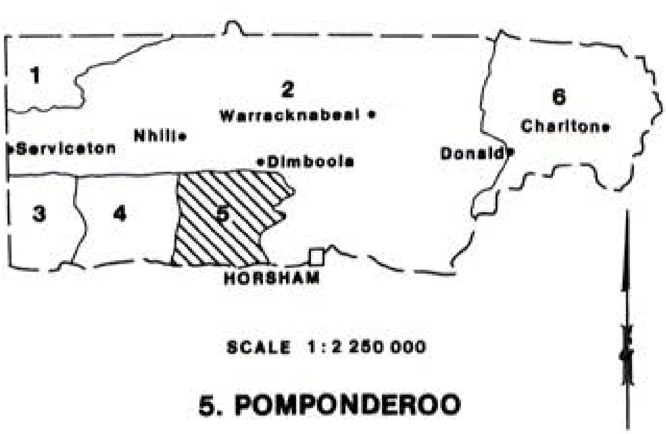
Rabbits are a constant problem, occasionally building up sufficiently in numbers to damage both farmland and native environments. Foxes and feral cats are a menace to some species of native fauna. Weeds mainly cause problems around the margins of public land areas and along tracks and disturbed areas.

5. POMPONDEROO

A. General

Pomponderoo block covers some 111,000 ha in the south-west of the area. It contains about 56,000 ha of public land - mainly the eastern section of the Little Desert (47,600 ha), including the Little Desert National Park (35,300 ha). East of the Wimmera River two blocks of reserved forest occupy some 3,850 ha - Wail (3,250 ha) and West Wail (600 ha).

A number of lakes surrounded by public land occur in the south-east, including



5. POMPONDEROO

Mitre Lake (740 ha), Lake Wyn Wyn (700 ha), and Lake Natimuk (370 ha). The rest of the public land consists of Wimmera River frontage and various small areas of reserved and unreserved Crown lands.

B. Nature of the Land

1. Climate

Average annual rainfall ranges from about 475 mm in the south-west to 410 mm near Dimboola in the north-east. Rainfall data for Dimboola appear in the climate chapter.

2. Geology and geomorphology

Irregular dunes and sandsheets of Lowan Sand form the easternmost part of the Little Desert, occupying the northern two-thirds of the block. The underlying NNW--SSE ridges of the Parilla Sand, which occasionally outcrop, give additional height to the dunes in many places and local relief is usually greater than in the more western blocks.

In the south-west, the surface of the alluvial plain is again influenced by the underlying Parilla Sand ridges. The

Mitre Rock and Mitre Lake. Mitre Rock is a resistant outlier of Grampians-type sandstone, while Mitre Lake is a saline groundwater discharge lake.

largest of these crosses the Horsham--Carpolac railway east of Duffholme and is overlain by extensive Lowan Sand deposits.

Swamps, often with lunettes, are common in the inter-ridge, low-lying areas. These are not saline, as they are generally groundwater recharge sites.

Mitre Rock, which is an isolated monadnock of Palaeozoic sandstone and siltstone, is an outlier of Mount Arapiles to the south. North-east and east of Mitre Rock lie a series of salt lakes, which are presumed to follow the course of an ancient river north-east, then diverge towards Lake Hindmarsh, and finally follow the western bank of the Wimmera River. These lakes are groundwater discharge sites, receiving very saline groundwater from the regional groundwater system associated with the Parilla Sand aquifer.

The Wimmera River is the only major drainage system. It flows northwards within its Recent alluvial plain, crossing the eastern tip of the Little Desert south of Dimboola.

3. Soils

The sand sheet of the Little Desert dominates in the northern half of Pomponderoo block. Uniform sandy soils

Open heaths are a feature of the Little Desert in this block.

predominate on the ridges, dunes, and undulating parts of the sandplain, while sandy mottled yellow duplex soils are common in the flatter, lower-lying areas.

In the southern half the soils are more variable. Red calcareous sodic duplex soils and red stony loams occur on and around Mitre Rock, and sandy mottled yellow duplex soils on ridges extending southwards from the Little Desert. Uniform grey clays or mottled yellow duplex soils occur on the plain, with red calcareous sodic duplex soils on better-drained sites. Lunettes typically have red calcareous duplex or brown calcareous gradational soils.

4. Vegetation

The siliceous sands of the Little Desert carry large areas of brown stringybark woodland I and open scrub, which merge into broad areas of treeless open heath. These are dominated by woody shrubs belonging to the families Proteaceae, Fabaceae, Epacridaceae, Casuarinaceae, Xanthorrhoeaceae, and Myrtaceae. Desert banksia is particularly prominent here.

Around clay-pans and salt lakes the communities have a somewhat different species composition, and Mallee honey-myrtle dominates. A good example of this occurs around Salt Lake in the Little Desert National Park.

A large stand of mature mallee--broom-bush grows on laterized sandstone in the Little Desert National Park south of Kiata, and smaller stands are interspersed among the brown stringybark and heath communities elsewhere in the National Park.

Along the Wimmera River, the banks carry tall stands of river red gum open forest II and woodland II, with black box woodland I growing further away on less frequently inundated sites.

East of the Wimmera River the Wail Forest Reserve contains brown stringybark woodland I and open scrub, with patches of yellow gum woodland II growing in interdune depressions. In the West Wail Timber Reserve yellow gum grows in mixture with slender cypress pine, bull-oak, and black box.

A large area of public land north of Nurcoung carries brown stringybark woodland I and open scrub, with patches of yellow mallee--broombush and dumosa mallee open scrub. It also contains the rare Kamarooka mallee. Other parcels of public land in the area - such as Jane Duff Highway Park - carry brown stringybark, mallee--broombush, and yellow gum communities. An almost pure stand of grey box woodland I grows at the base of Mitre Rock.

On the salt lakes and salt-pans in the south-east, low open shrublands of halophytes are dominated by several species of glasswort. The best examples are found at Lake Wyn Wyn, where broad bands of halophytes are present.

At several locations these halophytic shrublands are ringed by low closed forests and tall open shrublands of salt paper-bark. The best development by far occurs at Lake Wyn Wyn on the southern and north-western edges and the northern end of the channel connecting it to Lake Natimuk. Small stands occur around sev-

The Mallee fowl is a typical bird species of the Little Desert here.

eral salt lakes near Wyn Wyn, and to the west at the northern end of Mitre Lake.

5. Fauna

Common mammal species include the western pygmy-possum, western grey kangaroo, silky mouse, and a number of bats.

Typical bird species in the Little Desert include the Mallee fowl, variegated fairy-wren, rufous calamanthus, slender-billed thornbill, singing honeyeater, white-fronted honeyeater, and tawny-crowned honeyeater.

Reptiles are well-suited to the scrub and heath habitats of the Little Desert, and include dragons, common scaly-foot, shingle-back, and burrowing species such as *Aprasia striolata*, and the blind snake *Ramphotyphlops bituberculata*. A number of skinks, including *Morethia obscura* and the delicate skink, are also common.

The lakes in the south - particularly Lake Wyn Wyn, Mitre Lake, and Lake Natimuk - support large populations of water birds and waders.

C. Present Use and Capabilities

1. Nature conservation

A sizeable portion of the eastern third of the Little Desert has already been reserved in the Little Desert National Park. The Park includes extensive areas of heathland that provide a significant habitat for the variegated fairy-wren, slender-billed thornbill, rufous calamanthus, silky mouse, and common scaly-foot.

The Little Desert contains a wealth of orchids, many of them rare. They include the azure sun-orchid (*Thelymitra canaliculata*), green leek-orchid (*Prasophyllum brainei*), a greenhood (*Pterostylis biseta*), common spider-orchid (*Caladenia patersonii*), and the swamp diuris (*Diuris palustris*). Another, the pale leek-orchid (*Prasophyllum pallidum*), is considered one of the rarest plants in Victoria.

The salt lakes south of the Little Desert form unique and distinct habitats for both flora and fauna. All the lakes support populations of banded stilts, red-necked avocets, hoary-headed grebes, and black swans. Two salt-marsh species (the glassworts *Halosarcia flabelliformis* and *H. syncarpa*) occur in Mitre Lake and the smaller salt lake to the north. Both species have a high conservation significance, the former being extremely rare. The vegetation of salt lakes in general is under threat from grazing pressures and changing hydrology due to clearing of adjacent land.

2. Recreation

The Wail Forest Nursery attracts more than 30,000 visitors a year, including tourists and school groups on education-

The Wail Forest Nursery attracts more than 30,000 visitors a year.

al tours, as well as people purchasing plants. The nursery has attractive gardens, with a picnic area and tables.

Visitors to the Little Desert National Park in the north of the block average more than 12,000 a year. The interesting flora and fauna here and in the Wail Forest Reserve have made both popular for picnics, camping, four-wheel-drive touring, and nature observation. Nature trails have been developed in each area.

Swamps and lakes to the south provide for water-based recreation, especially duck-shooting and fishing. Lake Natimuk has facilities for camping and picnicking and is used for a variety of water sports, including power-boating, skiing, windsurfing, and swimming.

The weir on the Wimmera River at Dimboola creates a large section of open water suitable for boating and skiing. The Dimboola Rowing Club has been using the river for the past hundred years.

3. Timber production

Capability is generally low, with the exception of a sugar gum plantation at Wail that provides a source of farm timbers and poles. Sawlogs are also produced irregularly from this plantation - in 1983 a parcel of 66 cu.m was produced for a sawmill at Horsham. Sugar gum round timbers are preservative-

Water-skiing area on the Wimmera River upstream of Dimboola.

treated at a plant established in the plantation.

Stands of river red gum and black box along the Wimmera River, and yellow gum in West Wail forest, have been an important source of fencing materials for local use, and are capable of continuing this role in the future.

4. Agriculture and apiculture

Capability is low on the sandy soils of the Little Desert, which are infertile and erosion-prone. Some of the smaller areas of public land south of the Little Desert are held under grazing licences.

The Little Desert has a high capability for honey production and for overwintering of bees.

5. Water

The Wimmera River, flowing close to the eastern border of the block, is the only significant stream and the source of its water lies in the Grampians, far to the south of the study area.

No significant run-off occurs in the sandy Little Desert portion. In the south, some short non-perennial streams from the Parilla Sand ridges that terminate in swamps and shallow lakes may have some potential for stock water.

However, many of the larger lakes, which tend to occur in a north-easterly line between Mitre Rock and the Wimmera River, are far too salty to be useful sources of water.

The quality and yield of groundwater declines across the block from west to east. In the west - particularly the north-west - the Duddo Limestone aquifer can yield domestic-quality water. By contrast, the groundwater around Natimuk can have salt contents close to that of sea water, and is of little use.

6. Minerals and stone

Salt is mined in a number of shallow salt lakes in the south-west, including Mitre Lake and Lake Wyn Wyn. Production rates are relatively low and intermittent, depending largely on the wetness of the previous winter.

Some gypsum deposits are located east of the Wimmera River. A small pit is located in the West Wail Timber Reserve and other small deposits in the Wail Forest Reserve.

Sand is extracted from a very small pit located in the Wail Forest Reserve. Otherwise, the only other material taken is a small amount of road-making material from Parilla Sand exposures on ridges south of the Little Desert.

D. Hazards and Conflicts

The sandy surface soils of the Little Desert, the ridges that extend south from the Little Desert, and, to a lesser extent, the lunettes within the block are all highly susceptible to wind erosion. In most areas the retention of native vegetation cover has prevented the occurrence of any significant wind erosion.

Sheet erosion by water is a significant hazard on the ridges and lunettes throughout the block, and on the slopes of Mitre Rock. Gully erosion is uncommon, except on the lower slopes of some ridges and lunettes and the outwash slopes below Mitre Rock.

In recent years considerable concern has arisen about water quality in the Wimmera River.

High salinity, colour, and nutrient concentrations and depressed dissolved oxygen levels result from diffuse run-off from the catchment. In addition, the major point source of waste in the catchment - the City of Horsham's effluent discharge - adds to nutrient and dissolved oxygen problems in the lower river.

The heath and brown stringybark woodland of the Little Desert is highly flammable, and there is a very high risk of wildfires escaping into freehold land in summer, particularly when strong winds are blowing. Access in this sandy country is always a problem and the lack of surface water storages further hinders control measures.

Rabbits occasionally build up in number, damaging both farmland and native environments. Predators such as foxes and feral cats pose a threat to some native fauna. The prime areas of invasion by weeds are around the margins of public land, along tracks, and particularly in picnic and camping areas. All of these pests require control programs from time to time.

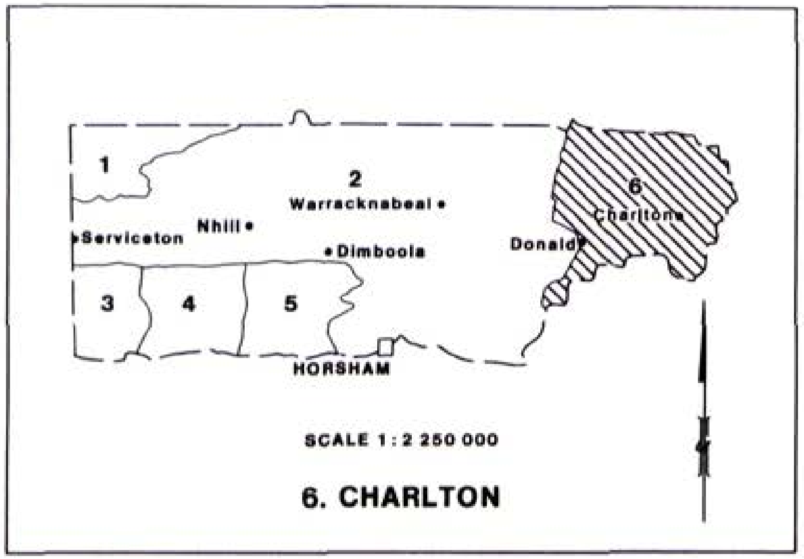
Grazing by domestic stock conflicts with conservation of ground flora and of animals that feed or breed on the ground. Sand and gravel extraction also conflicts with nature conservation.

6. CHARLTON

A. General

Occupying some 269,000 ha in the far east, Charlton block contains about 13,800 ha of public land, of which Lake Buloke (8,200 ha) covers the largest area. Much of Lake Buloke is held under perpetual leases and swamp leases.

The Jeffcott Flora Reserve (156 ha) is reserved under section 50 of the *Forests Act* 1958. Another small area of reserved forest (50 ha) is found near Corack East. The remainder of the public land comprises various stream frontages and reserved and unreserved Crown lands.



B. Nature of the Land

1. Climate

Average annual rainfall ranges from some 450 mm in the south-east of the block to about 370 mm in the north-west at Birchip. The moderate elevations of the Western Highlands to the south have a marked effect on rainfall distribution. Temperature, frost, and rainfall data for Donald are listed in the climate chapter as well as rainfall data for Birchip and Charlton.

2. Geology and geomorphology

This block contains land of two major geomorphic subdivisions - the Murray Basin plains and the Western Highlands.

Cambrio--Ordovician sediments - together with metamorphic rocks and Palaeozoic granite intrusions - constitute the north-western extremity of the Western Highlands. They occur in the east and south of the block, with monadnocks at

Granite tors on Mount Wycheproof.

Charlton, Jeffcott, and Wycheproof. These isolated hills rise to between 60 and 140 m above the surrounding plains, while the elevation of some of the highlands reaches 340 m - or about 190 m above the surrounding plains.

The Murray Basin plains to the west and north of the block consist of Quaternary to late Tertiary wind-blown, alluvial, and marine sediments. They can be further subdivided into the riverine plains to the north and east of Charlton, Lake Buloke with its extensive lunettes, and the plains largely to the west of the Avoca River. The last of these contain the easternmost outcrops of the east--west linear dune system (Woorinen Formation). Here the dune-field has begun to break up, existing as sheet-like areas and patchy discrete dunes. The underlying alluvium of the Shepparton Formation (or, in its absence, Pliocene Parilla Sand deposits) is exposed between the Woorinen deposits.

Two of the three major drainage systems fall within this block. The Richardson River runs close to the western boundary - skirting the highland front and then swinging north-west to terminate in Lake Buloke. The Avoca River enters near Yawong, flowing northwards in a confined flood-plain. North of Glenloth, the river splits into a series of diverging streams and anabranches, forming a broad flood-plain.

A sequence of lunettes lies to the east of Lake Buloke, some rising to 20 m above the lake. They represent successive stages of lake contraction, with the oldest ones located further to the east, a total distance of about 22 km. These lunettes developed 28,000--22,000 years ago. The flat, low-lying land between them, particularly close to the lake, represents prior sections of the lake floor and in some areas is still subject to periodic inundation or poor drainage.

3. Soils

Red duplex soils, which are usually calcareous and sodic, are dominant throughout this block, occurring on the plains, lunettes, and outwash slopes of the granitic and sedimentary rocks. Other commonly occurring soils include uniform sands on the rocky upper slopes on granite, stony uniform loams on the upper slopes on sedimentary rocks, reddish-brown calcareous sodic uniform clay soils on the lower outwash slopes around the granite, and similar but greyer soils on the poorer-drained parts of the Avoca River flood-plain and the easternmost area of the Wimmera plains.

4. Vegetation

Much of the native vegetation here has been cleared. River red gum woodland II fringes the Avoca and Richardson Rivers, Lake Buloke, and Wooroonook Lakes, with black box woodland I growing in the less frequently flooded sections.

Yellow gum woodland I, Jeffcott Flora Reserve.

The many small public land areas carry woodland I of black box and bull-oak in the north and grey box and yellow gum in the south. Understoreys are predominantly grassy, with exotic species often dominant.

Outcrops of Palaeozoic rock in the south-east carry widely spaced shrubs or small trees of lightwood, with wallowa often forming a second stratum. Understorey vegetation is sparse, and includes extensive areas of bare rock.

5. Fauna

The original mammalian fauna of this block has greatly declined, with western grey kangaroos and common brush tail possums being the only common native species. The introduced European rabbit, brown hare, and fox are also common.

Birds, however, are diverse and abundant. Notable species include the bush thick-knee, blue bonnet, black-eared cuckoo, Gilbert's whistler, grey-crowned babbler, and diamond firetail. Common species include sacred kingfisher, buff-rumped thornbill, red-capped robin, hooded robin, white-browed babbler, white-winged triller, rufous songlark, rufous whistler, and white-winged chough. Lake Buloke supports large numbers of waterfowl.

Common reptiles include the marbled gecko, Boulenger's skink, shingle-back, and eastern brown snake.

C. Present Use and Capabilities

1. Nature conservation

Few substantial parcels of public land remain in a natural condition in this area. Three on Mount Jeffcott and to the north of it contain good-sized examples of yellow gum and grey box woodlands. Although these have been heavily grazed they support populations of birds characteristic of woodlands.

Public land at Morton Plains north-north-west of Lake Buloke supports examples of nitre goosefoot *(Chenopodium nitrariaceum)*, a community now very rare in the Wimmera region.

A roadside reserve on the west of Lake Buloke carries a remnant of black box woodland with an interesting vegetation composition. Although in a degraded state, the woodland contains several very rare species - such as spiny lignum *(Muehlenbeckia horrida)*, long eryngium *(Eryngium plantagineum)*, pale beauty-heads *(Calocephalus sonderi)*, and Australian box-thorn *(Lycium australe)*.

Lake Buloke itself is one of the most important wetlands in Victoria for water birds. All the duck species regularly recorded in Victoria use it, including the freckled duck. This species is considered rare on a world-wide basis and is under pressure from shooters and from habitat alteration in Victoria.

Wooroonook Lakes comprise excellent wetlands and river red gum woodlands. These are good-sized samples of communities that are now uncommon. Similarly, the Avoca and Richardson River stream-side reserves, with their river red gum and black box woodlands, provide important corridors for animal movements through extensive farmland. They also act as refuges for species that were formerly far more widespread.

2. Recreation

Lake Buloke, the second-largest body of water in the study area, is the most important recreational resource in the block. It is held in high regard by duck-shooters, whose spending in the area boosts the local economy of Donald.

The other small pockets of public land in the block are valuable as nature observation points and picnic spots in an otherwise largely cleared landscape. Wooroonook Lakes have facilities for camping, picnicking, and water sports.

3. Timber production

Capability is low. The yellow gum and grey box growing on the few public land areas in this block are not actively sought for farm timbers because of their poor form and small size.

4. Agriculture and apiculture

A large portion of the public land is located in and around Lake Buloke. Most of this is held under perpetual leases and swamp leases, and is regularly grazed and occasionally cropped in suitable years.

Crop on leased public land at Lake Buloke that was wiped out by flooding in 1983. It is shown here being cultivated for resowing, in July of 1984.

Right: The rare freckled duck uses Lake Buloke.

Capability of most of the smaller tracts of public land for agriculture is low, but some areas of gum--box--bull-oak woodland have moderate capability. Many of these smaller areas are held under grazing licences.

The public land has moderate capability for apiculture, but most of the block is cleared freehold land.

5. Water

Although the Richardson River flows into the block and the Avoca passes through it, neither river receives a great deal of run-off from the land here. There are some small non-perennial streams and most of these rise in the Palaeozoic hills of the eastern part.

The Wimmera--Mallee Domestic and Stock Water Supply System supplements or provides water for most of the towns and properties on the plains. Again, the source of this water lies well south of the study area, in the Grampians.

Groundwater in the area is usually low-yielding and very high in salt. It is commonly associated with the Parilla Sand in the plains and fractured rock aquifers in the Western Highlands and their outliers.

Fresh groundwater occurs as springs on the granite near Yowang Hill and in the shoestring sands north of Charlton. The northern Avoca flood-plain also has groundwater with relatively low salt content.

The hardrock quarry near Charlton.

6. Minerals and stone

No commercial mineral deposits are mined in the block. There are, however, a few extractive industries. A large quarry at Woollen Rises near Narrewillock provides sandstone for local shire roads. It is located in an exposure of the Parilla Sand.

The only hardrock quarry in the study area operates in the hills of metamorphosed sedimentary rocks to the east of Charlton next to the Calder Highway. It occupies both private and public land, supplying crushed rock for local construction and road-making.

In addition, many sand-bearing lunettes and source-bordering dunes to the north can be used to provide sand for local construction purposes.

D. Hazards and Conflicts

Wind erosion is a severe hazard in all areas with sandy topsoils, especially on hills and outwash slopes on granitic rocks, and on the lunettes and isolated dunes east of Lake Buloke. Parts of the Avoca River plain with fine sandy to silty loam topsoils are also susceptible. The rest of the block has a moderate to low susceptibility.

Sheet erosion is a hazard in any sloping areas, especially where the soils have a low permeability. In this block, the steeper slopes of the granitic and sedimentary hills often suffer severe sheet erosion, and gully erosion is common on the surrounding outwash slopes. Sheet erosion and minor gully erosion occur on the lunettes near Lake Buloke.

Dryland salting occurs in some depressions between the lunettes near Lake Buloke, and on the lower northern slopes of the Western Highlands where they join the plain. Since the late 1970s, saline patches have also begun to appear on the grey cracking clays of the public land at Lake Buloke, which is farmed under lease. This has probably been due to a rise in the saline water table caused by continued clearing of catchments. Salt concentrations vary with seasons, but the problem could expand in the long term.

The small areas of public land are prone to fires and invasion by weeds, and can provide habitats for vermin. Unless control measures are carried out, they can often act as harbours from which the surrounding land can be re-infested.

Also a conflict arises between the needs of the modern large machinery for cropping and the retention of farm trees. Such machines have less manoeuvrability, making larger paddocks with few obstacles desirable. Trees in the cropping landscape are becoming rarer, confined mainly to areas around homesteads and along road reserves and some fence-lines - where grazing tends to prevent any regeneration.

Grazing by domestic stock conflicts with conservation of ground flora and of animals that feed or breed on the ground.

Sand and gravel extraction also conflicts with nature conservation.

APPENDICES

Appendix 1

PLANT SPECIES OF CONSERVATION SIGNIFICANCE

Species listed in this appendix are considered to be of conservation importance because they are endangered, rare (or geographically restricted), or otherwise significant. They are listed according to the numbered descriptive blocks, to indicate their distribution within the Wimmera area.

Descriptive blocks

1 : Telopea Downs
2 : Warracknabeal
3 : Minimay
4 : Spinifex
5 : Pomponderoo
6 : Charlton

? : indicates doubt regarding exact location or identification

( ): old (>40 years) or non-verified record, often only general locality given

: presumed extinct within that descriptive block

Species	Descriptive block					
	1	2	3	4	5	6
Acacia argyrophylla		( )				
A. enterocarpa		2			5	
A. glandulicarpa		2			5	6
A. havilandii		2				
A. lineolata	#					
A. pendula		2				
A. rupicola				4	5	
A. trineura		2			5	
Adenanthos terminales		2	3	4	5	
Aphanes pentamera				4		
Atriplex australasica		2				
Bergia ammanioides		2				
Boronia filifolia					5	
B. inornata					5	
Brachycome curvicarpa		( )				
B. trachycarpa		2				
Bromus arenarius		2				
Caladenia bicalliata				4	5	
C. patersonii		2			5	6
C. toxochila		2	3	4	5	
Calectasia cyanea var. *intermedia*					5	
Callitriche cyclocarpa		?			5	
Calocephalus sonderi		2				6
Choretrum spicatum					5	
Comesperma polygaloides		2	3	4	5	6
Cymbopogon obtectus		(#)				
Cyperus concinnus		?				
C. flaccidus		?				
C. rigidellus		( )				
C. squarrosus		2				
C. subulatus		( )				
Darwinia micropetala				4	5	
Daviesia pectinata		2	3	4	5	6
Digitaria ammophila		2				

Species	Descriptive block					
	1	2	3	4	5	6
Digitaria divaricatissima		2				
Diuris palustris		2			5	
Eleocharis pallens		2	3	4	5	6
Epaltes tatei		2			5	
Eriocaulon australasicum			3			
Eriochloa pseudoacrotricha		( )				
Eriostemon pungens			3		5	
Eryngium plantagineum						6
Eucalyptus froggattii					5	
E. odorata		2	3	4		
Frankenia angustipetala		( )				
Goodenia lunata		2				
Grevillea glabella			3			
Halosarcia flabelliformis					5	
H. syncarpa		2			5	
Helichrysum sp. aff. *apiculatum*					5	
Isolepis australiensis		2				
Kippistia suaedifolia		(#)				
Lepidium hyssopifolium		#			#	#
L. monoplocoides		#			#	
L. pseudohyssopifolia		( )				
Leptorhynchos elongatus		#				
L. medius		2				
L. panaetioides		2				
L. tetrachaetus		2				
Limosella curdieana		2				
Lycium australe		2				6
Maireana excavata		2			5	6
Marsilea angustifolia		2				6
Muehlenbeckia horrida						6
Mukia micrantha		2				
Najas tenuifolia		2				
Phebalium brachyphyllum					#	
P. lowanense	1	2				

Species	Descriptive block					
	1	2	3	4	5	6
Phyllota remota	1					
Pilularia novae-hollandiae		2	3	4	5	6
Poa crassicaudex					5	
P. drummondiana			3		5	
Podolepis canescens		2			5	
Pomaderris obcordata			3			
Prasophyllum brainei		#			5	
P. fuscum		2	3	4	5	6
P. pallidum		#			5	
Psilotum nudum					5	
Psoralea parva		#				
Pterostylis biseta		2	3	4	5	
P. sp. nov. aff.*scabra*		2				
Ptilotus erubescens		2	3	4	5	6
P. polystachus	( )					
Pultenaea vestita				4		
Quinetia urvillei					5	
Santalum acuminatum	1	2	3	4	5	
Schoenoplectus dissachanthus		2				
Schoenus fluitans			3	4		
S. latelaminatus		2	3			
Senecio hypoleucus					5	
S. macrocarpus		(#)				
Sporobolus caroli		( )				
S. mitchellii		2				
Spyridium bifidum					5	
S. spathulatum	1		3		5	
S. tridentatum		?				
Stellaria filiformis		( )			?	
Stenopetalum velutinum		2				
Styphelia exarrhena	1					
Swainsona murrayana ssp. *murrayana*		2				
Templetonia stenophylla		2			5	6
Thelymitra canaliculata		#	3		5	

Species	Descriptive block					
	1	2	3	4	5	6
Thelymitra epipactoides		2	?		?	
T. holmesii			3			
Triglochin hexagona		2				
Velleia arguta		2				
Westringia crassifolia				4		
Zoysia matrella					?	

Appendix 2

FAUNA

Appendix 2a - Mammals
2b - Birds
2c - Reptiles
2d - Amphibians
2e - Fish

These lists include only those species actually recorded in the study area. No predictions have been made.

Abbreviations

* introduced species

x recorded in that habitat

Distribution

Res	Restricted to small areas of suitable habitat
W	Widespread in study area
L	Within the study area occurs only in the Little Desert
B	Within the study area occurs only in the Big Desert
LB	Within the study area occurs only in the Little Desert and Big Desert

Habitat

1	River red gum open forest and woodland
2	Gum--box--bull-oak woodland

3	Brown stringybark woodland and open scrub
4	Mallee--broombush shrubby open scrub
5	Mallee open scrub
6	Salt paper-bark low closed forest and open shrubland
7	Heathland
8	Grassland
9	Wetlands
a	Shallow freshwater marshes
b	Permanent fresh water
c	Saline lakes

Status

C	Common in suitable habitat
U	Uncommon
R	Rare
V	Vagrant
M	Migratory, present for only part of the year
N	Nomadic, numbers fluctuate greatly
B	Known to breed in the study area (birds only)

Appendix 2a - Mammals

Common name	Scientific name	Distribution	Habitat 1	2	3	4	5	6	7	8	9	Status
Short-beaked echidna	*Tachyglossus aculeatus*	W	x	x	x	x	x		x	x		U
Platypus	*Ornithorhynchus anatinus*	Res									b	U
Yellow-footed antechinus	*Antechinus flavipes*	Res		x	x							R
Eastern quoll	*Dasyurus viverrinus*	no longer present										
Fat-tailed dunnart	*Sminthopsis crassicaudata*	W	x						x	x		C
Common brushtail possum	*Trichosurus vulpecula*	W	x	x						x		U
Western pygmy-possum	*Cercartetus concinnus*	Res		x	x							U
Feathertail glider	*Acrobates pygmaeus*	Res	x	x								R
Sugar glider	*Petaurus breviceps*	Res	x	x								R
Common ringtail possum	*Pseudocheirus peregrinus*	Res	x	x								U
Western grey kangaroo	*Macropus fuliginosus*	W	x	x	x	x	x		x	x		C
Red-necked wallaby	*Macropus rufogriseus*	Res		x	x							R
Swamp wallaby	*Wallabia bicolor*	Res	x									U
Little red flying-fox	*Pteropus scapularis*	Res	x	x						x		
White-striped mastiff-bat	*Tadarida australis*	W	x	x		x	x			x		
Little mastiff-bat	*Mormopterus planiceps*	W	x	x	x	x	x			x		
Gould's wattled bat	*Chalinolobus gouldii*	W	x	x	x	x	x			x		
Chocolate wattled bat	*Chalinolobus morio*	W	x	x	x	x	x			x		
King river eptesicus	*Eptesicus regulus*	W	x	x								
Little forest eptesicus	*Eptesicus vulturnus*	W	x	x		x	x					
Western broad-nosed bat	*Nycticeius balstoni*	W	x	x	x	x	x			x		
Lesser long-eared bat	*Nyctophilus geoffroyi*	W	x	x	x	x	x			x		
Water-rat	*Hydromys chrysogaster*	Res									b	C
*House-mouse	*Mus musculus*	W	x	x	x				x	x		C
Mitchell's hopping-mouse	*Notomys mitchelli*	B							x			
Silky mouse	*Pseudomys apodemoides*	Res			x				x			C
*Black rat	*Rattus rattus*	R									b	
*Dog	*Canis familiaris*	W	x	x	x	x	x		x			U
*Fox	*Vulpes vulpes*	W	x	x	x	x	x		x	x		C
*Cat	*Felis catus*	W	x	x	x	x	x		x	x		C
*Brown hare	*Lepus capensis*	W	x	x						x		C
*European rabbit	*Oryctolagus cuniculus*	W	x	x						x		C
*Goat	*Capra hircus*	Res		x								R
Total number of mammal species	33		23	25	15	12	12	0	9	16	3	

Taxonomy and nomenclature follow Menkhorst, P.W. (1983). Working list of Victorian mammals. *Arthur Rylah Institute for Environmental Research Technical Report Series* No. 7.

Appendix 2b - Birds

Common name	Scientific name	Distribution	Habitat 1	2	3	4	5	6	7	8	9	Status
Emu	*Dromaius novaehollandiae*	B,L	x	x	x	x	x	x	x	x		C,B
Great crested grebe	*Podiceps cristatus*	Res									b	R,N
Hoary-headed grebe	*Poliocephalus poliocephalus*	W									bc	U,N,B
Australasian grebe	*Tachybaptus novaehollandiae*	W									b	U,N,B
Australian pelican	*Pelecanus conspicillatus*	Res									b	U,B
Darter	*Anhinga melanogaster*	Res									b	U,N
Great cormorant	*Phalacrocorax carbo*	W									b	N
Pied cormorant	*Phalacrocorax varius*	Res									b	N,B
Little black cormorant	*Phalacrocorax sulcirostris*	Res									bc	R,N
Little pied cormorant	*Phalacrocorax melanoleucos*	W									bc	C,N
Pacific heron	*Ardea pacifica*	W								x	abc	U,N
White-faced heron	*Ardea novaehollandiae*	W	x							x	abc	C,N,B
Cattle egret	*Ardeola ibis*	Res								x		V,M
Great egret	*Egretta alba*	W									abc	U,N
Little egret	*Egretta garzetta*	Res									abc	R,N
Intermediate egret	*Egretta intermedia*	Res									abc	R,N
Rufous night heron	*Nycticorax caledonicus*	Res	x								b	U,B
Little bittern	*Ixobrychus minutus*	Res									a	R,N,B
Australasian bittern	*Botaurus poiciloptilus*	Res									b	R,B
Black-necked stork	*Xenorhynchus asiaticus*	Res									b	V
Glossy ibis	*Plegadis falcinellus*	Res									ab	R,N
Sacred ibis	*Threskiornis aethiopica*	Res								x	a	U
Straw-necked ibis	*Threskiornis spinicollis*	Res								x	a	U
Royal spoonbill	*Platalea regia*	Res									ab	R
Yellow-billed spoonbill	*Platalea flavipes*	W									ab	U
Magpie goose	*Anseranas semipalmata*	Res										V
Plumed whistling-duck	*Dendrocygna eytoni*	W									ab	R,N
Black swan	*Cygnus atratus*	W									abc	C,B
Freckled duck	*Stictonetta naevosa*	W									b	U,N,B
Australian shelduck	*Tadorna tadornoides*	W								x	abc	C,B
Pacific black duck	*Anas superciliosa*	W									abc	C,N,B
*Mallard	*Anas platyrhynchos*	Res									b	R
Grey teal	*Anas gibberifrons*	W									abc	C,N,B
Chestnut teal	*Anas castanea*	Res									bc	R,N

Appendix 2b - Birds (continued..)

Common name	Scientific name	Distribution	Habitat 1	2	3	4	5	6	7	8	9	Status
Australasian shoveller	*Anas rhynchotis*	W									abc	U,N,B
Garganey	*Anas querquedula*	Res									b	V
Pink-eared duck	*Malacorhynchus membranaceus*	W									ab	U,N,B
Hardhead	*Aythya australis*	W									bc	U,N,B
Maned duck	*Chenonetta jubata*	W									ab	C,B
Blue-billed duck	*Oxyura australis*	Res									b	R,B
Musk duck	*Biziura lobata*	Res									b	C,B
Black-shouldered kite	*Elanus notatus*	W	x	x					x	x		U,B
Letter-winged kite	*Elanus scriptus*	Res										V
Black kite	*Milvus migrans*	W								x		R
Square-tailed kite	*Lophoictinia isura*	Res	x	x								R
Whistling kite	*Haliastur sphenurus*	W	x	x							b	U,B
Brown goshawk	*Accipiter fasciatus*	W	x	x	x					x		U,B
Collared sparrowhawk	*Accipiter cirrhocephalus*	W	x	x			x					R
Grey goshawk	*Accipiter novaehollandiae*	Res	x									R
White-bellied sea-eagle	*Haliaeetus leucogaster*	Res	x								b	R
Wedge-tailed eagle	*Aquila audax*	W	x	x	x	x	x	x	x	x		U,B
Little eagle	*Hieraaetus morphnoides*	W	x	x	x				x	x		U,B
Spotted harrier	*Circus assimilis*	W							x	x		U
Marsh harrier	*Circus aeruginosus*	W							x	x	abc	U,B
Black falcon	*Falco subniger*	W								x		R
Peregrine falcon	*Falco peregrinus*	W	x	x						x	b	U,B
Australian hobby	*Falco longipennis*	W	x	x						x	b	U
Grey falcon	*Falco hypoleucos*	W	x	x						x		R
Brown falcon	*Falco berigora*	W	x	x	x				x	x		C,B
Australian kestrel	*Falco cenchroides*	W							x	x		C,B
Mallee fowl	*Leipoa ocellata*	Res			x	x	x					R,B
Stubble quail	*Coturnix novaezelandiae*	W	x							x		C,N,B
Brown quail	*Coturnix australis*	Res	x	x								U,N
Painted button-qail	*Turnix varia*	L	x	x	x							U,B
Little button-qail	*Turnix velox*	W	x	x	x					x		U,N,B
Red-chested button-qail	*Turnix pyrrhothorax*	Res								x		V,N
Plains-wanderer	*Pedionomus torquatus*	W								x		R,N
Buff-banded rail	*Rallus philippensis*	W									ab	U

Appendix 2b - Birds (continued..)

Common name	Scientific name	Distribution	Habitat 1	2	3	4	5	6	7	8	9	Status
Lewin's rail	*Rallus pectoralis*	Res									b	R
Baillon's crake	*Porzana pusilla*	W									abc	U,N
Australian crake	*Porzana fluminea*	W									abc	U,N
Spotless crake	*Porzana tabuensis*	W									ab	R,N
Black-tailed native-hen	*Gallinula ventralis*	W	x	x						x	ab	U,N,B
Dusky moorhen	*Gallinula tenebrosa*	W									ab	U,B
Purple swamphen	*Porphyrio porphyrio*	W									ab	R
Eurasian coot	*Fulica atra*	W									b	C,B
Brolga	*Grus rubicundus*	Res								x	a	R
Australian bustard	*Ardeotis australis*	Res							x	x		R
Bush thick-knee	*Burhinus magnirostris*	W	x	x						x		R,B
Painted snipe	*Rostratula benghalensis*	Res									ab	R,N
Masked lapwing	*Venallus miles*	W	x							x	abc	C,B
Banded lapwing	*Vanellus tricolor*	W								x		U,B
Grey plover	*Pluvialis squatarola*	Res									b	R,M
Red-kneed dotterel	*Erythrogonys cinctus*	W									ab	U,N,B
Double-banded plover	*Charadrius bicinctus*	Res									b	U,M
Red-capped plover	*Charadrius ruficapillus*	Res									bc	C
Black-fronted plover	*Charadrius melanops*	W									bc	U,B
Black-winged stilt	*Himantopus himantopus*	W									bc	U,B
Banded stilt	*Cladorhynchus leucocephalus*	Res									b	C,N
Red-necked avocet	*Recurvirostra novaehollandiae*	Res									b	C,N,B
Eastern curlew	*Numenius madagascariensis*	Res									b	R,M
Marsh sandpiper	*Tringa stagnatilis*	Res									abc	R,M
Greenshank	*Tringa nebularia*	Res									b	R,M
Latham's snipe	*Gallinago hardwickii*	Res								x	ab	U,M
Black-tailed godwit	*Limosa limosa*	Res									abc	R,M
Sharp-tailed sandpiper	*Calidris acuminata*	Res									bc	C.M
Red-necked stint	*Calidris ruficollis*	Res									bc	U,M
Curlew sandpiper	*Calidris ferruginea*	Res									bc	U,M
Australian pratincole	*Stiltia isabella*	Res								x		V,M
Silver gull	*Larus novaehollandiae*	Res									b	U
Whiskered tern	*Chlidonias hybrida*	Res									abc	U,N
Gull-billed tern	*Gelochelidon nilotica*	Res									ab	R

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Appendix 2b - Birds (continued..)

Common name	Scientific name	Distribution	Habitat 1	2	3	4	5	6	7	8	9	Status
Caspian tern	*Hydroprogne caspia*	Res									bc	R
*Feral pigeon	*Columba livia*	W								x		C
*Spotted turtle-dove	*Streptopelia chinensis*	Res										R
Peaceful dove	*Geopelia placida*	W	x	x						x		C,B
Diamond dove	*Geopelia cuneata*	W	x	x						x		R
Common bronzewing	*Phaps chalcoptera*	W	x	x					x			U
Brush bronzewing	*Phaps elegans*	LB			x	x	x					R
Crested pigeon	*Ocyphaps lophotes*	W	x							x		C,B
Red-tailed black-cockatoo	*Calyptorhynchus magnificus*	Res			x							R
Yellow-tailed black-cockatoo	*Calyptorhynchus funereus*	Res	x	x	x							U
Gang-gang cockatoo	*Callocephalon fimbriatum*	Res										R
Galah	*Cacatua roseicapilla*	W	x	x						x		C,B
Long-billed corella	*Cacatua tenuirostris*	Res	x							x		C,B
Little corella	*Cacatua sanguinea*	Res	x							x		U
Pink cockatoo	*Cacatua leadbeateri*	Res					x					R
Sulphur-crested cockatoo	*Cacatua galerita*	W	x	x						x		C
Rainbow lorikeet	*Trichoglossus haematodus*	Res	x	x								R,N
Musk lorikeet	*Glossopsitta concinna*	W	x	x								U,N
Purple-crowned lorikeet	*Glossopsitta prophyrocephala*	W	x	x								U,N
Little lorikeet	*Glossopsitta pusilla*	W	x	x								U,N
Regent parrot	*Polytelis anthopeplus*	Res	x									R
Cockatiel	*Nymphicus hollandicus*	W	x	x						x		U,B
Night parrot	*Geopsittacus occidentalis*	No longer present										
Budgerigar	*Melopsittacus undulatus*	W	x	x						x		U
Swift parrot	*Lathamus discolor*	W	x	x								U,M
Crimson rosella	*Platycercus elegans*	L	x	x								U
Eastern rosella	*Platycercus eximius*	W	x	x						x		C,B
Mallee ringneck	*Barnardius barnardi*	W	x	x	x	x	x			x		U
Red-rumped parrot	*Psephotus haematonotus*	W	x	x						x		C,B
Mulga parrot	*Psephotus varius*	W				x	x					U
Blue bonnet	*Northiella haematogaster*	W		x						x		U
Blue-winged parrot	*Neophema chrysostoma*	W							x	x		U,M
Elegant parrot	*Neophema elegans*	W							x	x		R,N
Pallid cuckoo	*Cuculus pallidus*	W	x	x	x					x		U,M

Appendix 2b - Birds (continued..)

Common name	Scientific name	Distribution	Habitat 1	2	3	4	5	6	7	8	9	Status
Fan-tailed cuckoo	*Cuculus pyrrhophanus*	W	x	x	x							C,M,B
Black-eared cuckoo	*Chrysococcyx osculans*	LB		x	x	x						U,M,B
Horsfield's bronze-cuckoo	*Chrysococcyx basalis*	W	x	x	x	x				x		C,M,B
Shining bronze-cuckoo	*Chrysococcyx lucidus*	W	x	x								U,M,B
Southern boobook	*Ninox novaeseelandiae*	W	x	x						x		U,B
Barking owl	*Ninox connivens*	W	x	x								R
Barn owl	*Tyto alba*	W	x	x						x		U,B
Tawny frogmouth	*Podargus strigoides*	W	x	x						x		U,B
Australian owlet-nightjar	*Aegotheles cristatus*	W	x	x								C,B
Spotted nightjar	*Caprimulgus guttatus*	LB				x	x					U
White-throated needletail	*Hirundapus caudacutus*	W		aerial								C,M
Fork-tailed swift	*Apus pacificus*	W		aerial								U,M
Laughing kookaburra	*Dacelo novaeguineae*	W	x	x						x		C,B
Red-backed kingfisher	*Halcyon pyrrhopygia*	W	x	x						x		R,M,B
Sacred kingfisher	*Halcyon sancta*	W	x	x								U,M,B
Rainbow bee-eater	*Merops ornatus*	W	x	x						x		C,M,B
Dollarbird	*Eurystomus orientalis*	Res	x									R,M
Singing bushlark	*Mirafra javanica*	W								x		U,B
*Skylark	*Alauda arvensis*	Res								x		U,B
White-backed swallow	*Cheramoeca leucosternum*	Res	x							x		U
Welcome swallow	*Hirundo neoxena*	W	x						x	x	abc	C,M,B
Tree martin	*Cecropis nigricans*	W	x							x	b	C,M,B
Fairy martin	*Cecropis ariel*	W	x							x	ab	C,M,B
Richard's pipit	*Anthus novaeseelandiae*	W							x	x		C,B
Black-faced cuckoo-shrike	*Coracina novaehollandiae*	W	x	x	x					x		U,M,B
White-bellied cuckoo-shrike	*Coracina papuensis*	Res	x									R
White-winged triller	*Lalage sueurii*	W	x	x	x					x		C,M,B
White's thrush	*Zoothera dauma*	Res	x									V
*Blackbird	*Turdus merula*	Res	x							x		U,B
Southern scrub-robin	*Drymodes brunneopygia*	Res		x		x	x					U,B
Rose robin	*Petroica rosea*	Res	x									R
Flame robin	*Petroica phoenicea*	Res								x		R,M
Scarlet robin	*Petroica multicolor*	Res		x	x							U,B
Red-capped robin	*Petroica goodenovii*	W		x	x				x			U,B

Appendix 2b - Birds (continued..)

Common name	Scientific name	Distribution	Habitat 1	2	3	4	5	6	7	8	9	Status
Hooded robin	*Melanodryas cucullata*	W	x	x	x				x			U
Eastern yellow robin	*Eopsaltria australis*	Res	x									R
Jacky winter	*Microeca leucophaea*	W	x	x	x					x		C,B
Crested shrike-tit	*Falcunculus frontatus*	Res	x	x								U,B
Red-lored whistler	*Pachycephala rufogularis*	Res				x						R,B
Gilbert's whistler	*Pachycephala inornata*	Res		x		x						U,B
Golden whistler	*Pachycephala pectoralis*	W		x	x	x				x		C,B
Rufous whistler	*Pachycephala rufiventris*	W	x	x	x		x			x		C,M,B
Grey shrike-thrush	*Colluricincla harmonica*	W	x	x		x				x		C,B
Crested bellbird	*Oreoica gutturalis*	Res		x		x	x		x			U,B
Satin flycatcher	*Myiagra cyanoleuca*	Res	x									R,M
Restless flycatcher	*Myiagra inquieta*	W	x	x	x					x		C,B
Grey fantail	*Rhipidura fuliginosa*	W	x	x	x		x			x		U,B
Rufous fantail	*Rhipidura rufifrons*	Res	x									V
Willie wagtail	*Rhipidura leucophrys*	W	x	x	x		x	x	x	x		C,B
Chestnut quail-thrush	*Cinclosoma castanotum*	Res				x	x					R
Grey-crowned babbler	*Pomatostomus temporalis*	Res		x						x		R
White-browed babbler	*Pomatostomus superciliosus*	W		x	x	x						U,B
Clamorous reed-warbler	*Acrocephalus stentoreus*	Res									b	U,M,B
Little grassbird	*Megalurus gramineus*	Res									b	U
Golden-headed cisticola	*Cisticola exilis*	Res									b	U
Rufous songlark	*Cinclorhamphus mathewsi*	W	x	x								U,M,B
Brown songlark	*Cinclorhamphus cruralis*	W								x		U,M,B
Superb fairy-wren	*Malurus cyaneus*	Res		x	x			x				C,B
Splendid fairy-wren	*Malurus splendens*	Res				x	x	x				U,B
Variegated fairy-wren	*Malurus lamberti*	Res			x	x			x			C,B
Mallee emu-wren	*Stipiturus ruficeps mallee*	Res					x					R
Shy hylacola	*Sericornis cautus*	Res				x			x			U
Rufous calamanthus	*Sericornis campestris*	Res							x			R,B
Weebill	*Smicrornis brevirostris*	W		x		x	x					C,B
Western gerygone	*Gerygone fusca*	Res	x									R
Brown thornbill	*Acanthiza pusilla*	W		x	x	x			x			C,B
Inland thornbill	*Acanthiza apicalis*	B		x	x	x	x					C
Chestnut-rumped thornbill	*Acanthiza uropygialis*	W		x						x		U,B

Appendix 2b - Birds (continued..)

Common name	Scientific name	Distribution	Habitat 1	2	3	4	5	6	7	8	9	Status
Buff-rumped thornbill	*Acanthiza reguloides*	W	x	x	x							C,B
Slender-billed thornbill	*Acanthiza iredalei*	L							x			U,B
Yellow-rumped thornbill	*Acanthiza chrysorrhoa*	W	x	x						x		C,B
Yellow thornbill	*Acanthiza nana*	W	x	x								U,B
Striated thornbill	*Acanthiza lineata*	L		x	x							C,B
Southern whiteface	*Aphelocephala leucopsis*	W		x						x		U,B
Varied sitella	*Daphoenositta chrysoptera*	W	x	x	x		x					U,B
White-throated treecreeper	*Climacteris leucophaea*	Res		x	x							C
Brown treecreeper	*Climacteris picumnus*	W	x	x								C,B
Red wattlebird	*Anthochaera carunculata*	W	x	x	x		x			x		C,B
Little wattlebird	*Anthochaera chrysoptera*	L		x								R,B
Spiny-cheeked honeyeater	*Acanthagenys rufogularis*	W		x	x	x	x					U,B
Striped honeyeater	*Plectorhyncha lanceolata*	Res				x						R
Little friarbird	*Philemon citreogularis*	Res	x	x								R,M
Regent honeyeater	*Xanthomyza phrygia*	Res	x	x								R,B
Blue-faced honeyeater	*Entomyzon cyanotis*	Res		x								R
Noisy miner	*Manorina melanocephala*	W	x	x						x		C,B
Yellow-throated miner	*Manorina flavigula*	Res	x	x			x					U
Yellow-faced honeyeater	*Lichenostomus chrysops*	L		x	x							U,M
Singing honeyeater	*Lichenostomus virescens*	W		x					x	x		U,B
White-eared honeyeater	*Lichenostomus leucotis*	W			x	x	x					C,B
Yellow-tufted honeyeater	*Lichenostomus melanops*	Res		x								R,N
Purple-gaped honeyeater	*Lichenostomus cratitius*	L				x	x					R,B
Yellow-plumed honeyeater	*Lichenostomus ornatus*	Res		x		x	x					U,B
Fuscous honeyeater	*Lichenostomus fuscus*	Res		x								R
White-plumed honeyeater	*Lichenostomus penicillatus*	W	x	x								C,B
Black-chinned honeyeater	*Melithreptus gularis*	Res	x	x								U,N,B
Brown-headed honeyeater	*Melithreptus brevirostris*	W	x	x	x	x	x					C,N,B
White-naped honeyeater	*Melithreptus lunatus*	Res	x	x								R,N
New Holland honeyeater	*Phylidonyris novaehollandiae*	W		x	x	x			x			U,N,B
White-fronted honeyeater	*Phylidonyris albifrons*	W			x	x			x			U
Tawny-crowned honeyeater	*Phylidonyris melanops*	Res			x	x			x			U,B
Eastern spinebill	*Acanthorhynchus tenuirostris*	Res										V
Black honeyeater	*Certhionyx niger*	Res				x	x					V

Appendix 2b - Birds (continued..)

Common name	Scientific name	Distribution	Habitat 1	2	3	4	5	6	7	8	9	Status
Pied honeyeater	*Certhionyx variegatus*	Res				x	x					V
Crimson chat	*Ephthianura tricolor*	Res			x			x	x			V,B
Orange chat	*Ephthianura aurifrons*	Res						x				R
White-fronted chat	*Ephthianura albifrons*	W						x	x	x		C,B
Mistletoebird	*Dicaeum hirundinaceum*	Res	x	x						x		U
Spotted pardalote	*Pardalotus punctatus*	L		x	x							U
Yellow-rumped pardalote	*Pardalotus xanthopygus*	W			x	x	x					U,B
Striated pardalote	*Pardalotus striatus*	W	x	x	x	x						C,B
Silvereye	*Zosterops lateralis*	Res		x	x	x			x			U,N,B
*European goldfinch	*Carduelis carduelis*	W								x		U,B
*House sparrow	*Passer domesticus*	W		x						x		C,B
Diamond firetail	*Emblema guttata*	W	x	x								U,B
Zebra finch	*Poephila guttata*	W		x						x		U,N,B
*Common starling	*Sturnus vulgaris*	W	x	x						x		C,B
Olive-backed oriole	*Oriolus sagittatus*	Res	x	x								R,M
White-winged chough	*Corcorax melanorhamphos*	W	x	x						x		C,B
Apostlebird	*Struthidea cinerea*	No longer present										
Australian magpie-lark	*Grallina cyanoleuca*	W	x	x						x		C,B
White-breasted woodswallow	*Artamus leucorhynchus*	Res	x									R,M
Masked woodswallow	*Artamus personatus*	W	x	x	x				x			U,M,B
White-browed woodswallow	*Artamus superciliosus*	W	x	x	x				x	x		C,M,B
Black-faced woodswallow	*Artamus cinerus*	W	x							x		R,M
Dusky woodswallow	*Artamus cyanopterus*	W	x	x	x				x	x		C,M,B
Grey butcherbird	*Cracticus torquatus*	Res		x	x	x						U,B
Pied butcherbird	*Cracticus nigrogularis*	Res	x	x								R
Australian magpie	*Gymnorhina tibicen*	W	x	x						x		C,B
Grey currawong	*Strepera versicolor*	Res		x	x	x						U,B
Australian raven	*Corvus coronoides*	W	x	x						x		U
Little raven	*Corvus mellori*	W	x							x		C,B
Total number of bird species	266		107	116	52	36	30	8	28	94	81	

Taxonomy and nomenclature follow Royal Australasian Ornithologists Union (1978). Recommended English names for Australian birds. *Emu*, 77 Supplement, 245--313.

Appendix 2c - Reptiles

Common name	Scientific name	Distribution	Habitat 1	2	3	4	5	6	7	8	9	Status
Long-necked tortoise	*Chelodina longicollis*	Res	x								x	U
Tessellated gecko	*Diplodactylus tessellatus*	Res										R
Wood gecko	*Diplodactylus vittatus*	Res	often found in rocky outcrops or other hard, cracked substrates									R
Marbled gecko	*Phyllodactylus marmoratus*	W	x	x	x					x		C
Thick-tailed gecko	*Underwoodisaurus milii*	Res	x	rocky outcrops						x		U
Legless lizard	*Aprasia striolata*	Res					x		x			R
Legless lizard	*Delma australis*	Res							x			U
Legless lizard	*Delma impar*	Res								x		R
Legless lizard	*Delma inornata*	W	x				x			x		U
Common scaly-foot	*Pygopus lepidopodus*	W			x				x			C
Hooded scaly-foot	*Pygopus nigriceps*	Res										R
Bearded dragon	*Amphibolurus barbatus*	W	x	x	x	x			x	x		C
Mallee dragon	*Amphibolurus fordi*	B				x	x		x			U
Jacky lizard	*Amphibolurus muricatus*	W		x	x	x	x		x			C
Painted dragon	*Amphibolurus pictus*	L,B			x	x			x			
Sand monitor	*Varanus gouldii*	W			x	x						R
Lace monitor	*Varanus varius*	Res	x									R
Snake-eyed skink	*Cryptoblepharus carnabyi*	W	x	x	x							U
Large-striped skink	*Ctenotus robustus*	W		x	x							U
Skink	*Ctenotus uber orientalis*	L,B		x		x						U
Tree skink	*Egernia striolata*	Res	x									R
Skink	*Hemiergis decresiensis*	Res			rocky outcrops							R
Delicate skink	*Lampropholis delicata*	W		x					x			U
Bougainville's skink	*Lerista bougainvillii*	W		x								U
Skink	*Menetia greyi*	Res			x				x			U
Skink	*Morethia adelaidensis*	Res	x									R
Boulenger's skink	*Morethia boulengeri*	W	x									C
Skink	*Morethia obscura*	L,B			x							C
Western blue-tongued lizard	*Tiliqua occipitalis*	Res				x						R
Shingle-back	*Trachydosaurus rugosus*	W	x	x	x	x	x		x			C
Blind snake	*Ramphotyphlops australis*	Res										R
Blind snake	*Ramphotyphlops bituberculata*	Res							x			R
Blind snake	*Ramphotyphlops nigrescens*	Res										R

Appendix 2c - Reptiles (continued)

Common name	Scientific name	Distribution	Habitat 1	2	3	4	5	6	7	8	9	Status
Blind snake	*Ramphotyphlops proximus*	Res										R
Marster's snake	*Drysdalia marstersi*	B				x	x					U
Bardick	*Echiopsis curta*	Res	x		x					x		R
Eastern tiger snake	*Notechis scutatus*	Res	x							x	x	R
Eastern brown snake	*Pseudonaja textilis*	W	x	x						x		C
Curl snake	*Suta Suta*		no data									R
Snake	*Unechis nigriceps*	L		x		x						U
Bandy-bandy	*Vermicella annulata*	W										R
Total number of reptile species	41		14	11	12	10	6	0	12	7	2	

Taxonomy and nomenclature follow Cogger, H.G., Cameron, E.E., and Cogger, H.M. (1983). Amphibia and reptilia. In 'Zoological Catalogue of Australia', Vol 1, ed. D. Walton.(Australian Government Publishing Service: Canberra.)

Appendix 2d - Amphibians

Common name	Scientific name	Distribution	Habitat 1	2	3	4	5	6	7	8	9	Status
Common eastern froglet	*Ranidella signifera*	W	x	x						x	x	C
	Ranidella parinsignifera	W									x	C
Eastern banjo frog	*Limnodynastes dumerilii*	W	x	x	x	x			x	x	x	C
Spotted grass frog	*Limnodynastes tasmaniensis*	W	x	x					x	x	x	C
	Neobatrachus pictus	W		x	x	x			x			C
	Neobatrachus sudelli	W		x	x	x			x			C
Brown toadlet	*Pseudophryne bibronii*	W		x	x	x	x		x			U
Brown tree frog	*Litoria ewingii*	Res	x							x	x	U
Peron's tree frog	*Litoria peronii*	Res	x							x	x	U
	Litoria raniformis	W	x							x	x	C
Total number of amphibian species	10		6	6	4	4	1	0	5	6	7	

Taxonomy and nomenclature follow Cogger, H.G., Cameron, E.E., and Cogger, H.M. (1983). Amphibia and reptilia. In 'Zoological Catalogue of Australia', Vol. 1, ed. D. Walton. (Australian Government Publishing Service: Canberra.)

Appendix 2e - Fish

Common name	Scientific name	Distribution	Status	Comments
Australian smelt	*Retropinna semoni*	Res	C	Rivers
Freshwater catfish	*Tandanus tandanus*	Res	U	Rivers
Murray cod	*Maccullochella peeli*	Res	U	Wimmera River, some lakes
Golden perch	*Macquaria ambigua*	Res	U	Rivers
Flat-headed gudgeon	*Philypnodon grandiceps*	Res	C	Rivers
Western carp gudgeon	*Hypseleotris klunzingeri*	Res	U	Avoca Rover
*Brown trout	*Salmo trutta*	Res	U	Stocked into lakes
*Rainbow trout	*Salmo gairdneri*	Res	U	Stocked into lakes
*Carp	*Cyprinus carpio*	W	C	Not in all water bodies
*Goldfish	*Carassius auratus*	W	C	Rivers and lakes
*Tench	*Tinca tinca*	W	C	Most water bodies
*Mosquitofish	*Gambusia affinus*	Res	C	Wimmera River
*English perch (redfin)	*Perca fluviatilis*	W	C	All water bodies

Taxonomy and nomenclature follow Cadwallader, P.L. and Backhouse, G.N. (1983). 'A Guide to the Freshwater Fish of Victoria.' (Victorian Government Printer: Melbourne.)

Appendix 3

RECORDED NOXIOUS WEEDS OF THE WIMMERA AREA

Common name	Botanical name	Common name	Botanical name
African box-thorn	*Lycium ferocissimum*	Musk weed	*Myagrum perfoliatum*
African love-grass	*Eragrostis curvula*	One-leaf cape tulip	*Homeria breyniana*
Bathurst burr	*Xanthium spinosum*	Onion-weed	*Asphodelus fistulosus*
Blackberry	*Rubus fruticosus* spp. agg.	Paterson's curse	*Echium plantagineum*
Boneseed	*Chrysanthemoides monilifera*	Saffron thistle	*Carthamus lanatus*
Buffalo burr	*Solanum cornutum*	St. Barnaby's thistle	*Centaurea solstitialis*
Caltrop	*Tribulus terrestris*	St. John's wort	*Hypericum perforatum*
Common bindweed	*Convolvulus arvensis*	Sand rocket	*Diplotaxis tenuifolia*
Common prickly-pear	*Opuntia stricta*	Silver-leaf nightshade	*Solanum elaeagnifolium*
Creeping knapweed	*Acroptilon repens*	Slender thistle	*Carduus tenuiflorus*
Fiddle-neck	*Amsinckia* spp.	Skeleton weed	*Chondrilla juncea*
Five-spined saltbush	*Sclerolaena muricata*	Soldier thistle	*Cirsium acarna*
Hedge wattle	*Acacia armata*	Soursob	*Oxalis pes-caprae*
Hemlock	*Conium maculatum*	Spear thistle	*Cirsium vulgare*
Hoary cress	*Cardaria draba*	Spiny burr-grass	*Cenchrus longispinus*
Horehound	*Marrubium vulgare*	Star thistle	*Centaurea calcitrapa*
Khaki weed	*Alternanthera pungens*	Stemless onopordum	*Onopordum acaulon*

Appendix 3 (continued)

Common name	Botanical name	Common name	Botanical name
Sticky ground-cherry	*Physalis viscosa*	Tree-of-heaven	*Ailanthus altissima*
Stinkwort	*Dittrichia graveolens*	Two-leaf cape tulip	*Homeria miniata*
		Variegated thistle	*Silybum marianum*
Sweet briar	*Rosa rubiginosa*	Weld	*Reseda luteola*

Weed status as proclaimed on 15th January, 1974

Appendix 4

AUTHORIZED ANNUAL EXTRACTIONS FROM GROUNDWATER RESOURCES

Parish	No. of bores	Irrigation			Industrial & commercial		Urban		Dairy	Domestic and or stock	Other
		No.	Area (ha)	Annual volume (ML)	No.	Annual volume (ML)	No.	Annual volume (ML)			
Babatchio	1									1	
Balrootan	21	4	51.5	317	1	5	4	1,250 Nhill Water Board (township of Nhill)	1	11	
Bambadin	25	3	178.0	1,068						22	
Bunguluke	2									2	
Charlton East	1									1	
Dahweddarre	1									1	
Ding-a-ding	8									8	
Dinyarrak	7	1	12.0	40.0						6	
Dooen	1									1	
Duchembegarra	4	1	8.0	25.0						3	
Durndal	2									2	
Gerang Gerung	11									11	
Gymbowen (part)	2 (estimate)									2	

Appendix 4 (continued..)

Parish	No. of bores	Irrigation			Industrial & commercial		Urban		Dairy	Domestic and or stock	Other
		No.	Area (ha)	Annual volume (ML)	No.	Annual volume (ML)	No.	Annual volume (ML)			
Jeruk (part)	4 (estimate)									4	
Kaniva	13	1	30.8	142.0			2 Shire of Kaniva (township of Kaniva)	459.0		10	
Katyil	1									1	
Kiata	14	2	10.0	33.0			1 Shire of Dimboola (township of Kiata)	40.0		11	
Koonik Koonik	1									1	
Lawloit	7	2	9.0	55.0						5	
Leeor	16	2	3.0	18.0			1 V/Line (Township of Serviceton)	25.0		13	
Lillimur	11	1	4.0	28.0			1 Shire of Kaniva (Township of Lillimur)	100		9	
Lorquon	15	2	37.3	231.0						13	

Appendix 4 (continued..)

Parish	No. of bores	Irrigation			Industrial & commercial		Urban		Dairy	Domestic and or stock	Other
		No.	Area (ha)	Annual volume (ML)	No.	Annual volume (ML)	No.	Annual volume (ML)			
Mahrong	1									1	
Minimay	12								1	11	
Mirampiram	5						1	7.0 Shire of Kaniva (Township of Miram)		4	
Mortat (part)	3 (estimate)									3	
Murrawong	12	1	10.0	65.0						11	
Narrewillock	1									1	
Neuarpur (part)	10 (estimate)									10	
Nurcoung	6									6	
Peechember	2									2	
Perenna	5									5	
Propodollah	1									1	
Tarranginnie	4	2	8.0	51.0						2	
Teddywaddy	2									2	

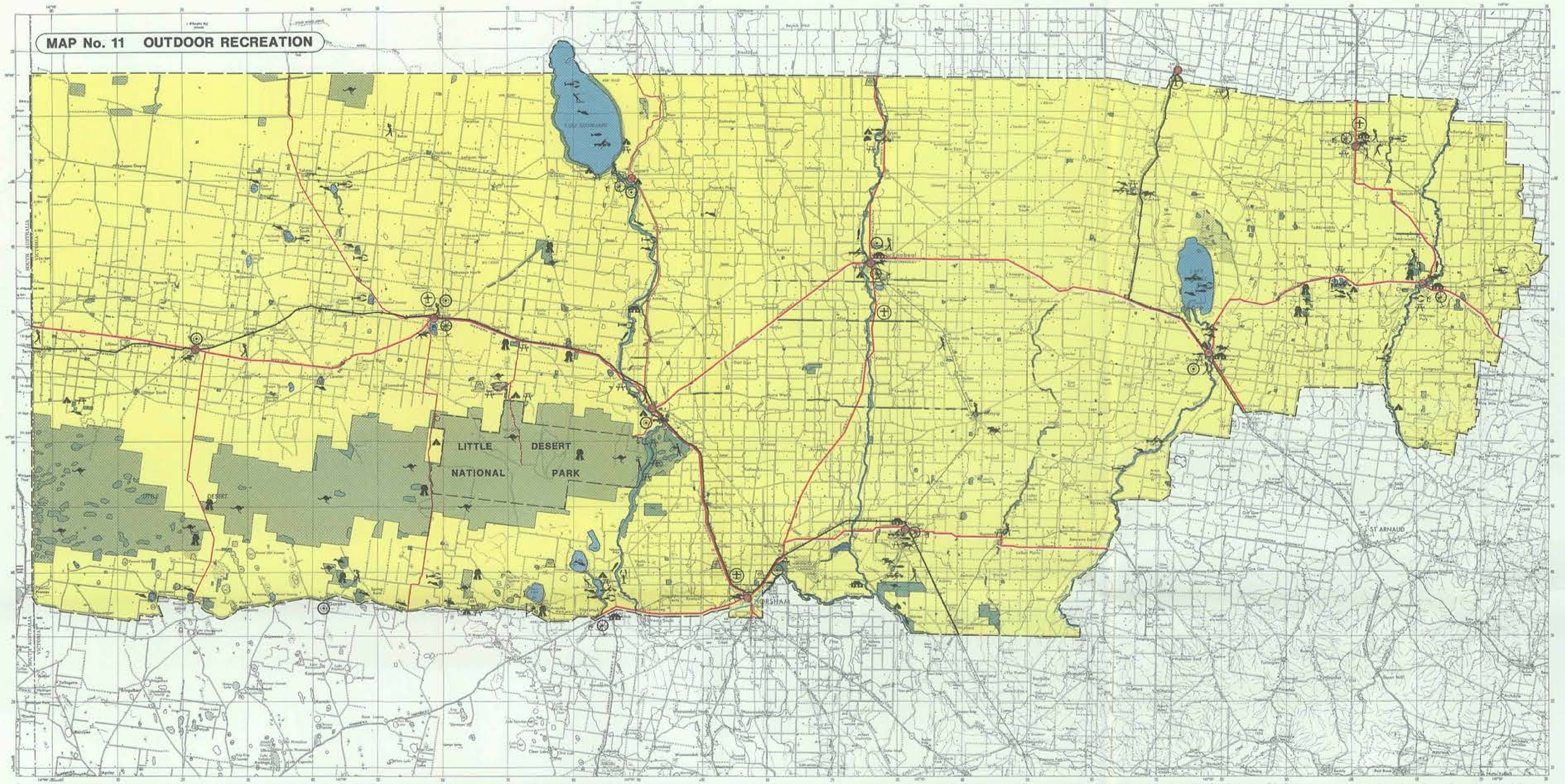
Appendix 4 (continued..)

Parish	No. of bores	Irrigation			Industrial & commercial		Urban		Dairy	Domestic and or stock	Other
		No.	Area (ha)	Annual volume (ML)	No.	Annual volume (ML)	No.	Annual volume (ML)			
Toonambool	1									1	
Tullyvea	1									1	
Wail	1									1	
Wallup	1									1	
Warraquil	7									7	
Watchegatchea	2									2	
Winiam	3	3	44.0	166.0							
Woorak	4									4	
Woraigworm	2	1	6.0	23.0						1	
Yanac-a-yanac	6	1	6.1	60.0					1	4	
Yanipy	4									4	
Yarrangook	1										1 (Road construction Auth.) 5.0
Yarrock	3									3	
Yearinga	7	3	54.5	349.0						4	
Yeungroon	1									1	

Notes: Domestic and stock use is registered, but no volumetric entitlement is granted.
Average domestic and stock use may be of the order of 2.5 ML per bore.

F D Atkinson Government Printer Melbourne


MAP No. 10 LAND ZONES
LAND ZONES
Wimmera Area
1:250 000
0 5 10 20
Kilometres
Land Conservation Council
Victoria
LEGEND
Land Form | Land Zone | Map Symbol
Hills | Hills on granitic rocks | HG
Hills on sedimentary rocks | HS
Alluvial Aprons | Gentle outwash slopes flanking granitic hills | AG
Gentle outwash slopes flanking sedimentary hills | AS
Dunes, Ridges, and Sandplains | East – west dunes and narrow inter-dune plains, sub-parabolic dunes, and ridges trending NNW -- SSE (Big Desert) | DS1
Undulating sandplain with dunes and ridges trending NNW -- SSE (Little Desert) | DS2
Prominent ridges trending NNW -- SSE | DS3
Predominantly Aeolian Plains | Undulating clay plain with ridges trending NNW -- SSE | Pa1
Gently undulating to flat clay plain with occasional dunes trending E -- W and subdued ridges trending NNW -- SSE | Pa2
Undulating plain with E -- W dunes | Pa3
Undulating plain with numerous saline lakes and associated lunettes | Pa4
Alluvial Plains | Almost flat alluvial plain of the Avoca River and adjacent areas | P1
Almost flat alluvial plain of the Wimmera and Richardson Rivers and Yarriambiack Creek | P2
Alluvial Plains with Aeolian Ridges | Alluvial plain with numerous lakes and lunettes, and ridges trending NNW -- SSE | Paa
Lakes and Lunettes | Lakes and lunettes in Lake Buloke area | LL1
Lakes and lunettes in Lake Hindmarsh area | LL2
Public land
Note: Various stream frontages and urban allotments are too small to be shown at this scale
Study area boundary
City, town or borough boundary
MAP No. 10



Grey numbered grid lines are 10,000 metre intervals on the Australian Map Grid, zone 54. Grid values are shown in full only at the south-west corner of the map.

OUTDOOR RECREATION

Wimmera Area

1:500 000

0 10 20 40

Kilometres

Land Conservation Council
Victoria

LEGEND

ENVIRONMENTS
- Woodland
- Scrub
- Agricultural land
- Lakes and swamps (permanent)
- Urban localities

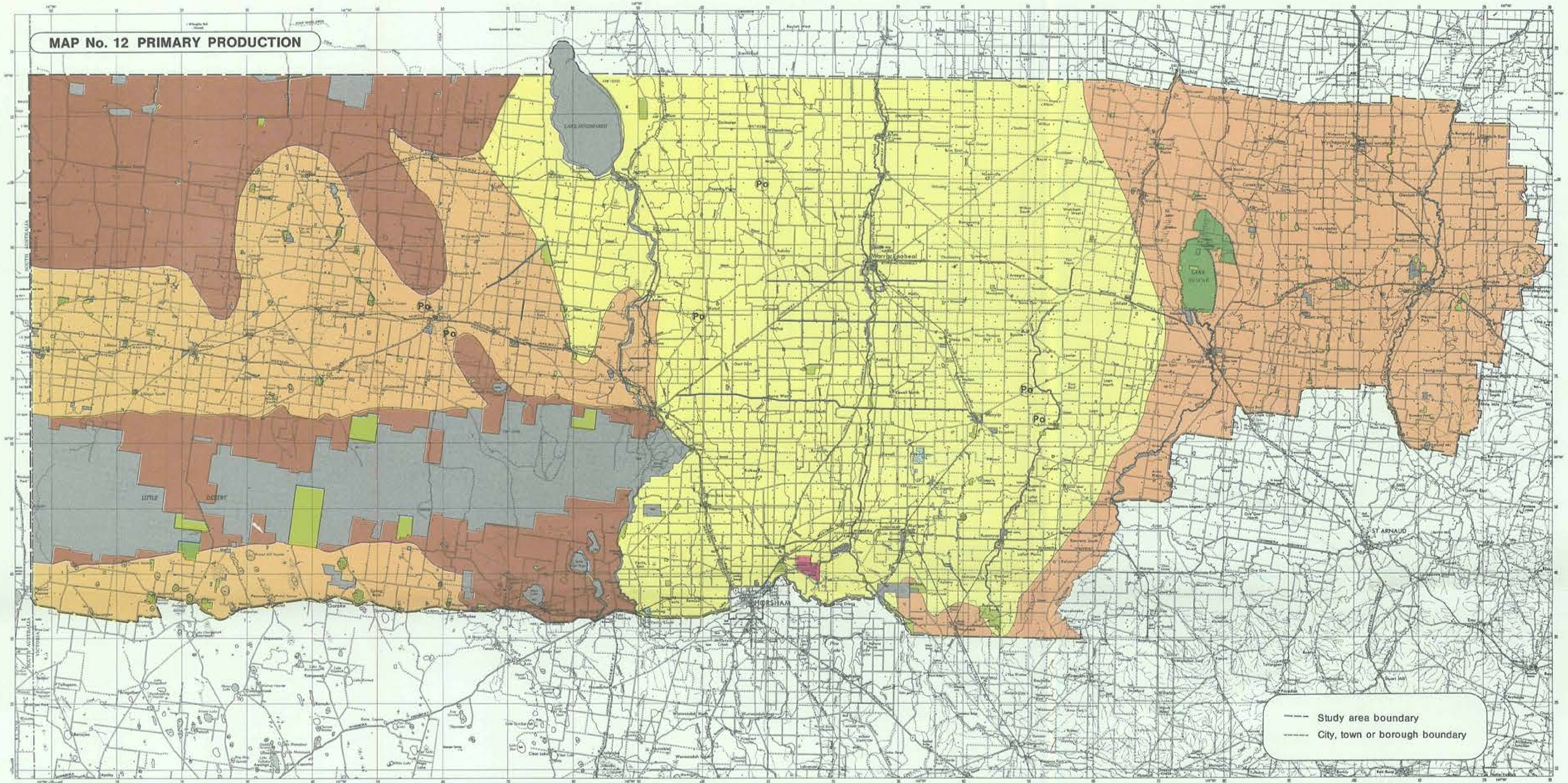
NATURAL FEATURES
- Lookout
- Rock climbing
- Popular wildflower viewing area
- Wildlife
- Fishing stream; lake
- Yabbies
- Waterfowl (hunting)
- Boating (power)
- Boating (non power)

HISTORIC FEATURES
- Early mining locality
- Historic marker
- Museum
- Historic building (classified by the National Trust)

FACILITIES
- Picnic area
- Camping area
- Racecourse
- Golf course
- Rifle range or pistol club
- Orienteering
- Motor cycle and go-kart track
- Aerodrome
- Community parkland

OTHER
- Study area boundary
- City, town or borough boundary
- Public land (NOTE: Many small areas of public land are not shown)

ACCESS
- Major highway
- Railway - passenger service
- Major tourist road
- Popular walking track



Grey numbered grid lines are 10,000 metre intervals on the Australian Map Grid, zone 54. Grid values are shown in full only at the south-west corner of the map.

PRIMARY PRODUCTION

Wimmera Area

1:500 000

0 10 20 40

Kilometres

Land Conservation Council
Victoria

LEGEND

1. Generalized use of agricultural land by main farming enteprises

- Mainly cropping of wheat, barley and oats. Peas, sunflowers, and rape in some areas. Some sheep for fat lambs and wool production
- Mixed cropping and grazing. Cropping involves wheat, barley, oats , and peas. Some areas of lupins on lighter soils. Grazing is mainly sheep for wool, with some beef cattle.
- Mainly sheep for wool. Limited cropping of wheat, oats, barley, and lupins. Some beef cattle in the Telopea Downs area.
- Irrigation mixed farming - sheep, dairy cattle.
- Po Poultry

Note: Pig farming enterprises are scattered throughout the area.

2. Use of public land for primary production

- Public land under lease (Perpetual swamp or Agricultural College) - these areas may be grazed or cropped.
- Public land licensed for grazing. Some of these areas are cropped.
- Public land grazed under agistment.
- Longenong (Victorian College of Agriculture and Horticulture)
- Other public land - used for recreation, nature conservation, timber production, honey production, and mineral and stone extraction.

MAP No. 2 PUBLIC LAND AND DESCRIPTIVE BLOCKS
1. TELOPEA DOWNS
2. WARRACKNABEAL
3. MINIMAY
4. SPINIFEX
5. POMPONDEROO
6. CHARLTON
LAKE HINDMARSH
LAKE BULOKE
LITTLE DESERT
HORSHAM
Warracknabeal
Nhill
Kaniva
Dimboola
Minyip
Murtoa
Donald
Charlton
Birchip
Wycheproof
ST ARNAUD
PUBLIC LAND AND DESCRIPTIVE BLOCKS
Wimmera Area
1:250 000
Land Conservation Council Victoria
LEGEND
Public land
Public land outside study area
Block name and number
3. MINIMAY
Block boundary
Study area boundary
City, town or borough boundary
Note: Various stream frontages and urban allotments are too small to show at this scale.
MAP No. 2
© Crown (State of Victoria) Copyright
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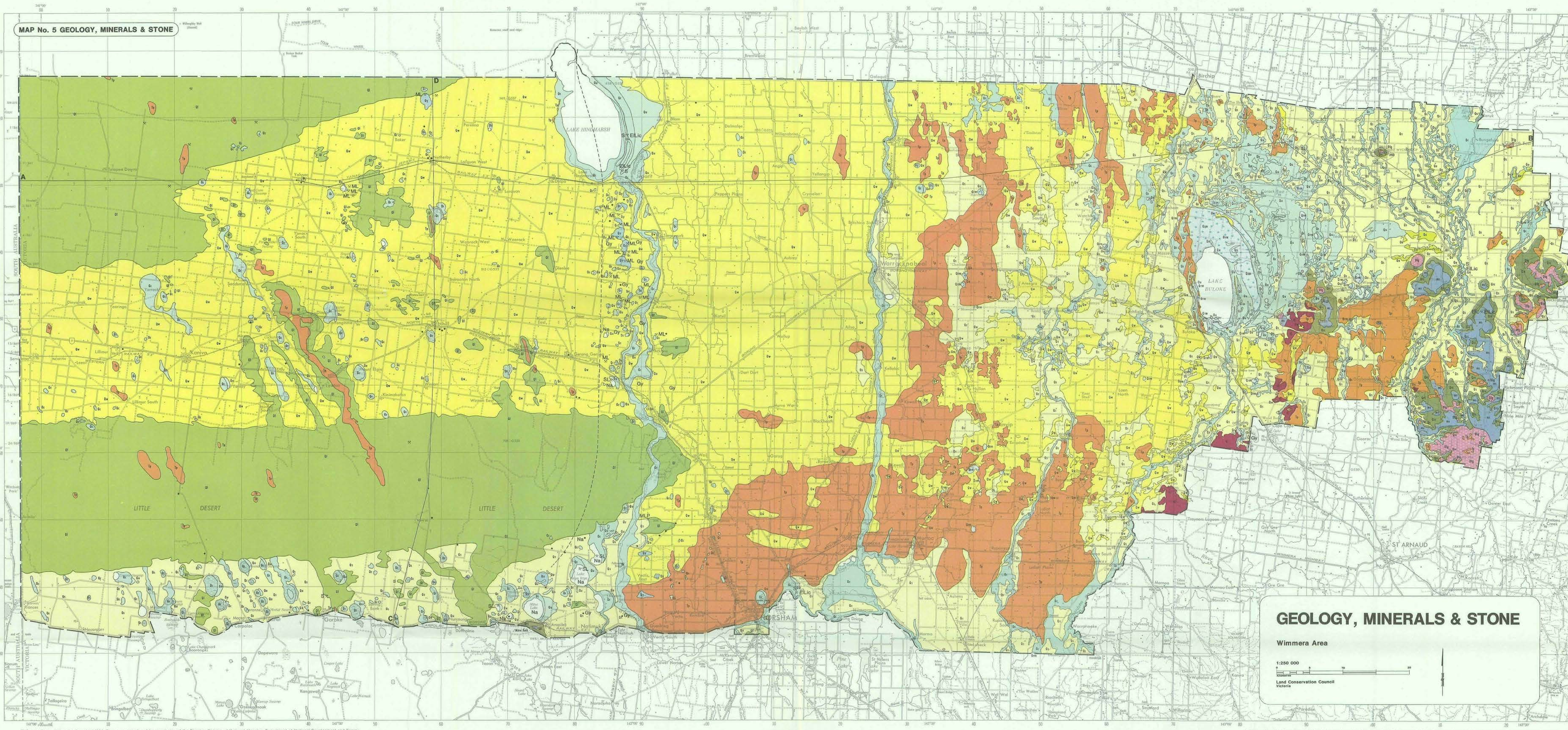
Grey numbered gridlines are 10 000 metre intervals on the Australian Map Grid, zone 54. Grid values are shown in full only at the south-west corner of the map.



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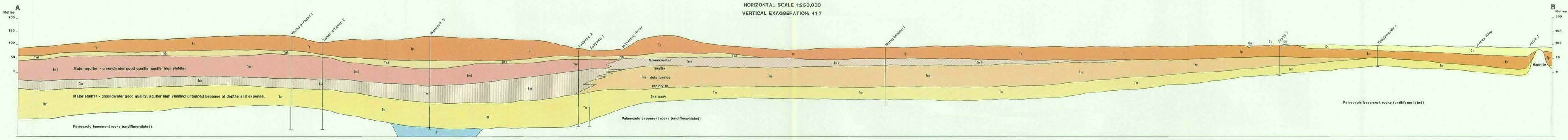
Grey numbered gridlines are 10 000 metre intervals on the Australian Map Grid, zone 54. Grid values are shown in full only at the south - west corner of the map.

SECTION A-B

HORIZONTAL SCALE 1:250,000

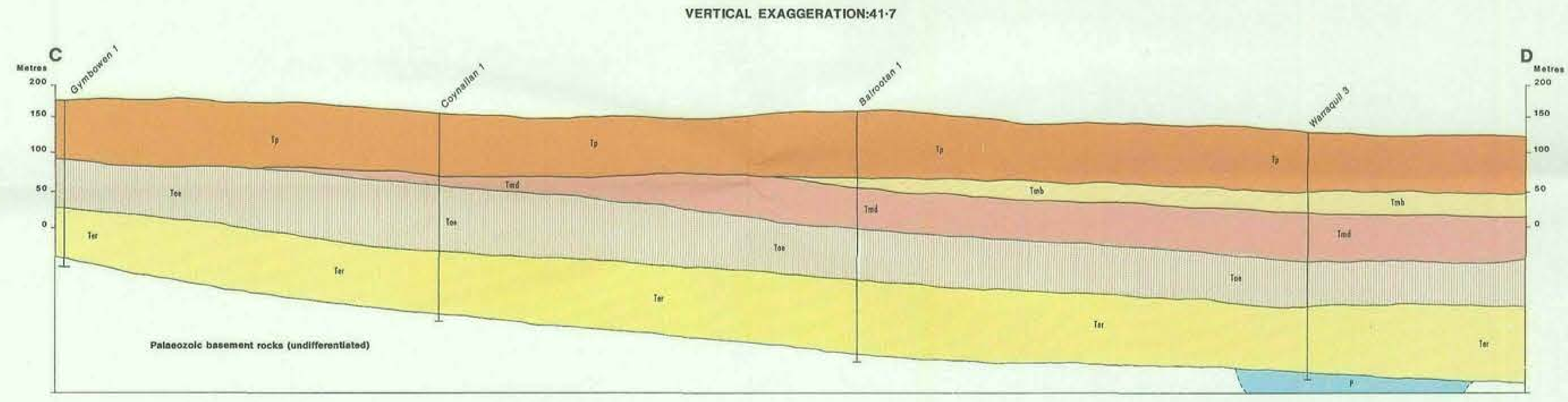
VERTICAL EXAGGERATION: 41·7



SECTION C-D

HORIZONTAL SCALE 1:250,000

VERTICAL EXAGGERATION: 41·7



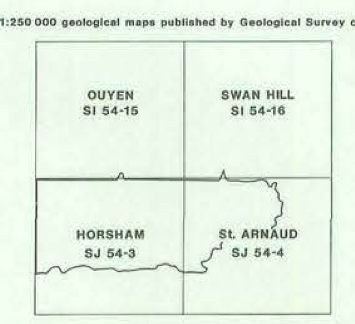
LEGEND

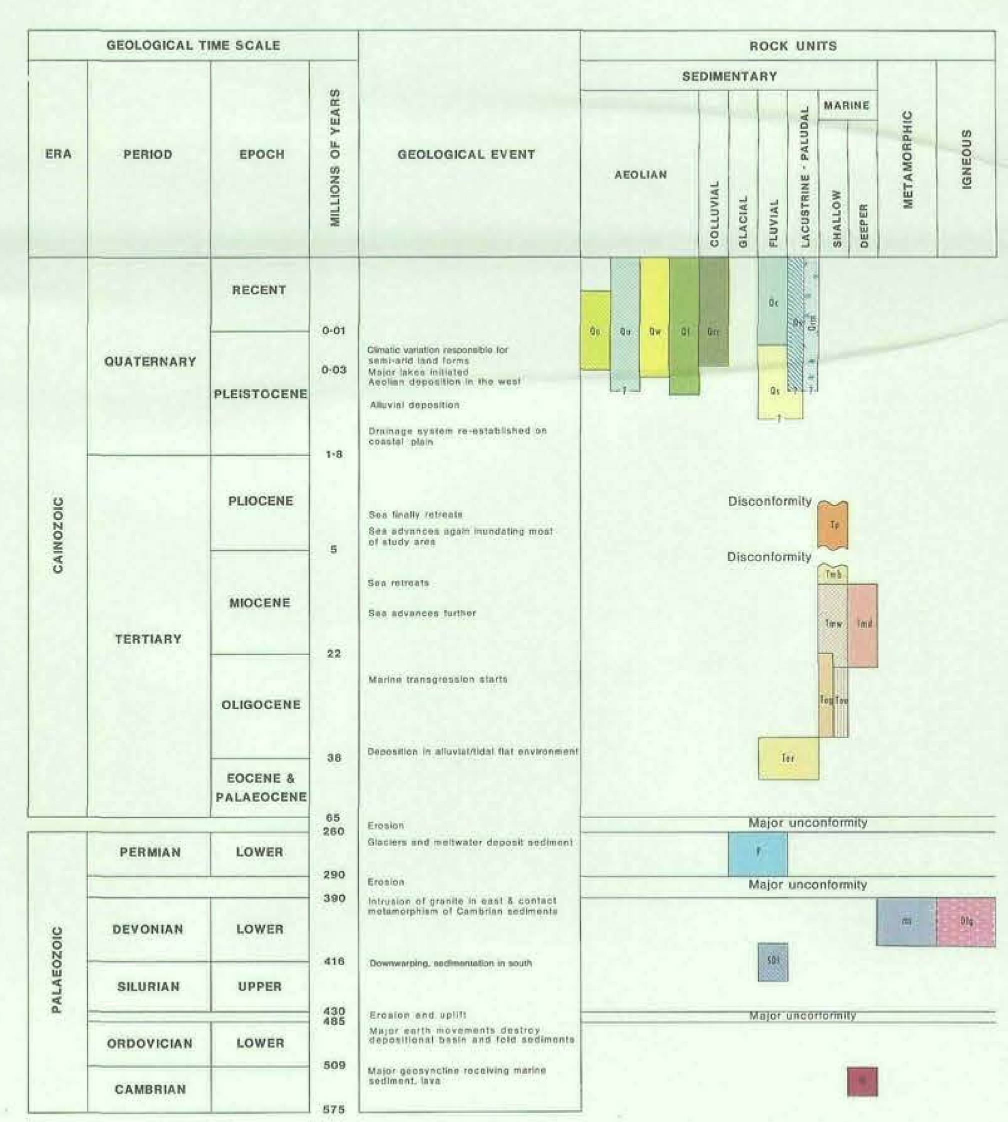
	Geological boundary	MLP	Mining lease on public land
	Fault inferred	ML	Mining lease on private land
Au	Gold	SL	Salt harvesting licence on public land
Gy	Gypsum	EIL	Extractive industries lease on public land
Na	Salt	EILic	Extractive industries licence on private land
•	Water bore	S	Licenced sand operation on public land
349	Radiometric age in million years (K/Ar. method)		Sandstone, gravel on public land

Study area boundary

City, town or borough boundary

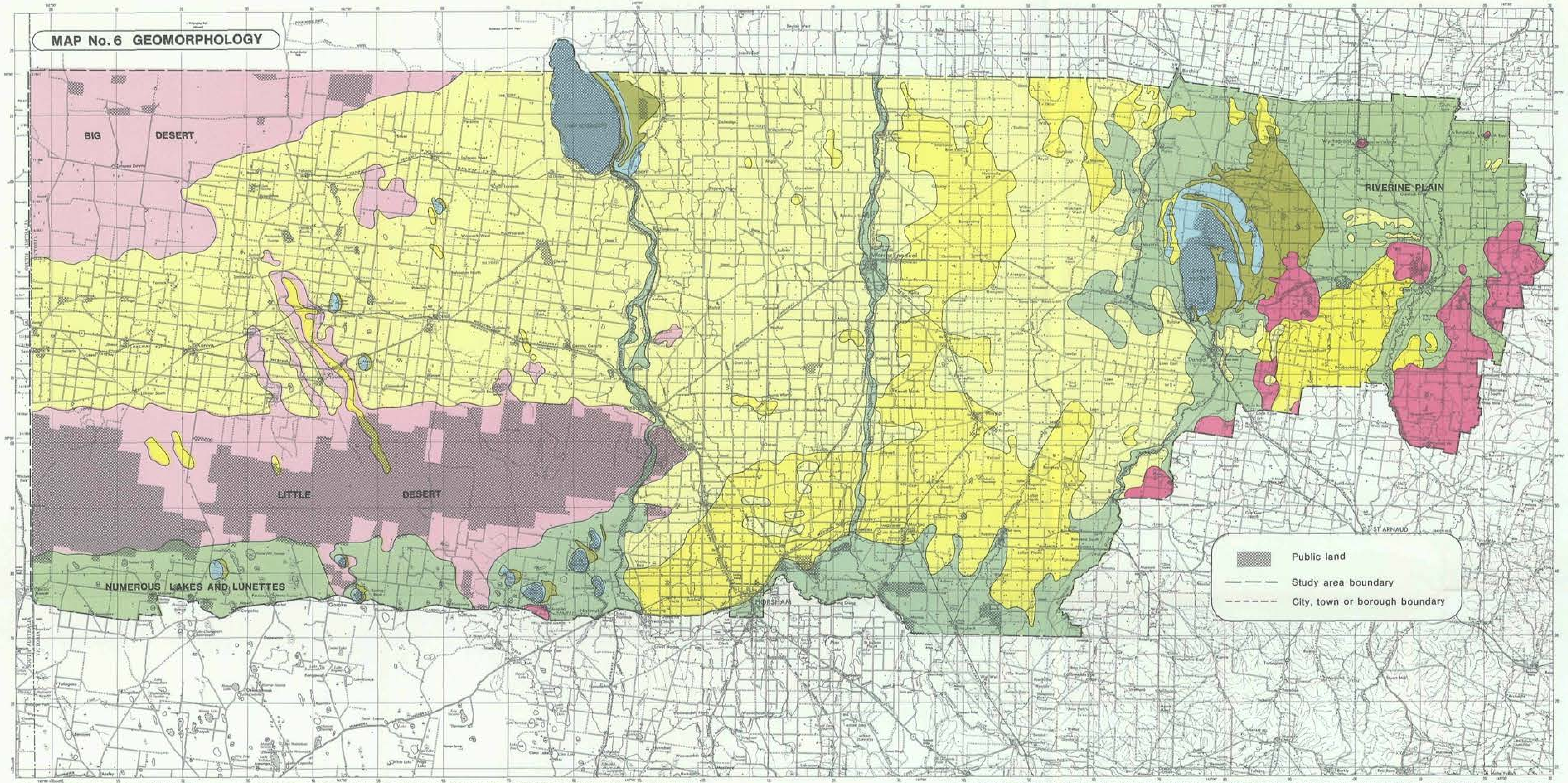
Key to 1:250 000 geological maps published by Geological Survey of Victoria





Coonambidgal Formation	Qc	Clay, sand, and sandy clay with slight soil development, playa deposits, often a grey clay; terraces with scroll pattern or plains with a network of channels
	Qrm	Swamp and lake deposits; clay, silt and mud
	Qrc	Fan deposits, hillwash, scree
Yamba Formation	Qy	Gypsum; evaporite deposits; macrocrystalline
	Qe	Source-bordering dunes; bedded quartzose sand, yellow to red
	Qu	Lunette deposits; clay, silt, sand, gypseous clay and gypsum. Includes several phases of deposition
Lowan Sand	Ql	Sand, white to yellow, fine to medium grained. Sub-parabolic, parallel and irregular dune networks
Woorinen Formation	Qw	Sand, reddish, clayey. Includes paleosol with prominent carbonate horizons. Dunes orientated east-west
Shepparton Formation	Qs	Clay, silt, sand, gravel; soil usually a red-brown earth; extensive plains traversed by leveed stream traces
Parilla Sand	Tp	Sand, sandstone and silt, white to yellow cross bedding, lateric weathering; in ridges aligned NNW-SSE, often with thin covering of dark grey clay in eastern part of study area and thin sandy dune in west.
Bookpurnong Beds	Tmb*	Calcareous clay, marl and silt
Duddo Limestone	Tmd*	Limestone
Winnambool Formation	Tmw*	Marly limestone; glauconitic silt and marl
Ettrick Marl	Toe*	Marl
Geera Clay	Tog*	Clay, rare silt, sometimes glauconitic
Renmark Group	Ter*	Siltstone, carbonaceous and dolomitic, lignite; sand, pyritic and carbonaceous
	P*	Tillite, fluvioglacial sand, silt, varved clay
	Dlg	Granite, granodiorite
	m	Schist, schistose hornfels, knotted schist, quartzite, phyllite, associated with granite intrusions as metamorphic aureoles
Grampians Group	SDl	Quartzose sandstone, siltstone, minor mudstone
	Є	Shale, siltstone and sandstone, tightly folded, thinly bedded, often showing slight metamorphism, slate

* Shown only subsurface in cross-sections



GEOMORPHOLOGY

Wimmera Area

1:500 000

0 10 20 40

Kilometres

Land Conservation Council
Victoria

LEGEND

WESTERN HIGHLANDS

MURRAY BASIN PLAINS

- †Ridged Marine Plain
- Aeolian Terrain
  - Irregular sub-parabolic dunes
  - †Linear dunes
  - *Lunettes
- Alluvial Plains (Includes riverine plain east of Lake Buloke)
- *Lake Floors

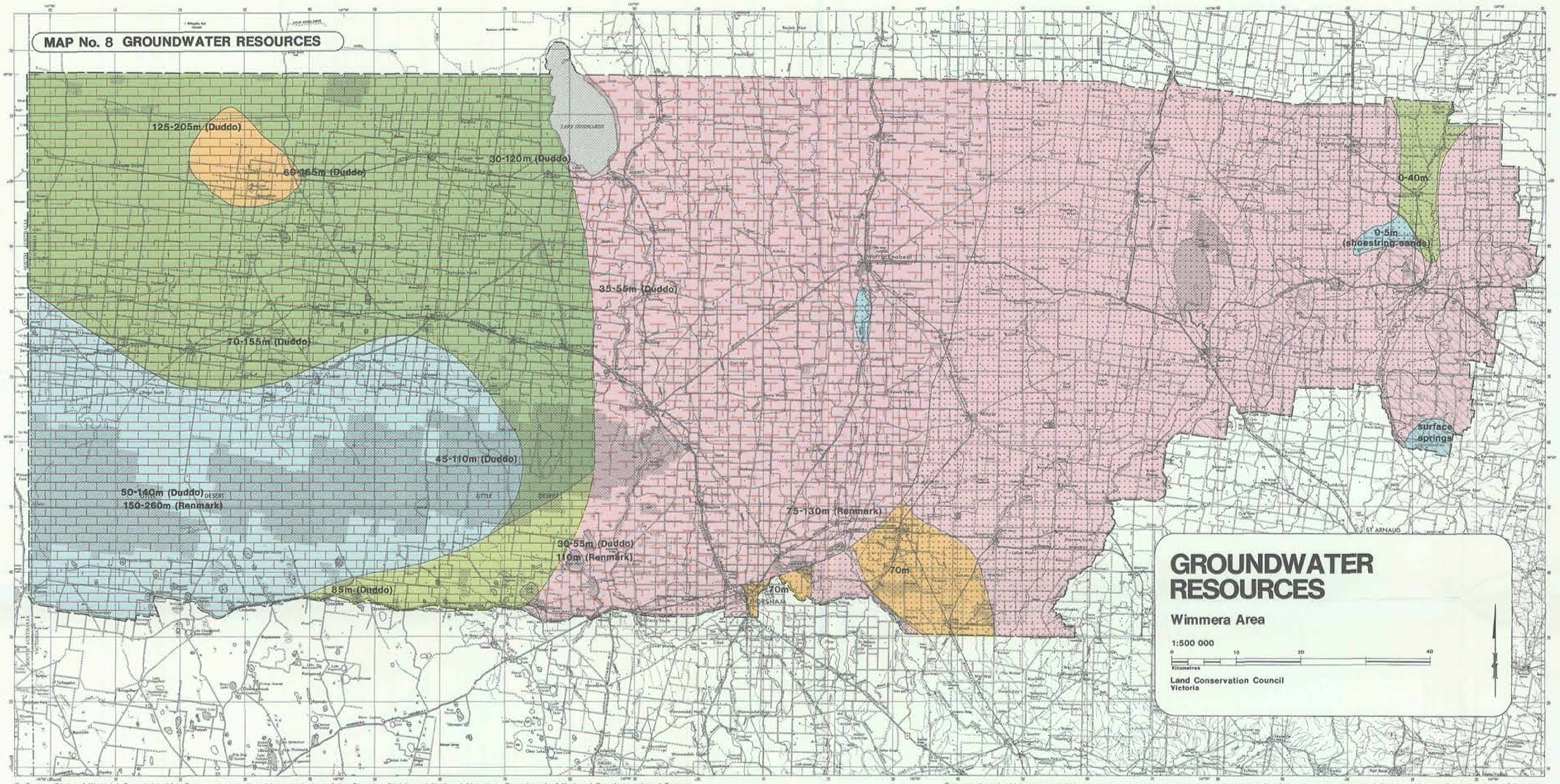
Note: This map is simplified. More detail is shown on the geology map.

†East of Yarriambiack Creek boundaries are generalized due to the patchy nature of linear dune and alluvium over the ridged marine plain.

*Only major lakes and lunettes are indicated.

Grey numbered grid lines are 10,000 metre intervals on the Australian Map Grid, zone 54. Grid values are shown in full only at the south-west corner of the map.

Grey numbered gridlines are 10 000 metre intervals on the Australian Map Grid, zone 54. Grid values are shown in full only at the south - west corner of the map.



Grey numbered grid lines are 10,000 metre intervals on the Australian Map Grid, zone 54. Grid values are shown in full only at the south-west corner of the map.

LEGEND

GROUNDWATER RESOURCES

	BORE YIELD* (litres/sec)	GROUNDWATER SALINITY* (milligrams/litre Total Dissolved Solids)	GROUNDWATER USE
SHALLOW AQUIFERS (blue)	>10 in west <10 in east	< 1000	Suitable for all stock, domestic, garden, and industrial uses. High yields (>10 l/s) are suitable for irrigation and town supplies.
(dark green)	>10	1000-3 000	Suitable for all stock, and for salt-tolerant plant species. High yields (>10 l/s) are suitable for irrigation.
(light green)	<10		
(orange)	>10	3 000-7 000	Suitable for most stock. Not suitable for poultry. Generally unsuitable for irrigation.
(pink)	Generally <10	7 000-30 000	Suitable for beef cattle up to 11 000 mg/l TDS, and for dry sheep up to 14 000 mg/l TDS. Higher salinities are unusable. Unsuitable for irrigation.

Note: The groundwater resource in the deep sand aquifers of the Renmark Group is not indicated.

* Figures are generalised, see text for details.

PRINCIPAL AQUIFER LITHOLOGY

(dotted)	Sandstone, sand, gravel, clay.
(brick pattern)	Limestone (Duddo).
(T pattern)	Marly limestone, silty marl.
(hatched)	Fractured and weathered sedimentary, metamorphic, and igneous rocks of Palaeozoic age.
50-140m (Duddo)	Depth range in which aquifer is located, with name of aquifer in brackets. Note: Single figures denote depth to top of aquifer.

— — —	Insufficient data to determine exact aquifer boundaries	— — —	Study area boundary
(shaded)	Public land	-------	City, town or borough boundary

Data compiled by Geological Survey of Victoria.

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Grey numbered gridlines are 10 000 metre intervals on the Australian Map Grid, zone 54. Grid values are shown in full only at the south-west corner of the map.

Alliance	Map symbol	Typical structural form at maturity	Major species of tallest stratum	Associated tree or shrub species	Common understorey species	Typical occurrence
RIVER RED GUM	1a	OPEN FOREST II/ WOODLAND II (15--28 m height)	River red gum	Generally as pure stands, occasionally with black box, yellow gum	Wattles, pale-fruit ballart, slender cypress pine, scarlet bottlebrush, prickly tea-tree, totem-poles, salt paper-bark, grasses and sedges	Wimmera River, Avoca River, swamps of Wimmera plains
	1b	WOODLAND II (15--28 m height)	River red gum	Generally as pure stands, occasionally with black box, yellow gum	Prickly tea-tree, silver banksia, creeping myoporum, pale-fruit ballart, grasses, knobby club-rush, blue rod, pale rush, spiny flat-sedge	Lake Hindmarsh, Red Gum Swamp (Little Desert)
	1c	WOODLAND I (5--15 m height)	River red gum	Black box	Swamp wallaby-grass, blown grass, Australian sweet-grass, water-milfoil, floating pondweed, common spike-rush, Pacific azolla, grass cushion. Less moist parts carry exotic grasses	Swamps of south-western Wimmera plains
GUM--BOX--BULL-OAK	2a	WOODLAND II (15--28 m height)	Yellow gum	Grey box, yellow box, bull-oak, black box, river red gum	Golden wattle, gold-dust wattle, ruby saltbush, common wallaby-grass, spear-grasses, exotic grasses	Marma, Barrabool, and Brynterion forests
	2b	WOODLAND II (15--28 m height)	Yellow gum	Black box, river red gum	Melaleucas, hakeas, eutaxia, fringe-myrtle, scarlet bottlebrush, muntries, holly grevillea, wattles, bush-pea, erect guinea-flower, daphne heath, sedges (esp. black bristle-rush), bristly wallaby-grass, grey germander, prickfoot, raspwort	Western and central blocks of Little Desert
	2c	WOODLAND II/ WOODLAND I (5--28 m height)	Yellow gum Slender cypress pine	Bull-oak, belah	Sweet bursaria, wattles, small hop-bush, akeake, ruby saltbush, eutaxia, burrobunga, hooked needlewood, desert cassia, leafless currant-bush, variable sida, turkey-bush, grasses, sedges	Glenlee and West Wail Timber Reserves
	2d	WOODLAND I (5--15 m height)	Yellow gum	Grey box, bull-oak, black box	Golden wattle, gold-dust wattle, ruby saltbush, bluebushes, common wallaby-grass, spear-grasses, exotic grasses	Mount Jeffcott, public land west of Charlton
	2e	WOODLAND II (15--28 m height)	Grey box	Yellow gum, yellow box, bull-oak, black box	Common wallaby-grass, variable spear-grass, exotic grasses	Marma, Barrabool and Brynterion forests
	2f	WOODLAND I (5--15 m height)	Grey box	Yellow gum, bull-oak	Gold-dust wattle, hedge wattle, sweet bursaria, ruby saltbush, common wallaby-grass, variable spear-grass, exotic grasses	Small areas of public land around Charlton and Jeffcott
	2g	WOODLAND I (5--15 m height)	Black box	Bull-oak; river red gum, yellow gum, grey box	Tangled lignum, saltbushes, blue-bushes, quena, sweet bursaria, umbrella wattle, common spike-rush wallaby-grasses, windmill grass, spear-grasses, rigid panic, Australian salt grass, couch, common nardoo, exotic grasses	Marma forest, Glenlee Timber Reserve, swamps, creek frontages
	2h	WOODLAND I (5--15 m height)	Bull-oak	Black box, yellow gum, belah	Gold-dust wattle, sweet bursaria, berrigan, bluebushes, hedge saltbush, harlequin mistletoe, common wallaby-grass, variable spear-grass, composites, common spike-rush, exotic grasses	Glenlee Timber Reserve, roadsides and small areas of public land throughout the Wimmera plains

Alliance	Map symbol	Typical structural form at maturity	Major species of tallest stratum	Associated tree or shrub species	Common understorey species	Typical occurrence
BROWN STRINGYBARK	3	WOODLAND I/ OPEN SCRUB (2--15 m height)	Brown stringybark	Oyster Bay pine, heath tea-tree	Desert banksia, silver banksia, she-oaks, guinea-flowers, bitter-peas, fringe-myrtle, hakeas, Austral grass-tree, parrot-peas, horny cone-bush, baeckeas, wattles, beard-heaths, sedges	Little Desert, Wail forest, Big Desert
MALLEE--BROOMBUSH	4	SHRUBBY OPEN SCRUB (2--8 m height)	Yellow mallee (occasionally other mallee species or mallees absent)	Broom honey-myrtle, broom baeckea, slender-leaf mallee, green mallee, dumosa mallee	Oyster Bay pine, melaleucas, hakeas, slaty she-oak, eutaxia, bush-peas, matted bog-rush, sword-sedges, orchids, lilies, sundews, ephemeral annuals	Little Desert, Big Desert
MALLEE	5a	OPEN SCRUB (2--8 m height)	Yellow mallee	Slender cypress pine, scrub cypress pine	Small-leaved clematis, large-leaf ray-flower, golden wattle, guinea-flower, velvet tobacco, sticky longheads, satin everlasting	Area of public land west of Ellam
	5b	OPEN SCRUB (2--8 m height)	Bull mallee	Bull-oak, grey box, yellow gum, other mallee species	Wattles, pink velvet-bush, sugarwood, ruby saltbush, common wallaby-grass, spear-grasses, windmill grass, black-anther flax-lily, New Holland daisies, pointed twin-leaf, exotic grasses	Roadsides and small areas of public land on the northen Wimmera plains
	5c	OPEN SCRUB (2--8 m height)	Dumosa mallee	Green mallee, yellow mallee, other mallee species	Melaleucas, broom baeckea, eutaxia, wattles, bush-peas, woolly daisy-bush, holly grevillea, scarlet mint-bush, coccid emu-bush, goodenias, rough halgania	Dimboola Flora and Fauna Reserve, small areas of public land on the northern Wimmera plains
SALT PAPER-BARK	6	LOW CLOSED FOREST -- TALL OPEN SHRUBLAND (2--8 m height)	Salt paper-bark		Beaded glasswort, grey glassworts, brown-head glasswort, coast sand-spurrey, Australian salt grass, karkalla, rounded noon-flower, glaucous goosefoot, exotic grasses (where conditions less saline)	Lake Wyn Wyn, mouth of Wimmera River at Lake Hindmarsh
ROCK OUTCROP COMMUNITIES	7	TALL OPEN SHRUBLAND (2--8 m height)	Lightwood	Wallowa	Rock correa, slender rice-flower, wedge-leaf hop-bush, raspwort, rock fern, wallaby-grasses, spear-grasses, exotic grasses	Yowang Hill, Mt, Gowar
HEATH	8	OPEN HEATH (<2 m height)	Heath tea-tree Desert banksia She-oaks	Mallee honey-myrtle, baeckeas, beard-heaths, heaths, grass-trees, guinea-flowers	Tassel rope-rush, sword-sedges, coarse twine-rush, scale-shedder, spear-grass, bristly wallaby-grass, sticky longheads, annual bluebell	Little Desert (central and eastern blocks)

Alliance	Map symbol	Typical structural form at maturity	Major species of tallest stratum	Common associated species	Typical occurrence
HALOPHYTES	9	LOW OPEN SHRUBLAND (<2 m height)	Beaded glasswort Grey glassworts Brown-head glasswort Other glassworts	Creeping brookweed, wilsonias, Australian salt grass, prickly arrowgrass, pennywort, composites, Australian saltmarsh grass, toad rush, glaucous goosefoot, sea-heath, lawrencias, exotic grasses (where conditions less saline)	Lake Wyn Wyn and other salt lakes of the south-western Wimmera plains
WETLAND COMMUNITIES	10a	LOW OPEN SHRUBLAND (<3 m height)	Tangled lignum	Common spike-rush, cane grass, blown grass, common nardoo, narrow-leaf nardoo, poison pratia, goodenia, swamp wallaby-grass	Darlot Swamp, Wimmera River downstream of Jeparit
	10b	GRASSLAND	Cane grass, swamp wallaby-grass, blown grass, Australian sweet-grass, common spike-rush	Water-milfoil, floating pondweed, Pacific azolla, grass cushion, common billy-buttons	Swamps on the Wimmera plains
EUCALYPT PLANTATION	11	OPEN FOREST III/ OPEN FOREST II (15--35 m height)	Sugar gum is main species planted	Brown mallet, swamp yate, swamp mallet, yellow gum and black box have also been planted	Wail forest, Barrett and Glenlee Timber Reserves
CLEARED LAND/ GRASSLAND	12	GRASSLAND	Includes public land used for agriculture, gravel extraction, and water supply. Vegetation includes native grasses and remnants of former woodlands, but mostly comprises pasture species and exotic weeds, especially annual grasses		Small areas of public land throughout the Wimmera plains

Note: This map does not show the vegetation of all the small blocks of public land

Permanent or seasonal water

Study area boundary

City, town or borough boundary