Land Conservation Council Victoria

South-Western Area, District 2

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GOVERNMENT OF VICTORIA

LAND CONSERVATION COUNCIL

464 ST. KILDA ROAD, MELBOURNE, VICTORIA, 3004

REPORT

SOUTH-WESTERN AREA, DISTRICT 2

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

All such submissions must reach the Secretary no later than Friday, 13 July 1979.

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

f. I. KUNARATNAM
Secretary
Land Conservation Council

SOUTH-WESTERN AREA, DISTRICT 2

ERRATA

Page 55, column 2, paragraph 2

Read ". . . height of 1,067 m on the Major Mitchell Plateau; this and Mount William (1,167 m) . . ."

for heights of "1,173 m" and "1,168 m" respectively.

Page 358, wetland No. N30

Area should read: 100(95).

LAND CONSERVATION COUNCIL, VICTORIA

Melbourne May 1979

14973/79

REPORT

on the

SOUTH-WESTERN AREA, DISTRICT 2

Land Conservation Council, Victoria

14973/78—PL

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FOREWORD

The *Land Conservation Act* 1970, established the Land Conservation Council, whose function is to "carry out investigations and make recommendations to the Minister with respect to the use of public land in order to provide for the balanced use of land in Victoria".

This report sets out to describe and assess the natural resources of the public land in the South-western study area, District 2 and provides a factual basis on which members of the community may base their submissions to the Council. It ensures that all those persons and bodies who have an interest in the future use of public land in this area can obtain and study the basic information, which the Council itself will study, and so make informed and constructive suggestions to the Council for its consideration.

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

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

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

S.G.McL. DIMMICK
Chairman

Land Conservation Council
464 St. Kilda Road
MELBOURNE 3004

LAND CONSERVATION ACT 1970

EXTRACT

Public land

Section 2.

(1) "Public land" means -

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

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

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

(iii) vested in the Melbourne and Metropolitan Board of Works; and

(b) any other land which the Governor in Council declares under sub-section (2) to be public land for the purposes of this Act

"Reserved forest" and "State forest" have the same meanings as in section 3 of the *Forests Act* 1958.

(2) The Governor in Council may on the recommendation of the Minister made after consultation with -

(a) any Minister of the Crown in whom any land is vested; or

(b) the Minister responsible for a public authority in which any land is vested -

by proclamation published in the *Government Gazette* declare any such land to be public land for the purposes of this Act.

Functions of the Council

Section 5.

(1) the Council shall -

(a) carry out investigations and make recommendations to the Minister with respect to the use of public land in order to provide for the balanced use of land in Victoria;

(b) make recommendations to the Governor in Council as to the constitution and definition of water supply catchment areas under the *Soil Conservation and Land Utilization Act* 1958; and

(c) advise the Soil Conservation Authority concerning policy on the use of land (whether public land or any other land however vested) in any water supply catchment area.

(2) In making any recommendation the Council shall have regard to the present and future needs of the people of Victoria in relation to -

(a) the preservation of areas which are ecologically significant;

(b) the conservation of areas of natural interest beauty or of historical interest;

(c) the creation and preservation of areas of reserved forest;

(d) the creation and preservation of areas 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 any investigation under paragraph (a) of sub-section (1) of section 5 the Council shall publish a notice in the *Government Gazette*, in a newspaper circulating throughout the State and in a newspaper circulating particularly in or in the vicinity of the area or district to be investigated stating that an investigation of the district or area described in the notice is to be carried out for the purposes of this Act.

(3) On completing an investigation of a district or area under paragraph (a) of sub-section (1) of section 5 the Council shall -

(a) publish a report of the investigation;

(b) give notice in the *Government Gazette* of the publication of the report, the address where copies of the report may be obtained or inspected and stating that any submissions to the Council in relation to such report will be considered by the Council if they are made within 60 days of such notice; and

(c) publish notice in a newspaper circulating throughout the State and in a newspaper circulating particularly in or in the vicinity of the area or district investigated of the publication of the report, the address where copies of the report may be obtained or inspected and stating that submissions may be made to the Council and the date before which they should be made.

(4) The Council shall consider any submissions in relation to such report made by any person or body within 60 days of notice being given under paragraph (b) of sub-section (3).

Notice to be given to public departments and authorities in certain cases.

Section 10.

(1) Not earlier than 60 days after notice being given under paragraph (b) of sub-section (3) of section 9, the Council shall send a copy of its proposed recommendations to -

(a) the Council of any municipality in the municipal district of which any part of the area or district to which the recommendation relates is situated;

(b) any other public authority or government department that in the opinion of the Council has an interest in the area of the proposed recommendation; and

(c) any person or body who made a

submission under section 9 -

and shall consider any submissions received within 60 days of the sending of such copy to the council, authority, department, person or body or in the case of a public authority or government department within such longer period as may be agreed upon between the Minister and the Minister administering that department or responsible for that authority.

(2) Where any recommendation is made to the Minister under this Act it shall be accompanied by a copy of any submissions received from any person body department authority or council pursuant to the provisions of sub-section (4) of section 9 or sub-section (1) of this section.

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

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

Section 11.

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

A copy of the *Land Conservation Act* 1970 can be obtained from the Government Printing Office, 7a Parliament Place, Melbourne, 3002.

ACKNOWLEDGEMENTS

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

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

The following officers of those departments were closely involved in preparing chapters for the report: Miss J. Dixon and Messrs. G. Ebbs, W. Emison, C. Evans, J. Heath, L. Kellond, R. King, P. Langley, A. Pitt, G. Presland, I. Weir, and A. Windust.

Many other people and organizations supplied information or photographs, helped by checking drafts, or contributed discussion or advice. They include Arapiles Conservation Committee; Central Victorian Apiarists Association; Federation of Victorian Walking Clubs; Melbourne University Mountaineering Club; Messrs. C. Austin, R. Bird, L. Elmore, G. Fulton, J. Gillespie, I. McCann, J. McQueen, W. Middleton, E. Neil, K. O'Kane, R. Parsons, and D. Turner, Mrs. H. Turner, and Mr. A. Willett.

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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, its history and prehistory.

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

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

Part IV provides more detailed information and, for convenience, the study area has been divided into five blocks. The information 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. THE STUDY AREA

The study area lies on the South Australian border adjoining the coast, between 36°40' and 38°29' S and 141° and 143° E (see locality plan facing this page). The South-western District 1 study area was investigated in 1971--72, and Final Recommendations on the use of public land there were published in May 1973. Most of these recommendations have now been implemented.

Most of the public land in District 2 is in the Grampians ranges, and on the plains of the south-western Wimmera. The public land occupies 337,000 ha, which is 22% of the total study area (1,533,000 ha). The counties (or parts thereof) of Lowan, Borung, Dundas, Ripon, Villiers, and Normanby fall within the study area.

This part of western Victoria consists mainly of undulating plains. Elevations vary from sea level to 240 m on the Dundas Tablelands and 160 m on the south-western Wimmera plains. The rugged Grampians ranges rise steeply from the plains to a maximum elevation of 1,167 m at Mount William.

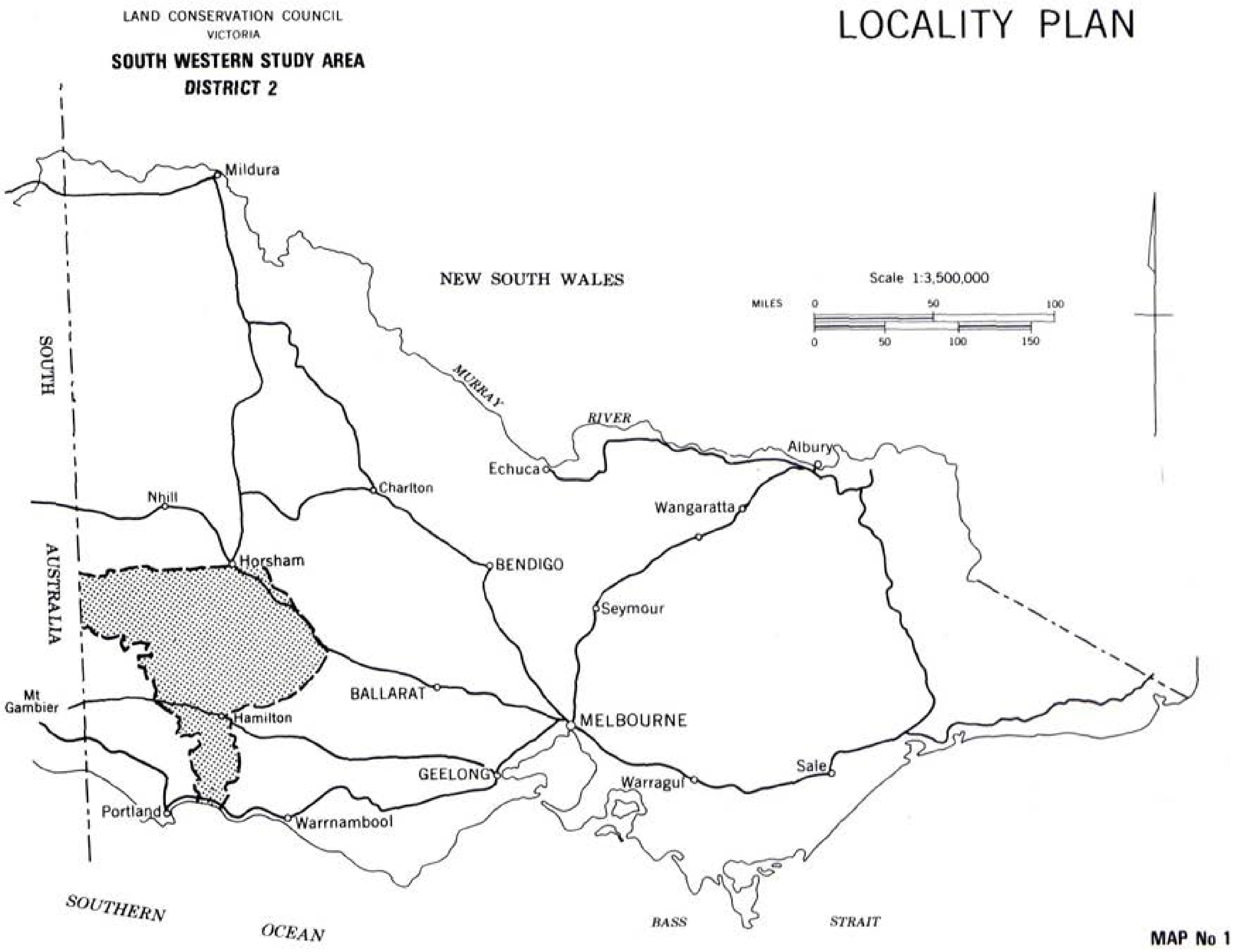
Average annual rainfall varies from 425 mm on the northern plains to 800 mm on the coast and 950 mm on the higher parts of the Grampians. Most rain falls during winter and spring. The Grampians are important catchments for storages supplying water to large areas of farmland in the dry country to the north.

The native vegetation has generally been cleared from private land, although many large red gums remain in the farmlands of the Dundas Tablelands and south-western Wimmera plains. Native vegetation covers almost all the public land and includes forests, woodlands, scrubs, and heaths. The Grampians are noted for their diverse native vegetation, and the rocky hills attract many tourists.

The public lands are used for recreation and conservation, and produce logs, water, gravel, forage, and honey. The farmlands of the area produce wool, beef, fat lambs, and, in the north, wheat and oats.

Population

The study area includes the Shires of Wannon and Dundas, and parts of Kowree, Arapiles, Wimmera, Stawell, Ararat, Mount Rouse, Minhamite, and Belfast. The cities of Horsham, Ararat, and Ham-



MAP No 1

14973/78—2

Table 1

POPULATION STATISTICS

Local government areas	Population (% change) 1961	1966	1971	1976
Shires				
Wannon	4,154	4,059	3,646	3,460
Dundas (part)	4,072	3,923	3,667	3,520
Kowree (part)	4,790	4,735	4,234	3,900
Arapiles (part)	1,583	1,589	1,429	1,394
Wimmera (part)	1,668	1,645	1,438	1,414
Stawell (part)	858	915	794	929
Ararat (part)	1,840	1,858	1,671	1,780
Mount Rouse (part)	697	693	614	597
Minhamite (part)	1,860	1,807	1,602	1,473
Belfast (part)	246	239	211	216
Total	21,768	21,463 (-1.4)	19,306 (-10)	18,683 (-3.2)
Hamilton (City)*	9,495	10,062	9,673	9,790
Horsham (City)	9,240	10,562	11,045	11,990
Ararat (City)	7,934	8,246	8,312	8,540
Stawell (Town)	5,506	5,909	5,800	6,330
Total	32,175	34,779 (8)	34,830 (0.1)	36,650 (5.2)
Grand total	53,943	56,242 (4.2)	54,136 (-3.7)	55,333 (2.2)

(Source: Australian Bureau of Statistics)
* Note that the cities and the town are not technically in the study area.

Left: Tall forest around a picnic ground in the Grampians ilton, the Town of Stawell, are the main urban centres.

The 1976 census put the population of the study area at 55,333. As Table 1 shows, most of these people (36,650) live in the urban areas, and 18,683 live in the rural shires. The rural population has been declining since the late 1950s. Over the period 1971--76 it fell by 623, compared with an increase of 1,197 in the urban areas.

3. PREHISTORY

At present the prehistory of Victoria is not sufficiently well known to permit a detailed sequence for any specific part of the State. In the study area it is simplest to divide the prehistoric past into an early period - more than 10,000 years ago - and a late one - from 10,000 years ago to 1834. The Hentys settled at Portland in 1834, which is taken as the beginning of the historic past in south-western Victoria.

The study area contains no direct evidence of Aboriginal occupation during the early prehistoric period, although sites dating from this time have been found in the Mallee to the north and at Lake Colongulac to the south-east. Sites in the vicinity of Discovery Bay may also be early prehistoric.

A number of sites within the study area have been dated to the late prehistoric. These include a rock art site in the western Black Range dating from 3,300 years ago and a small mound near Toolondo, which was in use around 850 years ago. Other mounds situated near the Hopkins River, comparable to those in the study area, are from 600 to 2,000 years old. Similar dates could be expected from mounds within the study area.

There is strong evidence, therefore, both direct and indirect, of Aboriginal occupation of the study area for at least 3,000 years.

It is difficult to assess the effect the Aborigines had upon their environment. Most of the landscape has changed since European settlement and a great deal of evidence of Aboriginal activity destroyed. From studies done in other parts of Australia we know that Aboriginal groups often used fire to promote fresh growth of grass and to drive game. This probably took place in the study area during prehistoric times, and had an influence on the nature and distribution of the plant and animal communities.

European contact

European settlement in south-western Victoria was rapid following the Henty brothers' landing at Portland in November 1834. By 1844 squatters occupied all of the study area to the Wimmera River north of Stawell; and 4 years later European settlement stretched to the north of Lake Hindmarsh. For up to 30 years before this land rush, however, whaling crews had been operating along the coast of western Victoria.

The impact on the Aboriginal population of the occupation of their exploitation territory, once pastoral settlement began, was immediate and great. For instance, George Robinson, Chief Protector of Aborigines, recorded in 1841 that a number of residential groups of Aborigines had already been completely wiped out. One such group had lived close to Portland. It is estimated that squatters had killed 158 Aborigines in western Victoria before 1860 - this is probably a conservative figure. A far greater devastation stemmed from the introduction of afflictions such as venereal diseases and smallpox, which sometimes spread faster than the actual settlement of Europeans.

As a result of these dramatic events, the Aboriginal tribal organization and traditional way of life broke down. The number of Aborigines in south-western Victoria fell rapidly and by 1877 the full-blood population was only 170 individuals.

Aboriginal Relics

Despite the great changes since European settlement, many signs of Aboriginal activity remain. Large numbers of relics have been discovered and more are being found as research progresses. These relics of Aboriginal culture occur throughout the study area and take various forms. Some forms are relatively numerous; others are unique examples of their kind. All of them, however, are important to our understanding of Aboriginal culture and all need further study. The following brief description covers the types of relics found here to date.

Lithic scatters

Probably the most common evidence of Aboriginal occupation in the study area is the presence of lithic scatters - accumulations of chipped stone waste from stone found in that locality and elsewhere. Usually located near camp sites, they resulted from activities such as the manufacture, maintenance, and reshaping of tools. They are somewhat distinct from workshops, which were larger in scale. Quarries, in the archaeological sense, are sites that have been used for the extraction of stone for tools.

While the study area does not contain any known quarries or lithic sites of great importance, a large scatter in a blown-out dune at Toolondo could be particularly valuable for research.

Mounds

The most numerous type of Aboriginal relic recorded here so far is the mound site (also called (*Myrnyongs*, "earthen heaps" or "ovens"). More than 70 examples have been found to date, most of them on the plains surrounding the Grampians. Some have been found near Toolondo Reservoir, and another group has been located near Bessiebelle in the south. Those around Lake Muirhead, Mount William Swamp, Lake Lonsdale, Lake Fyans, and near Toolondo Reservoir occur on or near public land.

The mounds vary greatly in dimensions, but at least 60% of the examples measured in a recent survey were between 2 and 20 m in diameter. Their shape tends to be circular. They are often characterized by the presence of darker soil due to the accumulation of charcoal, burnt earth, and organic matter. In most cases erosion has taken place and the original height cannot be determined. The majority, however, would have been less than a metre high.

Our knowledge of their function is limited. Early settlers' journals indicate that the Aborigines probably camped on them, and this has been verified by archaeological research for certain sites in the central Western District.

Only two mounds in the study area have been excavated to date: one near the Toolondo Channel and the other close to the stone houses at Wallacedale. The Toolondo mound - a small structure, approximately 12 m in diameter and about 20 cm high - was excavated to investigate its internal structure. Unlike the mounds of the central Western District, it had no clear demarcation between the occupation layer and the underlying basal clays. This operation did not uncover any stone tools, flakes of stone waste, food debris, pits, or burnt rocks.

Excavation of several mounds near the Hopkins River, on the other hand, showed that they were general camp sites. They included a wide variety of archaeological remains, indicating that they had been used for cooking, and also for burials.

Rock art sites

At least 40 examples of Aboriginal rock art are located in the Grampians and the eastern and western Black Range. The designs and motifs appear to be simpler than those elsewhere in Australia.

Different substances have been used to paint on rock surfaces. Red ochre was the most frequently used medium; yellow and white ochre were used also and some drawings in charcoal have been found. The designs and motifs vary from place to place, but they often depict human figures. Some shelters contain many paintings - the Cave of Hands in the Grampians, for instance, has several hundred. Recent investigations have shown that floor deposits in some of these caves contained charcoal, tools, chipping waste (especially from quartz and quartzite), and fragments of animal bone, indicating that the rock shelters had occasionally been used as living areas as well. (One cave had also been used as a sheepfold.)

Aboriginal rock art - the Cave of Ghosts

Scarred trees

Scarred trees are important because they are often the only surviving evidence of the use of organic material by Aborigines. At least 30 examples have been recorded in the study area - the majority east of the Grampians, with others near Horsham and Harrow.

The bark stripped from trees had a number of uses, including slabs for the construction of huts, canoes, dishes, and water containers. Various criteria can verify whether or not humans made the scar, such as its position, shape, and symmetry, but it is impossible now to determine the exact use to which the bark, once removed, was put.

Middens

Middens abound along the coast of Victoria. These are accumulations of shell and bone (and often include stone fragments), the debris from repeated visits by the Aborigines to exploit the coastal environment for food. Sometimes they are discrete localized heaps, but in other places they stretch for hundreds of metres. Middens occur frequently along the coast of the study area.

Fish traps

At Lake Condah, a number of these highly significant Aboriginal relics have been constructed from the local basalt rocks. The traps are situated on various levels

An Aboriginal canoe tree

and would have been used at different times according to the level of the lake. A series of banks, positioned in such a way as to channel the rising water, carried the fish to where they could be taken more easily. The operation of

Exposed midden material

such a system required a thorough knowledge of the local environment and the movement of water.

Stone houses

Clustered around these traps, and undoubtedly associated with them, are Aboriginal houses, generally in groups of threes and fours. Of the hundred or so of these structures, only about half have been adequately recorded. The houses are semi-circular or horseshoe-shaped and average about 3 metres external diameter, with entrances facing east or south-east; the walls consist of a couple of courses of stone, now about 40 cm high. When in use they probably were roofed with boughs or bush. The entire site is on public land.

About 5 km to the north lies another complex of some 50 house sites. These houses are of similar construction and type to those associated with the fish traps.

In a third group, about 40 houses, further north in the Wallacedale area, have similar dimensions and construction, but the entrances face north-east or east - probably to avoid the prevailing north-west and south-west winds. The walls of the structures have collapsed, but one of these, when rebuilt, measured about a metre in height.

These shelters were probably built after contact with Europeans. An excavation of one hut site yielded numerous fragments of glass and of clay pipes. In contrast, only 58 stone flakes were recovered, one of which had been used as a tool.

Water channel

In the central north of the study area, near the Toolondo Reservoir, is a unique example of the Aborigines' manipulation of their environment. Between Clear Swamp and Budgeongutte Swamp a drainage channel ran for a distance of more than 2.5 km. The precise purpose of this drain is unknown at present, but it has been suggested that it may have been used to catch eels.

Whatever the use of this channel, its construction represented a very sizeable investment of labour on the part of the Aboriginal residents.

Significance

While the more unusual types of Aboriginal relics have the highest priority for preservation, in one sense every individual site is unique, whatever its similarities to sites elsewhere. All Aboriginal sites result from human activity that, although somewhat patterned, depended on the particular combination of resources in that locality. It is these small differences that are important to the archaeologist in his task of explaining how the Aborigines adapted to and exploited their environment.

There are other reasons for preserving sites. Aboriginal relics form part of our national heritage. Although Australian history is commonly conceived as beginning in 1770, Aboriginal occupation is now known to have been of at least 40,000 years' duration. Hence, the sites that provide evidence of this immense period of settlement are as much a part of our historical heritage as anything built here by Europeans in the past 200 years.

Recording and Preservation

Lithic scatters and mounds can be disturbed greatly by agricultural activity - this disturbance alters the pattern of the deposit and reduces the value of the site for archaeological interpretation. Wherever possible these sites should be excavated and recorded.

Similarly there is an imperative need to develop an adequate system for recording rock art, as these relics are deteriorating at a rapid rate. At 18 of 20 rock shelters studied in a recent survey, the paintings were fading; at 16 flaking and exfoliation were taking place; and 12 were being damaged by water flowing across the rock surfaces.

In the Grampians, a number of rock shelters containing art are subject to frequent visits by tourists. In all except three of the ten most frequented sites, and in twelve of the twenty shelters surveyed, there had been some interference with the art work - usually despite the presence of protective grilles. In some shelters, campfires lit by tourists provided charcoal for anybody who wished to make inscriptions, in addition to directly damaging the paintings with smoke and heat. The conflict between tourism and preservation in these instances is severe, as highly important relics of Aboriginal culture are being destroyed.

The scarred trees in the study area - like the mounds - appear to be similar to examples from other more-intensively studied areas. Where good examples of these relics exist in the study area, however, they are important to the study of Aboriginal culture and, accordingly, should be preserved. In particular circumstances, scarred trees are of more than ordinary significance. For instance, where there are living trees with well-defined scars, or a group of trees exhibiting a variety of shapes of scar, the significance for further study is considerable. Accessibility is important as well, in terms of the educational value of these relics.

Scarred trees are significant also because they are *in situ* relics. The dimensions of as many such relics as possible should be recorded, in order to determine if regional patterns exist as well as aiding our understanding of the use to which bark was put. This will be a continuing programme, as more scarred trees are being reported each year. On the other hand trees are liable to be cut for firewood or posts, or to burn or decay away.

The Clear Swamp--Budgeongutte channel has been partly obliterated by agriculture as, doubtless, have many other relics. For instance, journals of the early settlers mention large eel-traps south-east of Mount William, but no trace remains of these today.

Other rarer types of relic in the study area, for instance the fish trap at Lake Condah and the nearby stone house sites, have very great significance to the study of Aboriginal culture. Further intensive study of these sites is needed before any adequate appreciation can be made regarding their place in Aboriginal life. For the moment, until such research can be undertaken, measures must be introduced to ensure protection and preservation of these valuable sites.

The *Archaeological and Aboriginal Relics Preservation Act* 1972 was enacted to protect these relics. Under this legislation it is an offence to negligently deface, damage, or interfere with a relic, or to excavate without the appropriate permit in order to uncover a relic. Further, if a person discovers a relic it must be reported to the Protector of Relics appointed under the *Act*. Where sites of great significance are threatened there is provision in the *Act* for the declaration of areas as "Temporary Archaeological Areas" or "Archaeological Areas" and, under special circumstances, for compulsory acquisition of land that contains the threatened relic. The legislation is being reviewed currently and could be amended at some future time.

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4. HISTORY

Exploration

The history of European settlement in south-western Victoria began in December 1800. At that time, Lt. James Grant, R.N., commander of the 60-ton brig "Lady Nelson", was ordered from the Cape of Good Hope to survey the newly discovered Bass Strait. He named Mount Gambier, Capes Bridgewater, Nelson, and Sir William Grant, Portland Bay, Lawrence Islands (now Lawrence Rocks), and other coastal features.

Throughout this period, official fear persisted in Britain and New South Wales that the French would claim part of Australia, and Flinders' sloop "Investigator" was despatched from London, via the Cape of Good Hope, to further explore the southern coastline. Meanwhile, the French corvette "Le Geographe", under Baudin, had sailed south from Port Jackson. The two vessels met in Encounter Bay, at the mouth of the Murray, during 1802. Both voyages yielded accurate maps.

During the next quarter century sealers and whalers camped along the coast, especially at Portland Bay, but the country inland remained unexplored.

The first squatter

Capt. William Dutton, after an earlier visit, returned in 1829 and built the first house in what is now Portland. Various trading vessels called at his whaling station. One brought Edward Henty from Launceston in winter 1833. He met Dutton and decided to settle there.

Henty and his brothers crossed Bass Strait from Van Diemen's Land (Tasmania) in the "Thistle" and landed at Portland on November 19, 1834, with stock, implements, supplies of seeds, and five farm labourers. Their occupation had not been sanctioned by the New South Wales administration, and thus was illegal.

The Hentys built houses and established vegetable gardens. Soon they were supplying meat and other provisions to whalers and passing seamen, and their increasing herds and flocks were grazing around the bay. In 1835 they exported hides, whalebone, and more than 700 tonnes of whale oil.

Mitchell's epic journey

Meanwhile the Surveyor-General, Major (later Sir) Thomas Mitchell, had left

Sydney with bullock drays, boats, and about 30 people, including Aborigines, to attempt to follow the inland rivers that Sturt had recently discovered.

This expedition reached the junction of the Murray and the Darling at the site of present-day Wentworth. Travelling back up the Murray, the party deviated east of the Loddon River to Pyramid Hill. Mitchell climbed it and, seeing the rich plains to the south-west, decided to change course and journey overland to Encounter Bay.

On July 11, 1836, Mitchell's expedition ascended the Pyrenees at a point some 10 kilometres south of modern St Arnaud and saw (in the words of Stapylton, his second-in-command) "from the high ground the full extensive view of the Coast Mountains splendidly high and broken; no snow visible as yet". Mitchell named them the Grampians after the central ranges of his native Scotland.

Leaving Stapylton to bridge the Richardson River, Mitchell and a small party rode to the Grampians and took sights on distant landmarks from the highest peak, which he named Mount William after the reigning king. The detour took 3 days. The party had insufficient rations and icicles hung from the rocks and bushes on the summit. Stapylton was amazed: "The Surveyor-General's constitution must be as hard as iron to stand three days of it, without food, wet through the whole time, and a bitter wind from the southward on the summit chilling the frame violently heated with perspiration from the fatigue of the ascent."

Mitchell's party crossed the Richardson and Wimmera Rivers. His Aborigines ascertained the latter name from the local tribesmen, for Mitchell always 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 Surveyor-General climbed Mount Zero for more sightings before continuing west to Mount Arapiles, which he named after a mountain near the Plains of Salamanca in Spain. He had served there during the Peninsular wars and the date of his ascent marked the anniversary of a battle in that campaign in which his brother had been killed. Mitchell was particularly interested in the large number of circular saline and freshwater lakes, and their bordering dunes, which are visible from the mountain.

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". This left unresolved the destinations of the Richardson and Wimmera Rivers. Mitchell was 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.

The party continued south and crossed the Glenelg and Wannon Rivers. Most of this journey had been through grassy woodlands eminently suitable for grazing. Stapylton was left in charge of a base camp near today's Dartmoor while others rowed downstream to the mouth of the Glenelg. Mitchell was very disappointed to find the entrance to the ocean barred by sand.

On regrouping the expedition turned east through the swamps and heavy soils of the Crawford River country. Mitchell again despatched a party and rode south to Portland Bay.

The settlers were astonished to see Mitchell's men and, at first, imagined them to be bushrangers. Mitchell himself had had no inkling of the existence of the settlement. He told Edward Henty of the fine grazing in the north. The news spurred the latter to subsequently take up vast holdings there for his flocks.

Mitchell climbed Mount Napier, passed close to the site of modern Hamilton, ascended Mount Abrupt, and continued north-east across the plains to Mount Cole and beyond.

This was his journey through "Australia Felix". His party had had little close contact with the natives of the region, although many times they saw and heard tribesmen in the distance.

The consequences

Mitchell's encouraging observations were rapidly made known through New South Wales and Van Diemen's Land, and pastoralists moved in with stock to take up runs. By the end of the 1840s all of the western part of the Port Phillip colony to the edge of the Mallee scrub had been selected.

Holdings probably covered between 15,000 and 60,000 ha. They were unfenced, stocking was low, and the squatters' sheep and cattle lightly grazed the native grasses. Annual licence fees were nominal.

One of these squatters was T.A. Browne - better known as Rolf Boldrewood, author of "Robbery Under Arms" - who came to Squattleseamere, near Macarthur, in 1844.

High prices for wool in London coincided with the beginning of this expansion and stimulated it, but a severe slump soon afterwards helped to bring about the Australia-wide depression of 1841--43.

With little demand for wool or meat, the pastoral industry was in difficulties. Fortunately a Yass squatter realized that stock could be boiled down for

"Mount Abrupt and The Grampians", by Nicholas Chevalier

tallow, which Britain would import for soap and candle manufacture. This trade assisted the newly established pastoralists - and indeed the colonies themselves - to survive, and confidence gradually returned.

Embryonic Hamilton had its first inn in 1843, as well as a store, post office, blacksmith shop, and two houses. Horsham was founded at the junction of two tracks, one along the Wimmera River and one running north from the Glenelg. In 1847 a court was established there and by 1851 the settlement had 18 houses and was growing as a trading centre for the surrounding pastoral country. Neighbouring Glenorchy grew around the Four Posts Inn, built in 1847.

On Black Thursday (February 6, 1851) bushfires swept through the pastoral country from Geelong to Mount Gambier and destroyed stock and hundreds of buildings. Many settlers died.

The Gold Rushes

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

In the short term this opened new and lucrative markets to the graziers, although the scarcity of agricultural labour hindered expansion. Portland, in particular, increased in its importance to traders. It was closer to the north-western gold-fields than was Melbourne. In the longer term, gold led to the development of new provincial towns, municipal government, industries, inland transport, and to a consolidation of agriculture.

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. 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 and South Australia.

The venture proved very successful. The escort made 18 journeys during 1852--53 and carried gold worth a total of more than £1 million in the currency of the time. The weight of the precious cargo varied, but was probably close to half a tonne on most trips.

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

Mining at Stawell, c. *1880*

were too formidable to attract bushrangers. Stories of Captain Melville 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.

Doubtless prospecting took place throughout the study area in the second half of last century, wherever the older series of rocks outcropped, but the important discoveries were all made east of the Grampians.

In May 1853, William McLachlan discovered gold at Pleasant Creek. The diggings here had a population of around 30,000 in 1857, which had declined to about 6,000 by 1866. This community became the town of Stawell, and its renowned foot race, the Stawell Gift, was first staged in 1878.

Stawell's mining history is typical of Victorian gold-fields. The rich alluvial deposits were limited, and the operations of individual miners and small syndicates soon exhausted them. Later a multitude of companies worked the deep leads and quartz reefs, the last mine closing in 1920.

Ararat's development followed a similar pattern during this period. The Canton shallow lead, discovered by Chinese diggers in 1857, was immensely productive. By 1859 most of the 20,000 who took part in this rush had moved on, many to nearby Moyston, Subsequent mining activities centred for years on acid dykes, deep leads, and quartz reefs.

Great Western was also an important field, and miners dug some of the extensive cellars that are still in use at the local winery.

The last real gold rush in Victoria occurred in the Grampians at Mafeking, at the foot of the Major Mitchell Plateau, in 1900. At its peak the population numbered 9,000. In 1908 the Stony Creek flats above Halls Gap were dredged, but returns were slight.

The Fate of the Aborigines

The previous chapter discusses Aboriginal occupation of the study area, and its relics. As European settlement developed, the indigenous Aborigines declined. Tribesmen viewed the squatters' stock as a source of food. Hearsay accounts of massacres (such as Bonwick describes) give an indication of the ferocity of the settlers' retaliation - a reaction doubtless intensified by fear and isolation.

When the remnants of the nomadic tribes clustered on the fringes of villages and around station homesteads, they were further decimated by alcohol, disease, and poor diet. In this reduced and demoralized state, their links with their ancestral lands severed, fewer and fewer Aboriginal children were born, and extinction became inevitable.

There was, however, some government action in western Victoria to protect the Aborigines. An Aboriginal station had a brief existence at Mount Rouse, near Penshurst, from 1841 to 1848, and the residents had a few hectares under cultivation.

The Central Board for the Protection of Aborigines was set up in 1860 with the aim of educating the natives to support themselves. Working closely with missionaries, the Board set up reservations and depots to house and supply the remaining Aborigines. Western Victorian stations were at Antwerp (Ebenezer), Condah, and Framlingham. Established during the 1860s, these stations were closed down during the period 1890-

-1910, although Aborigines continued to live near some of these localities.

In bizarre contrast, Aboriginal cricketers from Edenhope visited Britain in 1868, 10 years before the first representative Australian side travelled abroad. After playing through western Victoria, the Aboriginal eleven left for Sydney and London, despite official attempts to prevent the tour because of its suspected commercial nature.

Of 47 English matches, including one against the MCC, the team won 14, lost 14, and drew the remainder. The grave of Johnny Mullagh, the best player in the series, is at Harrow cemetery.

Successors to the Tribesmen

European settlement had rapidly displaced the nomadic Aborigines. By the 1860s south-western Victoria supported a vigorous and cosmopolitan - although very raw and far-flung - community engaged in grazing, mining, timber-getting, and many other pursuits.

A few contemporary accounts of the life of the people of this community have survived. James Bonwick, Inspector of Denominational Schools, gave a vivid description of a journey he made through the Western District in 1857. Although his work as an inspector was primarily concerned with education, and he had a deep interest in the propagation of religion and temperance, Bonwick also depicted the vastness of the country and its loneliness. He described the difficulties that the citizens of the burgeoning townships faced, and the even greater privations of the squatters on their scattered runs.

Bonwick found the Hamilton of 1857 a village of some 700 people with "a good number of quiet saving Prussians" established "on the farms of German Town" (now Tarrington). The village contained "three hotels, three bakers, six butchers, six stores, three saddlers, ten bootmakers, and one watchmaker".

He recorded that: "The Episcopalians have erected a pretty stone church, with a Sunday attendance of ... nearly forty. The Presbyterians meet at present in the public room of the Victorian Hotel to the number of ... one hundred and fifty; a church is shortly to be built. The Roman Catholics have a wooden chapel on a hill, but no service, unless upon the chance visit of a clergyman. The German residents hold regular services."

The National School, which had opened in 1852, occupied a wretched building, but a Hamilton Mutual Improvement Society had been formed to establish a town library.

Other influences were at large. Inside his hotel Bonwick "could get no sleep for hours from the loud abuse vented against the house by a woman whose husband was drinking inside".

Bonwick's intelligent observations of the Wannon landscape and volcanic features such as Mount Napier and Mount Eccles (then known as Mount Eeles) remain of great interest. His narrative also reveals the distribution of the native vegetation on the plains of the Western District, long since almost completely cleared for agriculture.

Lost in the bush

Emphasizing further the isolation of bush life is the story, familiar to generations of Victorian primary students, 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.

In August 1864 the Duff family were living on an isolated part of Spring Hill station, near the present Nurcoung, on the northern boundary of the study area and 20 km west of Natimuk. The father was a shepherd. While collecting broom-bush for their mother, the children strayed. The search had become hopeless 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 during the 1930s.

The story was widely related and 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.

Effects of selection

When the mining boom quietened in the 1860s, a vigorous and lengthy campaign, which included agitating former miners, brought a series of land selection bills culminating in the *Land Act* 1869. This legislation allowed settlers of limited means to select, and eventually purchase, up to 260 ha (640 acres) for farming within proclaimed areas, provided conditions of residence and improvement were met.

A squatter leasing that land beforehand would have had to give it up, or somehow select and purchase the land himself. The early *Acts* were loose, and the balloting provisions could be exploited by the subterfuge of "dummying" - the illegal use of nominees. This favoured the wealthy, whether speculators or existing farmers. Land in the southern half of the study area was quickly acquired.

Under the *Land Act* 1869, all remaining Crown land in Victoria was made available for settlement, even if unsurveyed, but the maximum area for selection was reduced to 130 ha (320 acres).

The drier Wimmera country had been leased for grazing since the mid 1840s, but had deteriorated. The original kangaroo grass had been replaced by less-productive weeds and annuals; plagues of rabbits assisted in this change. During the mid 1870s settlers migrated there in large numbers. Many were experienced farmers of German descent, practical and frugal people who moved from South Australia to continue wheat-growing.

The Regional Economy Broadens

Agriculture expanded and diversified in south-western Victoria in the late 19th Century, despite periodic economic depressions and natural adversities such as floods, drought, and disease.

Much of the region was ideal for growing fine wool from Merino and Merino-cross sheep. Cattle were also important - mainly for beef, although dairying could be practised in the milder southern regions. Wimmera-bred draught horses were valued.

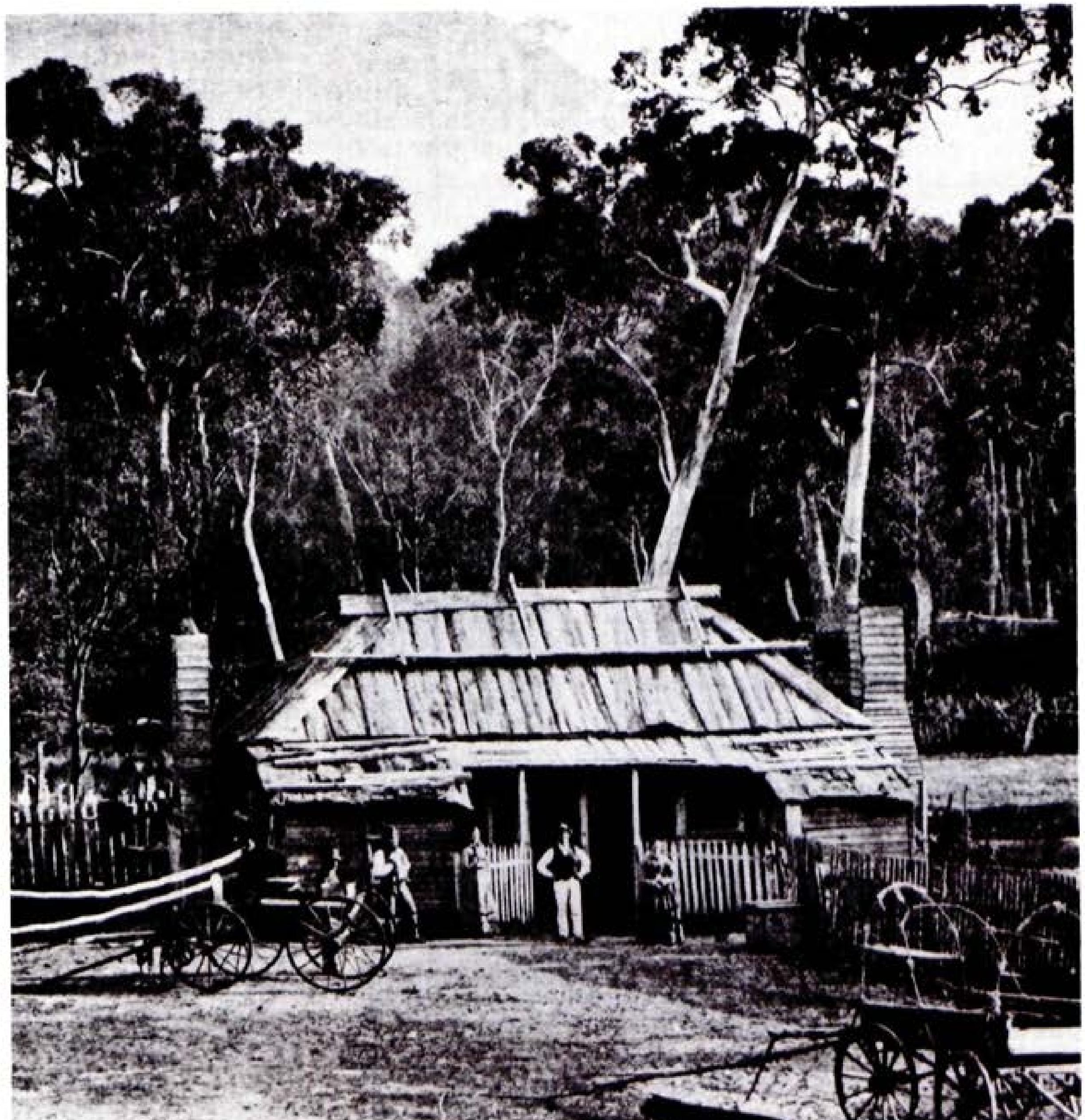
Wheat production on the Wimmera plains became much more rewarding with the development of agricultural knowledge, machinery for cultivating soil and harvesting crops, superphosphate fertilizer, and varieties of cereals suited to Victorian conditions. Vineyards, orchards, and olive groves were planted, as at Great Western, Pomonal, and Laharum.

A series of severe droughts emphasized the need to supplement water supplies from streams. The Mackenzie River was dammed in 1887 to form Wartook Reservoir, the first irrigation storage in Victoria and possibly Australia. The engineer was John Dickson Derry. Lake Lonsdale was completed in 1903, and Lake Fyans in 1916.

In the early 1880s a few farmers had begun 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 Riversdale, Burnlea, Vectis, and Quantong, were established using water from Lake Wartook as well. Derry himself invested heavily in several schemes. Each colony was subdivided into small allotments of a few hectares or less.

The movement attracted swindlers as well as settlers - A.F. Spawn promoted the Mount Arapiles Irrigation Colony west of Natimuk and then absconded with its funds - and many of the colonists knew nothing about horticulture. Most colonies were in difficulties during the mid 1890s, but they laid the foundations of the present irrigated cropping and dairying around Horsham.

The depression of the 1890s, which caused severe unemployment, especially in the cities, gave birth to the Village Settlement Association under Rev. Horace Finn Tucker. The Association's ideal was communal labour. When a village was established, individual families were given blocks of several hectares close by, but they also had to help on the other villagers' allotments. Families could work on local properties, also, to



Delley's Homestead, near Halls Gap, in 1880.

bring in more money. Tucker settlements at Wonwondah South, Moora Moora, and Haven had a brief life. Within a few years most of the settlers had returned to the city.

Secondary industries developed, especially to serve mining and 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.

Road and rail

The earliest communications were by horse-drawn dray and bullock wagon along the roughest of tracks.

The first bodies charged with the maintenance and improvement of highways and other thoroughfares were the District Road Boards. Under a series of *Acts* passed between 1863 and 1869, the Victorian government established local administration in the State. Gradually the road boards were supplanted by elected shire councils; the *Local Government Act* 1874 eliminated the last few boards by absorbing them into existing councils or elevating the districts into shires. The Shire of Portland was declared in 1863; the Shire of Stawell dates from 1864.

Railway construction occurred largely during the last quarter of the 19th Century. Ararat was linked with Melbourne in 1874, and with Portland in 1878. Horsham's first rail connection to the metropolis was made via Murtoa in 1878. Its link with Adelaide was completed in 1887. Heywood traffic could join the South Australian rail system at Mount Gambier after 1917.

The Grampians

Sheep and cattle were grazed throughout the Grampians from the 1840s onwards. Abandoned fence-lines in rugged parts of the Victoria Range show how extensive this practice was. In the latter half of the century the mining industry required large quantities of timber for underground workings, surface construction, and fuel. Cutters moved into the Grampians. Wattlebark was another important forest product. Fires were frequently lit for clearing land, promoting new growth for forage, and improving access; at the same time they destroyed useful timber.

In the 1850s a police post was located in the Grampians at Rose Gap to protect travellers, to deter horse thieves (for a flourishing traffic in stolen horses operated between south-western Victoria and the far west of New South Wales), and to collect the poll tax from Chinese using the "Chinese Track" between Guichen Bay (Robe) and the diggings in Victoria. (The poll tax was a levy intended to deter Asiatic migration to Victoria. Bonwick mentioned a party of some 350 Chinese having passed through Apsley in 1857 a few days before he did.)

Reservations of State Forest were made in the Grampians between 1872 and 1884. Mr. Walter Bowie had been appointed Forest Caretaker in 1875. Following the creation of the Forests Department in 1907, a large portion of the public land was designated as reserved forest. Most of the Grampians was declared a sanctuary in February 1914.

An interesting enterprise was the Mount Difficult sandstone quarry, which provided the freestone used in the construction of Melbourne buildings such as Parliament House, the G.P.O., and the Town Hall, as well as the Stawell Court House and Post Office. A broad-gauge tramway, constructed in 1882, intermittently transported loads of stone from the quarry to Stawell, until it was closed in 1949.

By the 1920s tourism had become important, especially through the efforts of the Victorian Railways. Halls Gap flourished because of its accessibility to the railway, and its guest houses had beds for 300 holiday-makers. The popularity of Halls Gap increased when it was linked by road with both Dunkeld and Zumsteins, where visitors to apiarist Walter Zumstein's pleasant property on the Mackenzie River stayed in huts made by their host from rammed earth.

The Twentieth Century

The present century has generally been, despite fluctuations in world trade, a time of consolidation and steady economic growth for the south-western region of Victoria.

Runners in the 880 yds final at Stawell in 1899

Some reasons for this strengthening lie in the agricultural developments of the late 19th Century already listed, and since much-refined: increased understanding of local conditions, the invention of cultivators and harvesters, and the introduction both of superphosphate to maintain fertility and of new disease-resistant grain varieties suited to the dry climate.

As well, by the turn of the century, water supplies and transport had become much more assured, and many unsuccessful farmers had left their holdings, thus allowing their neighbours and others to expand their own operations.

Pasture improvement - the combination of "super" and subterranean clover - gradually became accepted by farmers in the four decades 1920--1960. Other important advances have been in the control of rabbits and of soil erosion.

After both world wars, government-sponsored "closer settlement" schemes led to the acquisition and partitioning of many bigger estates to enable large numbers of small farmers, particularly former servicemen, to establish themselves on the land. By contrast, the last two decades have seen a consolidation of farming properties by the absorption of small holdings. Although the populations of some of the larger provincial towns and cities have grown, that of the rural areas has declined.

The major natural disasters that have been faced by the region in this century have been severe bush fires, such as occurred in 1939, 1944, and 1977. In contrast the many man-made water storages are the region's security from drought.

The development of decentralized secondary industries on a moderate scale throughout the region, the marked increase in tertiary (service) industries and in tourism, and the improvements to the harbour at Portland have all stimulated regional growth.

Origins of Place Names

Ararat	Named by W.J. Wills, 1839: "...like Noah's ark, we rested there..." (presumably in reference to Mount Ararat).
Cherrypool	Originally Jerripool, after Jerri, an Aboriginal who lived there.
Chetwynd	After Mitchell's second-in-command, William Granville Chetwynd Stapylton (as was Mount Stapylton, a recent designation).
Coleraine	Town in northern Ireland.
Dunkeld	Town in the Grampians, Scotland.
Eumeralla	Aboriginal - land of plenty.

Glenelg River	After Lord Glenelg, Secretary of State for the Colonies in 1835.
Glenorchy	After the locality in Argyll, Scotland, home of John Gleeson, whose Four Posts Inn and forge formed the nucleus of the Victorian town in 1846.
Halls Gap	After C.B. Hall, pioneering pastoralist who came from the Monaro to the Grampians in 1839.
Hamilton	(Originally The Grange, after the Grange Burn, Mitchell's name for a local creek.) Named after the Hamilton family, early pastoralists in the Edenhope district.
Horsham	Town in Sussex, England.
Lady Julia Percy Island	Corruption. Originally named by Grant after Lady Julian Piercy.
Macarthur	After an Administrator and Lieutenant-Governor of Victoria, Major-General Sir Edward Macarthur, son of John Macarthur.
Mount Arapiles	Mountain in Spain. Mitchell had fought nearby in the Battle of Salamanca.
Mount Eccles	Draughtsman's mistake, perpetuated. Originally named Mount Eeles by Mitchell after a comrade-in-arms (as was Mount Rouse).
Mount William	After William IV.
Natimuk	Aboriginal - little creek.
Noradjuha	Aboriginal - wind.
Richardson River	After John Richardson, Mitchell's plant collector.
Rose Gap	After P.A. Rose, an early pastoralist.
Stawell	After William Stawell - Victoria's first Attorney-General and Chief Justice.
Serra Range	After its serrated appearance (named by Mitchell).
Victoria Range	After the then Princess Victoria (named by Mitchell).
Wannon River	Aboriginal name, as told to Mitchell.
Wimmera River	Aboriginal name, as told to Mitchell; reputedly - throwing stick.

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PART II

NATURE OF THE LAND

5. GEOLOGY

Reference to Table 2 (the stratigraphy table) and Maps 2 and 3 (Geology and Physiography) will assist the reader to understand the complex geology of the study area. This chapter describes successively the rocks of each period, from oldest to youngest. As a further aid, a glossary on pages 48--50 contains the meanings of many of the technical terms used.

Outline

The known geological records of the area go back 570 million years to the Cambrian period, early in the development of a marine trough called the Tasman Geosyncline, which extended from Tasmania to Queensland. At that time, eruptions were sending sheets of lava across the sea bottom. The volcanic rocks and associated dykes at Mount Stavely, Wando Vale, and the western Black Range are the exposed remnants of this activity (see diagrams in Figure 1).

The volcanism gave way to the deposition of sediments, derived from a land mass outside the study area, on the floor of the marine trough as it gradually subsided. Ultimately these sediments built up thousands of metres in thickness. Later, forces generated in the earth's crust folded and metamorphosed (altered) the rocks and raised them above sea level to be subjected to erosion. Some of these rocks now outcrop along the eastern boundary of the study area, and in the Dundas Tablelands. At the same time, magma (molten rock from deep below the crust) was injected into the crust. It cooled to form granitic rocks, some of which now outcrop between Harrow and Coleraine.

A long period of erosion followed, and intermittent volcanism extruded lava between Rocklands Reservoir and Hamilton, and at Wickliffe.

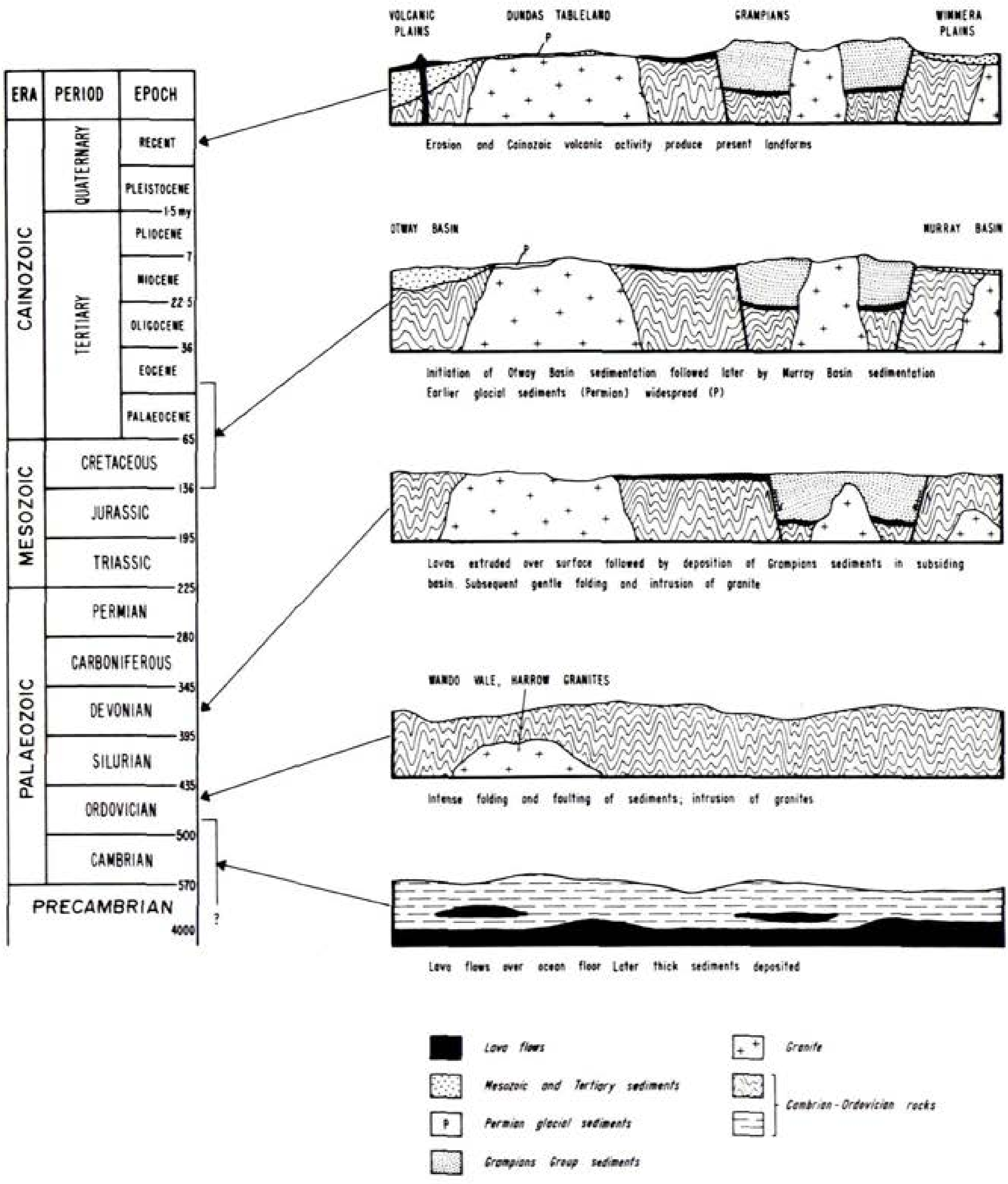
Later, a deep north--south trough developed in which thick deposits of sand and mud were laid down. These are preserved in the Grampians, the western Black Range, the Dundas Range, and at Mount Arapiles. Renewed compression caused folding and faulting of the Grampians sediments and the older rocks; more magma was intruded, forming more granitic rocks, some of which outcrop in the Victoria Valley and other Grampians localities. These were the final signs of the

TABLE 2, STRATIGRAPHY

ERA	PERIOD		OTWAY BASIN	DUNDAS TABLELANDS AND GRAMPIANS MIDLANDS AREA	SOUTHERN MURRAY BASIN	MAJOR EVENT
CAINOZOIC	QUATERNARY	RECENT	Colluvial and alluvial deposit, swamp deposit, coastal dune			
			Malanganee Sand Bridgewater Fm. stranded coastal dune Newer Volcanics	Erosion	Aeolian (Lowan Sand) and swamp deposits Fluviatile and lacustrine deposits; sand, silt, clay	Final regression of sea. Volcanicity
		PLEISTOCENE 1.5 m.y.		Erosion Lateritization		Faulting, uplift and erosion Lateritization
	TERTIARY	PLIOCENE	Dorodong Sands; stranded coastal dunes and shallow marine sandstones and fine sand		Parilla Sand: stranded coastal dune and shallow marine sandstone and siltstone	Marine regression Faulting
		7 m.y. MIOCENE TO OLIGOCENE	Heytesbury Gp; marine calcareous sand, overlain by limestone and marl	Erosion	Murray Group; marine, marl and limestone	Major marine transgression
				Older Volcanics		Volcanicity
		EOCENE AND PALAEOCENE	Wangerrip Gp; marine to non-marine sand and silt reflecting continental shelf, estuarine and swamp conditions		Renmark Group; non-marine sand and silt	Continued earth movements and marine transgression
MESOZOIC	CRETACEOUS	65 m.y. UPPER	Sherbrook Gp; marine sandstone, siltstone, sand;	(Subsurface and outside SW.2) Erosion	Erosion	Marine transgression Faulting
		LOWER	Otway Gp; non marine sediment; lacustrine and swamp. Siltstone and sandstone. Volcanics interbedded			
	JURASSIC	136 m.y.	Extrusion of trachyte (Volcanic)			E–W block faulting initial rifting of Otway Basin, erosion
		195 m.y. 260 m.y.				
PALAEOZOIC	PERMIAN	LOWER	Glacial sediments; tillites, sandstone, varved clay			Glaciation
		289 m.y. 395 m.y.		Erosion		
	DEVONIAN	LOWER	Erosion	Intrusion of granite at MacKenzie Ck, Zumsteins, Mafeking, etc. Slight folding and faulting of Grampians Gp	Erosion	Folding and faulting Contact metamorphism
	SILURIAN	416 m.y.		Grampians Gp; non marine sediment, Sandstone, siltstone, mudstone		
				Extrusion of acid lavas (Volcanic)		N–S block faulting
				Erosion		Uplift and erosion
	ORDOVICIAN	446 m.y.	Period of intense folding, intrusion of granites at Harrow, Wando Vale, Mt Ararat, metamorphism of surrounding sediment to schist			Folding, faulting
			Marine sediment, sandstone, greywacke siltstone, mudstone			
	CAMBRIAN	509 m.y. 575 m.y.	Submarine lavas (greenstones) shale and chert			Volcanic activity and sedimentation

SOUTH-WESTERN STUDY AREA - DISTRICT 2

FIG. I SIMPLIFIED GEOLOGICAL HISTORY



activity of the Tasman Geosyncline in the study area.

The succeeding 250 million years saw these basement rocks subjected to erosion that produced a nearly flat plain. The only known interruption occurred during the Permian ice age. The extensive deposits of boulder clay outcropping between Coleraine and Chetwynd show where glaciers moving across the area deposited part of their rock loads.

The pattern of Victoria's geology radically altered about 150 million years ago, during the Jurassic. It is thought that, until then, Australia was joined to Antarctica. At that time, however, an east--west rift developed (imposed upon the generally NNW--SSE strike of the older rocks), and lavas were extruded as the two continents separated (a separation now known as "continental drift"). The areas both north and south of the Grampians subsided to form respectively the Murray and Otway sedimentary basins (see Figure 2).

Later a series of earth movements alternately uplifted the land in each basin or caused it to subside below the sea. Sediments have been laid down in these basins to the present day, the type of deposit varying according to whether the study area was exposed land or under the sea at the time of deposition.

Late in geological history, volcanoes and fissures extruded vast sheets of

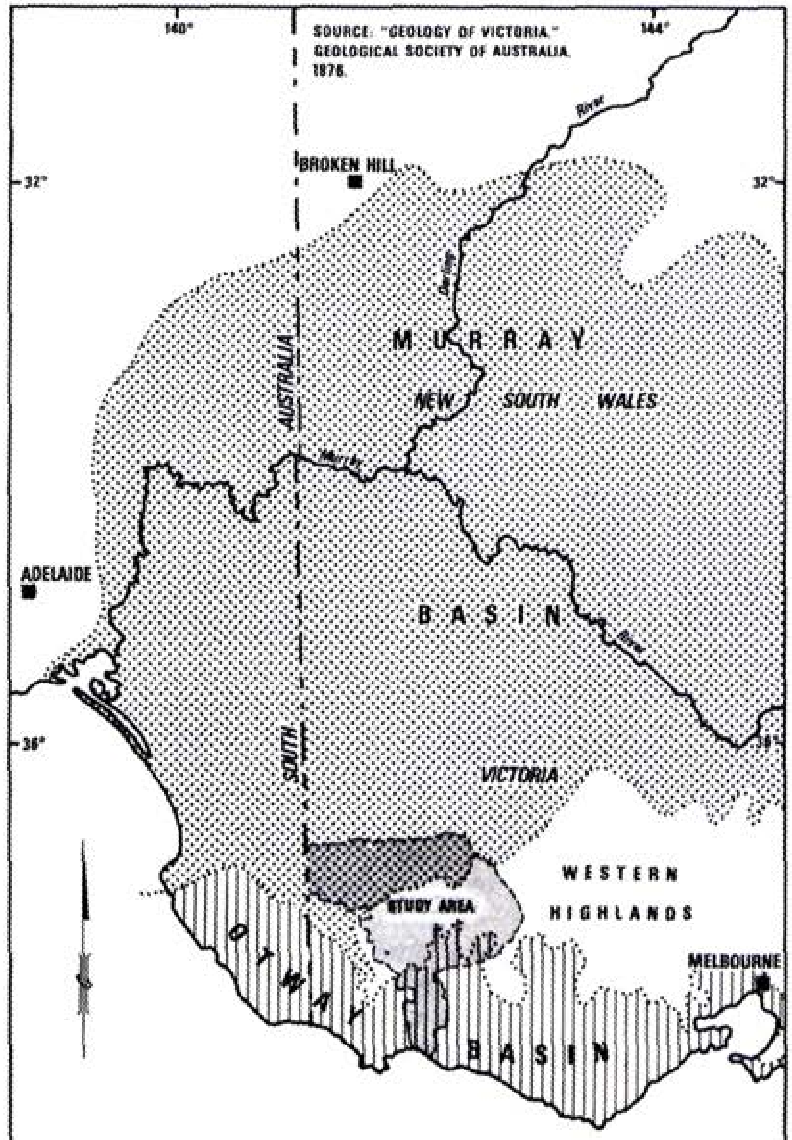


FIGURE 2
MURRAY AND OTWAY SEDIMENTARY BASINS

basalt lava in the southern half of the study area. The oldest dated flows occurred several million years ago, while Mount Eccles and Mount Napier last erupted less than 7,000 years ago.

During this period the final recession of the sea from the Murray Basin left a series of stranded coastal dunes, which show today as the long conspicuous ridges of Parilla Sand in the Little Desert, north of the study area. Parilla Sand also lies close below the surface of the plains of the south-western Wimmera.

Prolonged weathering of the surface rocks throughout the study area, in a humid climate, led to the formation of beds of laterite that outcrop extensively today, especially in the Dundas Tablelands.

Meanwhile, about two million years ago, renewed uplift of the Great Dividing Range took place. Although the uplift was strong in eastern and central Victoria, it was much smaller in the western part of the State. Nevertheless, streams were rejuvenated; they have sculpted the spectacular cuesta and razorback topography of the Grampians and cut down into the Dundas plateau. The study area, therefore, covers parts of two distinct sedimentary basins, the Otway in the south and the Murray Basin in the north.

The Otway Basin contains a maximum of more than 7,000 m of Mesozoic and Cainozoic sediments, which are masked by later flows of basalt between Hamilton and the coast. The southern margin of the Murray Basin contains Tertiary sediments partly obscured by dunes and alluvium of Quaternary age.

A ridge of Palaeozoic rocks separates the two basins. These rocks form a structural high where they outcrop east of the Grampians along the Divide, and in the rugged Grampians themselves. They are exposed in the valleys of the Dundas Tablelands and at Dergholm (beyond the Glenelg River and outside the study area) and continue at shallow depth into South Australia.

Detailed Geology by Periods

Cambrian rocks

During the Cambrian, a long narrow marine basin, known as the Tasman Geosyncline, extended down the eastern side of Australia. Sediments were laid down, and lavas extruded across the floor of the trough. These rocks were later folded and faulted by intense earth movements, probably about the middle of the Ordovician. A Cambrian age has been assigned to them (after comparison with rocks of similar lithology and structure in other parts of Victoria). The oldest in the study area, they now outcrop in two thin belts trending SSE--NNW.

The Mount Stavely--Mount Drummond belt to the east of the Grampians protrudes through the Cainozoic rock cover as a series of low hills. The second belt is in the western Black Range. Greenstones (altered submarine lavas) predominate in both belts; they are interbedded with and overlain by black and grey cherts and white shales.

These exposed Cambrian belts are associated with major faulting and stratigraphic displacements. The eastern side of the Mount Stavely--Mount Drummond belt is a high-angled fault juxtaposing Cambrian and Ordovician rocks. Similar faults probably form the western boundary. These earth movements have produced vertical and overturned beds in the thick sandstones of younger age along the north-eastern edge of the nearby Grampians (discussed later in this chapter).

In the western Black Range, sediments similar to those of the Grampians are displaced against Cambrian greenstones by high-angled reverse faults.

Cambro--Ordovician rocks

Deposition of sediments continued in the Tasman Geosyncline.

During the Cambrian and Early Ordovician the Tasman Geosyncline continued to subside, and a thick sequence of sandstones and greywackes interbedded with shales were deposited. East of the study area, around Ballarat, similar sediments contain Lower Ordovician fossils (graptolites). Moving west from Ballarat, towards the study area, the regional dip of these sediments is to the east - that is, the beds become older, and graptolites disappear. It is inferred therefore that the rocks shown as Cambrian--Ordovician on Map 2 are at youngest Early Ordovician but most likely range well down into the Cambrian in age.

Cambrian--Ordovician sediments outcrop extensively both west and east of the Grampians (in the western Black Range and along the Divide near Ararat) and in the valleys of the main streams draining the Dundas Tableland. They strike parallel to the Cambrian strata and are tightly folded.

Ordovician rocks

Intrusion by granites and granodiorites accompanied this folding and caused contact and regional metamorphism of the surrounding sediments to form schists, gneisses, hornfels, and calc-silicate rocks. Isotopic datings of Wando Vale granodiorite suggest that the intrusions are of Middle Ordovician age. These plutonic and metamorphic rocks outcrop in the west of the study area, and are exposed along streams in the Dundas Tablelands.

Silurian--Devonian rocks

Two major and distinct groups of rocks, the Rocklands Rhyolites and the Grampians Group of sediments, originated during the Silurian and Devonian periods. Their exact ages are uncertain, but isotopic dating has recently been used to supplement geological evidence, including records of fossils, to allow more precise estimates.

Modified by the Middle Ordovician earth movements, the edge of the Tasman Geosyncline shifted eastward from the study area to central Victoria and the basin continued to receive sediments. The newly folded strata in the study area were subjected to a long period of erosion, which produced an irregular surface over which thick acid lavas (the Rocklands Rhyolites) were later extruded.

Porphyritic rhyolites, agglomerates, and tuffs form some of the gently undulating country south-west and west of the Grampians and outcrop along much of the valley of the Wannon River. These deeply weathered rocks are usually capped by laterite.

A north--south crustal weakness remained in western Victoria. It developed into a deep trough, flanked entirely by mountains. Major sedimentation commenced, depositing more than 6,000 m of massive and cross-bedded sandstones - and minor red siltstones, conglomerates, and mudstones - forming the Grampians Group.

These sediments appear to be predominantly unfossiliferous, suggesting that they were laid down in fresh water. The brachiopod shells and fish spines in the Silverband Formation (found in a few localities) show, however, that the sea was nearby and brief marine incursions took place in part of the sequence. Grampians conglomerates often contain pebbles of rhyolite, Cambrian--Ordovician sediments, and Cambrian greenstone and chert (indicating that they are younger than these three groups of strata).

The Grampians Group was tilted and, in places, folded into broad open structures. The present Grampians are bounded by faults that appear to be related genetically to the folding. The effects of a major fault can be observed between Mount William and Mount Zero on the north-eastern margin of the range where beds have been dragged to vertical and overturned.

Fossil evidence suggests a Lower Carboniferous age for the Grampians Group, although the fauna present is not strictly diagnostic. Comparison with well-known and apparently similar sequences in Europe suggests an Upper Devonian--Lower Carboniferous age. The Mackenzie River, Victoria Valley, Stony Creek, and Mafeking granitic rocks, however, have intruded and metamorphosed the Grampians Group to form porphyritic dykes and sills, and hornfels in contact zones. As isotopic dating of the intruding granitic rocks indicates that they are of Middle or Lower Devonian age, the Grampians sediments are probably older than previously suggested, and Lower Devonian or Silurian in age.

The position of the Rocklands Rhyolites, between Middle Ordovician granites and the sediments of the Grampians Group, indicates therefore that they are no older than Middle Ordovician and no younger than Lower Devonian.

Sediments of the Grampians Group form the present western Black Range, Dundas Range, and Mount Arapiles, and the Grampians proper. Several minor outcrops also occur west of the Grampians.

Granites and granodiorites of roughly similar age to the granitic rocks intruding the Grampians Group are found west of Ararat and south of Stawell. They form the eastern Black Range, including the well-known Sister Rocks. Some metamorphic aureoles resulting from these intrusions remain as prominent ridges (for example, Mount Ararat) due to differential erosion.

Permian rocks

Prolonged erosion followed the end of the sedimentation that produced the Grampians Group. Glaciation subsequently occurred, and the retreat of the ice sheets left flat-lying tillite (boulder clay) and fluvio-glacial sand, silt, and varved clay.

A comparison of these glacials with similar deposits elsewhere in Victoria suggests a Permian age. Lying beneath thin Tertiary deposits and resting unconformably on Cambrian--Ordovician and Ordovician formations, they have been exposed by the drainage system that dissected the Dundas Tablelands, and have been observed in bores at Netherby and Penshurst.

The tillites contain a wide range of rocks, some of which are foreign to the Australian mainland. (Glacial striations at Bacchus Marsh indicate that the ice moved in from the south-west. This implies the sometime existence, at least until the Permian, of an elevated continental land mass in that direction.)

Mesozoic rocks

A period of prolonged erosion occurred from late Permian to early Jurassic.

Devonian granite in the Black Range, near Stawell

Tilted beds of Grampians Group sandstones outcropping in the Serra Range

During the Jurassic period, trachyte lavas were extruded over the surface of portion of the study area. They outcrop extensively in the Coleraine, Carapook, Pigeon Ponds, and Nareen districts on the Dundas Tablelands. Isotopic dating suggests a Middle Jurassic origin.

Oceanic and terrestrial drilling reveals that in the Late Jurassic a narrow and shallow east--west depression developed from Robe, S.A., to around Casterton. Terrestrial sediments were deposited in the depression. Interbedded tuffs and thick basalts found in the bores indicate subsequent volcanic activity.

Subsidence continued, and by the Early Cretaceous a major east--west trough or rift valley had developed across southern Victoria. It was separated from the present continental shelf.

The fresh-water and estuarine sediments, with tuffaceous horizons from contemporaneous volcanic activity, which were deposited in the trough, formed the rocks of the Otway Group - 3,000 m of blue-grey feldspathic sandstone, mudstone, shale, and minor coals and conglomerates.

Sedimentation was rapid; all beds appear to have been laid down in shallow water. Fossil plant remains are abundant and there are occasional fresh-water pelecypod shells and fish remains. Similar sediments are found in the Murray Basin. They outcrop near Kadnook and have been recorded from a deep bore in the far north-western corner of Victoria.

Studies have shown that the material forming the sandstones of the Otway Group had a southern origin, yet no land now lies to the south of the study area. In fact, the present southern continental shelf descends to depths around 5,500 m on the bed of the ocean. This evidence lends weight to the supposition that Antactica and Australia were once joined as a great southern continent (named by geologists "Gondwanaland"), but they have since gradually separated.

The rifting continued and, at the end of the Lower Cretaceous, the sea first gained access to the Otway Basin. During the Upper Cretaceous, marine and estuarine sedimentation on the edge of the continental shelf formed the Sherbrook Group. These rocks do not outcrop, being known only from deep bores; they include sands, greensands, and shales. As far as is known, they are absent from the Murray Basin. The uplift of the Otway Ranges and Merino Tablelands began at this time.

Palaeocene--Miocene rocks

From the Upper Cretaceous onwards, at least four or five cycles of oceanic advance and retreat across the land have occurred.

Each marine transgression, which typically lasted many millions of years, was controlled by crustal warping and the subsequent re-adjustment of the continental land mass. By the Early Tertiary continued subsidence led to a greater marine influence in the Otway Basin (with the deposition of the Wangerrip Group), and the initiation of non-marine Renmark Group sedimentation in the Murray Basin.

In the Late Eocene or Early Oligocene, basalts of the Older Volcanic phase were extruded over the high land that divided the two sedimentary basins. Much reduced in area, the present outcrops are scattered around Coleraine, and along the Glenelg River between Mooree and Powers Creek. Basalts of the same series are also found at depth in the Otway Basin.

Transgression of the sea continued, submerging part of the Murray Basin. Sedimentation went on in both basins during the Oligocene and the Miocene. Besides terrestrial and estuarine deposits, marine sediments were laid down, with sands and sandy sediments inshore, clays and marls further out, and limestone in the deeper waters. Most strata contain abundant fossils.

The richly fossiliferous limestone and the marls and clays of the Heytesbury Group (locally called the Glenelg Group) outcrop from the Glenelg River valley around Harrow to the coast but thicken south of the Dundas Tablelands towards the Otway Basin proper.

At the same time the Murray Group of limestones, sandstones, and marls were being deposited in the northern basin. By the end of the Miocene the sea had reached its maximum occupation of the Murray Basin. It lapped the Grampians, extended eastwards as far as Glenorchy and the Gredgwin Ridge, and made an island of Mount Arapiles. The Avoca and Wimmera Rivers were estuarine.

Along the eastern margin of the Grampians (north-east and east of Lake Lonsdale) deposits of ferruginous sand, gravel, and clay form a tableland surface (since partly eroded) on an undulating base of Ordovician rocks. Miners won gold from deep leads here. A thin horizon with marine fossils found in one lead suggested a Miocene age. These strata probably resulted from the interfingering of marine and non-marine deposits on the margin of the basin.

At the end of the Miocene, upwarping in the Otway Basin interrupted deposition, causing the sea to regress from most of the Dundas Tablelands.

Pliocene rocks

Sea level varied greatly throughout the Pliocene epoch.

The Dorodong Sands Formation - which outcrops south and south-east of Wannon, and consists of ferruginous sandstones, fine conglomerates, clays, and siltstones characteristic of shallow marine (coastal) conditions - was laid down at this time in the Otway Basin.

Along the Tea Tree Creek and Grange Burn, calcareous sandstones, contiguous with the Dorodong Sands, give an indication of the fluctuating depth of the waters of the Otway Basin at this time.

In the Murray basin numerous shallow near-shore marine deposits of sand and clay were laid down, and existing coastal deposits, including some of the older deep leads, were reworked at the same time. Newer deep leads were formed when the sheets of sand and silt of the Parilla Sand (equivalent to the Dorodong Sands) covered the coarse gravels and sands transported out into the basin by the major streams.

Deposits of Parilla Sand are found west, north, and east of the western Black Range and in the Harrow and Kadnook districts.

The upper surface of the Parilla Sand has been moulded into a series of linear ridges trending NNW--SSE. These are regarded as the positions of stranded coastlines developed by the retreating Pliocene sea. Northwards, into the basin, much of the Parilla Sand is masked by later Quaternary deposits and only the ridgetops of the former protrude.

The extensive Dundas and Merino ferruginous strata, in places up to 10 m thick, capping the tablelands surfaces south-west and west of the Grampians (and possibly also occurring beneath the basalt) have been grouped on the geological map under the name "laterites". Most of these laterites are very similar across a variety of host rocks, but some include transported sands and angular reef quartz gravels. The laterites are thought to be Upper Pliocene in age, and to have developed in a humid climate where marked seasonal changes in the water table took place.

Quaternary rocks

Around the end of the Pliocene the sea was retreating. Crustal warping, and the consequent elevation of the land, intensified, and many important fractures (such as the Kanawinka Fault, just west of the study area) were formed or renewed.

Volcanic activity, which had been sporadic throughout the Tertiary, greatly increased, culminating in the basalt sheets and fragmental scorias and tuffs widespread throughout the Western District.

Recessions of the sea

The sea continued to retreat in stages. The calcarenites - consolidated dune (sandy) limestones - of the Bridgewater Formation represent the positions of former coastlines in the Otway Basin. They have the typical structure of backshore and longshore dune deposits, and in places underlie the present coastal sand ridges.

As more land was exposed, leaching and weathering commenced and the loose siliceous sands that developed were redistributed by the wind to form sand sheets and low terrestrial dunes. These formations are called the Lowan Sand in the Murray Basin and the Malanganee Sand in the south and along the western flank of the Grampians. The Murray Basin deposits are probably the oldest of this group of strata.

North of the Glenelg River catchment, and west of the Wimmera River, extensive alluvial and aeolian deposits overlie Pliocene sandstones to form the plains of the south-western Wimmera.

The Basalt Province

The basalt plains and volcanoes belong to the Newer Volcanic phase that occurred between Late Pliocene and Recent geological time (that is, between several million years and 7,000 years ago). In the study area, basalt flows (forming portion of the Western District volcanic plain) extend southwards from the Wannon River to the coast. Estimates of the ages of three of the younger flows are:

Mount Napier	7,265 ± 140 years
Mount Eccles (Tyrendarra flow)	6,260 ± 120 years
Mount Gambier (South Australia)	1,435 ± 90 years

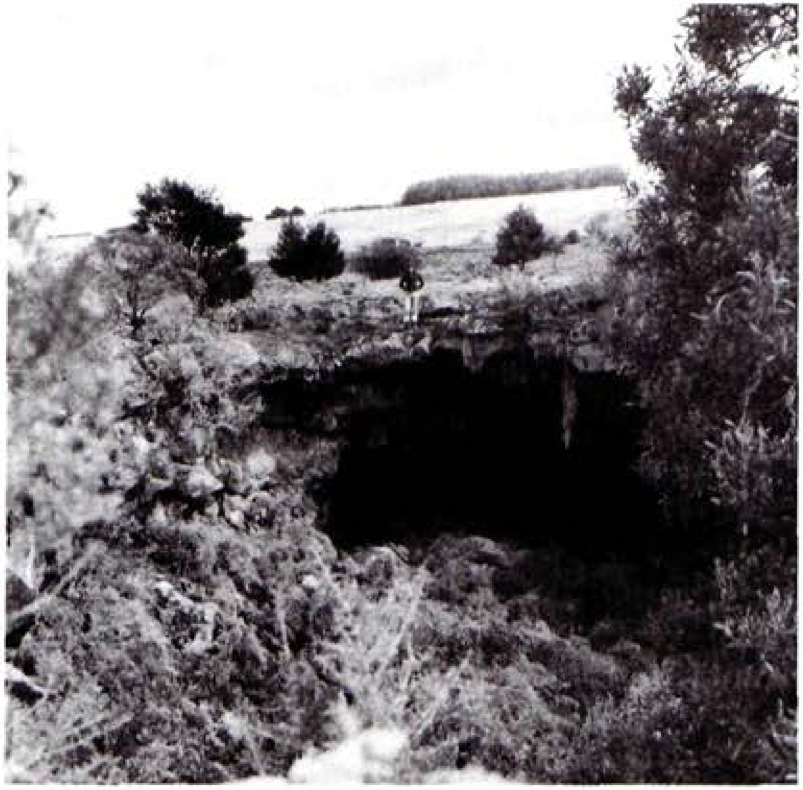
These estimates have been obtained by taking radiocarbon dates of samples from the base of peat deposits that developed after the lava flows blocked drainage lines and caused swamps to form. They therefore indicate minimum ages for the respective eruptions.

There are three types of lava emission:

1. Extensive basalts, forming most of the plain and representing extrusions of large volumes of very fluid magma onto flattish surfaces. Low-angled hills of basalt or lava cones have developed at points of eruption.

2. A more explosive (pyroclastic) phase represented by scoria cones, basaltic tuff, and ash and confined to the environs of certain eruption points like Mount Eccles and Mount Napier.

3. Smaller flows, in comparison with the first-mentioned enormous extrusions, often limited to valleys and forming small plains of stony rises (for example, the areas of lava extending out from Mount Eccles and Mount Napier discussed below). They include phenomena such as lava caves, which are caused by the complex effects of surface cooling on the movement of fluid rocks. A very young flow from Mount Napier down Harman Valley runs for 24 km; the Tyrendarra extrusion along Darlot Creek to the coast covers 34 km and



One of the lava caves at Byaduk

extends a further 16 km into Portland Bay.

The earlier lavas are deeply weathered, as are the cones, which may be low and rounded (for example, Mount Bainbridge) or display an ill-defined crater (for example, Mount Pierrepoint). The soils are generally deep; some are lateritic.

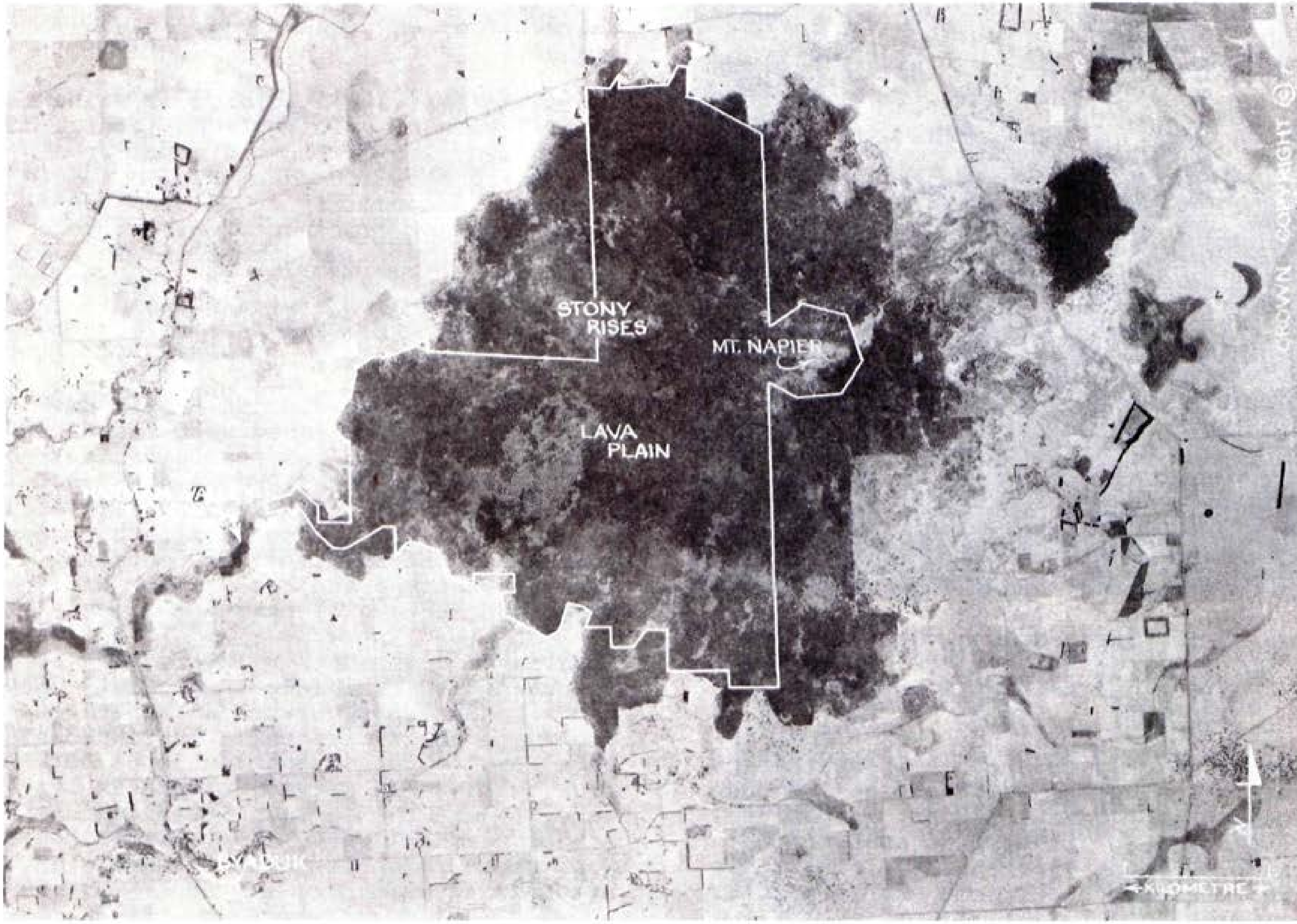
Although these basalt flows interrupted the existing drainage system, there has generally been sufficient time for new watercourses to become fully established.

Two of the largest stretches of volcanic country remaining in western Victoria as public land lie within the study area - at Mount Eccles and Mount Napier. Both of these features are scoria cones offering abundant evidence of recent volcanic activity (such as negligible soil development and disrupted or sub-surface drainage, and also a wide range of ejected material, from fine ash to basalt blocks and bombs).

Lake Surprise, the flooded crater of Mount Eccles, is aligned with a series of smaller spatter and scoria cones, one of which (on private land) has an open vent 3 m wide. Magma withdrawal created a vertical cavern, some 30 m deep, known locally as The Shaft. This contains lava stalactites and has a floor of loose scoriaceous blocks.

Lava caves form another interesting feature of the volcanic landscape. They occur in lava masses when an upper crust cools and solidifies while the internal lava remains liquid and continues to flow, ultimately leaving a void in its wake. Where the surface lava remains supported and intact, a cave is formed. Most caves resemble railway tunnels in section and plan.

Harman Valley, on Crown land, includes a dozen such caves. They occur also at



Aerial photograph of the Mount Napier region, showing the lava plain and Harman Valley flow

Mount Eccles on both public and freehold land.

The Tunnel Cave on public land just north-east of Lake Surprise is one of the finest lava caves in Victoria.

Another example is Church Cave at Byaduk (Mount Napier); it has a chamber 50 m long with 7-m vertical walls.

Both the Inner Turk Cave at Byaduk and Gothic Cave at Mount Eccles have cross-sections with peaked ceilings, which suggests in each case that pressure from subsequent flows of plastic lava nearby deformed the cave before its walls had fully cooled and solidified, but was insufficient to fracture the roof (that is, the surface crust).

The walls of many tunnels display flow marks, wrinkles, drip marks, and stalactites, often up to 40 mm long, testimonies to the lava's original liquid state.

Often, however, buckling occurs and caves collapse, at least partially, causing the crust to form a confused and rough surface topography of hummocks and depressions, made the more jagged by the jointing of the outer lava. Generally with a relief of 6--10 m, these complex features are known as stony rises. Where the entire length of roof has collapsed, long, sinuous, deep-walled depressions are formed, as at Mount Eccles and between Turk and Tunnel Caves at Byaduk.

Lava blisters are hollow features that have formed on the surface due to steam generation beneath the flow (especially when the flow passed over swamps). No true lava blisters are known in Victoria.

What have been called "lava blisters" (for example, features at Wallacedale) are better described as "tumuli". These are lumps on the lava sheet where localized pressure from underlying liquid has forced up the early-cooled lava skin in a bulge, without rupturing it.

The Harman Valley flow also contains lava barriers on both Crown and freehold land. These are ridges, either across a flow or on its edges, which are pushed up when pressure is developed by the internal movement of the lava.

Great Barrier, on public land near the junction of the Napier lava plateau with the Harman Valley, extends for 150 m. It has a fracture along its crest 6 m deep and a trough 14 m deep in its lee.

Scree and Alluvial Deposits

Below the scarps of the Grampians, and along some of the internal valleys, extensive sandstone scree slopes gradate outwards to finer-grained outwash deposits. This sedimentary sequence is the product of the erosion of the Grampians. Detritus blankets most of the valley of the Glenelg River upstream from Victoria Gap. To the east and north of the Gram-

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pians, outwash fans merge into the alluvial deposits of the plains.

Also to the north and east are extensive deposits of medium-grained sand, gravel, and clay. Laid down over the Pleistocene epoch by a drainage system that probably carried more water and was larger in area than the present one, these plains are characterized by the subsequent surface development of dark, heavy clay soils.

Recent alluvial deposits of gravel, sand, and clay are confined to valleys of the present drainage system. They are clearly defined in the Grampians and along the main rivers, but become less well-defined on the basalt country and the Wimmera plains, especially the latter.

The down-cutting of present streams has formed terraces in earlier alluvium and trimmed older outwash deposits.

Soil development on these deposits is minimal and they are inundated during flooding.

Numerous lake and swamp deposits of sand, silt, and clay occur on the Wimmera plains and, in the south, on the basalt and coastal plains.

Glossary

backshore - the upper shore zone beyond the reach of ordinary waves and tides

basement - a series of (generally) older, metamorphosed, or igneous rocks, overlain by younger sediments: the basement acts as a foundation for the overlying strata

bombs - fragments of liquid or plastic lava, ejected from volcanoes, which are shaped aerodynamically during flight and retain this shape on cooling

calcareous - containing calcium carbonate

conformable - strata lying one above another in unbroken, undisturbed, and parallel order are said to be conformable (cf. unconformable, where adjoining beds are not parallel, or disconformable, where adjoining beds are parallel, but there has been a break in deposition and subsequent erosion of the surface of the lower stratum)

conglomerate - a sedimentary rock consisting of water-worn fragments of stone and pebbles cemented together by another mineral substance

cross-bedding - where laminations in a rock vary in orientation, instead of being parallel to the plane along which deposition took place; found only in granular sediments

cuesta - an unsymmetrical ridge: the back slope is long and gentle and generally agrees with the dip of the resistant beds forming the ridge; the other is steep or even precipitous and exposes the beds in cross-section

deep leads - see glossary - Mining and Quarrying

differential erosion - the development of an uneven surface because of variations in the hardness of rocks and their resistance to erosion

dyke - a tabular body of igneous rock cutting across the strata of adjacent rocks or filling a fissure in massive rocks

fault - a fracture zone along which the strata on one side have been displaced relative to the strata on the other: in a reverse fault, one side has been sheared and uplifted in such a way that it overhangs the other side

feldspathic - containing feldspar, the name of a major group of rock-forming minerals, such as orthoclase and plagioclase

ferruginous - containing iron

fluvio-glacial deposits - deposits made by streams flowing from glaciers

fossiliferous - containing fossils

geosyncline - large, generally linear trough, which subsided deeply over a long period and in which a thick succession of stratified sediments and possibly extruded volcanics accumulated

greensands - sands containing glauconite, a green mica-like mineral

greywacke - a dark-coloured tough sandstone, with quartz grains set in a clayey matrix

hornfels - a fine-grained (contact) metamorphic rock found close to igneous intrusions

interfingering - where deposits grade from one to another through a series of interlocking layers

intrusion - a body of igneous rock that invades and replaces an older rock

isotopic dating - estimates of the age of a material can be obtained by comparing the proportion of radioactive and non-radioactive isotopes of certain elements with the known rate of decay (fission) of the radioactive isotope: fission-track dating using uranium isotopes will determine ages from a few hundred years to hundreds of millions of years; the isotope

	carbon 14 is used for ages to around 40,000 years; potassium and argon isotopes are used for dating rocks older than this
laterite	- granular to massive concentrations of complex iron and aluminium hydroxides formed on the surfaces of various rock types due to prolonged leaching in a humid climate
lava	- fluid rock issuing from a volcano or a fissure in the earth's surface; the same material cooled and solidified
lithology	- the physical character of a rock
marl	- calcareous clay or impure limestone
metamorphic rocks	- rocks formed in the solid state by pronounced changes in temperature, pressure, and chemical environment but not, in general, at the surface by weathering or cementation
razorback	- a sharp narrow ridge
sedimentary rocks	- rocks formed by the accumulation of sediments in water or on the surface through wind action
siliceous	- containing abundant silica, or quartz
sill	- a large body of igneous rock intruded parallel to the bedding planes of older rocks
structural high	- the upper part of a dome or anticlinal structure
tillite	- boulder clay; sediment carried or deposited by a glacier that has neither sorted nor stratified
varved	- continuous seasonal sedimentation; therefore neighbouring layers contrast

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6. PHYSIOGRAPHY

This chapter describes the landscape and the way it has been formed, and also separates it into physiographic units.

The land forms in the study area reflect the variety of different rock types found there, and the sequence of alternate periods of land formation and erosion that have occurred throughout geological time. They also reflect the effects of the climate of the last several million years, particularly through the actions of weathering and stream erosion.

Drainage

The most prominent physiographic feature of the study area is the Grampians - the extensive central range of mountains. The major streams originate in (or are fed from) this range and flow north onto the Wimmera plains or south to the ocean.

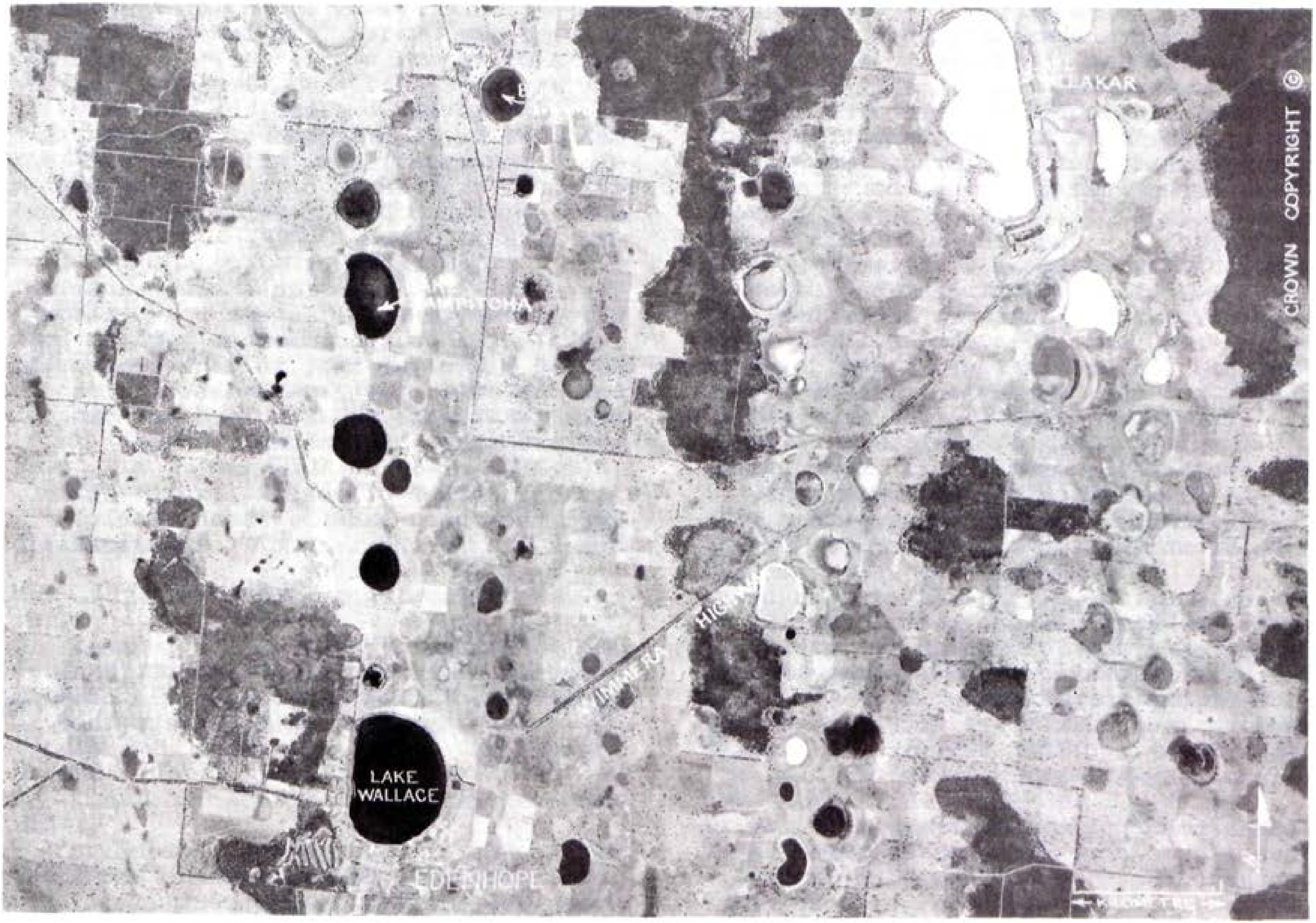
The Great Divide, which includes the Grampians, separates the streams that flow inland from those that run coastwards. It is well defined at the boundary between the catchments of the northward flowing Wimmera River and the Hopkins River, and in the Grampians and Black Range, where it sharply delineates the watersheds of the MacKenzie River and other streams from that of the Glenelg River.

West of the western Black Range it follows the northern rim of the Glenelg's deep valley and peters out on the plains towards the South Australian border.

The main streams flowing northwards from the Grampians are, from west to east, Norton Creek, MacKenzie River, and Mount William Creek; each enters the Wimmera River system. All of the streams that run northwards lose much of their water during dry periods through percolation and evaporation. There are only a few short, non-perennial streams further west on the plains between Natimuk and Apsley, but a multitude of lakes and swamps.

The Wannon and Glenelg Rivers both drain southwards by complex and sinuous courses.

Parts of the Major Mitchell Plateau and Serra Range form the upper catchment of the Wannon. The valley here is broad



Strings of lakes aligned NNW--SSE on the south-western Wimmera plains between parallel ridges of sand; most of the ridges remain uncleared and shallow. It narrows between Teddy Bear and Mirranatwa Gaps then widens again, allowing the river to follow a shallow swampy course. Emerging from the Grampians through a breach at the end of the Mount William Range, the river spreads out into Brady Swamp then flows westwards, skirting the basalt edge along an ill-defined marshy course to Cavendish. Compared with this middle stretch, the sections of the river above Brady Swamp and downstream from Cavendish are mature (in terms of profile, definition, and efficiency of drainage). Probably the Wannon once flowed directly south, but was dammed and diverted west by lava flows.

The southern Dundas Tablelands feed the Dundas River--Stony Creek and Koroite Creek--Konong Wootong Creek systems, both of which join the Wannon.

The head of the Glenelg River lies between the Victoria Range and the low dissected granitic mass to the east. The river flows northwards along the foot of the granodiorite to the broad, sand-choked plain where Moora Moora Creek joins it, then trends north-west, maintaining a swampy course.

It has been postulated that the Glenelg once flowed north but was captured by a southward-flowing stream. The latter had enlarged its catchment by headward erosion until it could tap the waters of the Glenelg and force it to drain directly to the ocean.

South of Cherrypool and on the northern part of the Dundas Tablelands, the Glenelg and its tributaries are more incised, having eroded the Silurian rhyolites and, in places, exposed the older sediments below. This contrast of swamps above Cherrypool and incised stream-beds below is the result of the doming and tilting of the Dundas Tablelands during the Late Pliocene.

The Eumeralla River flows southwards across the coastal flats through a series of wide swamps. Recent sand dunes dammed the river and, in consequence, it was forced to turn south-east and run parallel to the coast before entering the sea south of Yambuk.

A short series of coastal swamps inland from the dunes and the marshy Darlot Creek lie to the west of the Eumeralla.

Physiographic Units

The main physiographic units in the study area are shown on Map 3. To a large extent they can be correlated with major rock types. Map 4 depicts the topography of the study area.

Wimmera plains

Within the study area the bedrock outcrops of the Dundas Tablelands and the Grampians define the southern limit of the Wimmera plains, which fall away gently to the north and are studded with lakes and swamps.

Tertiary marine sediments with an upper veneer of Quaternary fluvial and aeolian deposits overlie the plains. Low, parallel, elongated ridges of Parilla Sand trending NW--SE protrude through this cover in places, or their underlying presence may be indicated by the conformation of the Lowan Sand that forms the dunes. West of Mount Arapiles the Wimmera plains are gently undulating, with most streams petering out rapidly through chains of swamps and lakes developed in low-lying corridors between the ridges and dunes. Lunettes often bound the lakes to the north-east and east. To the east of Mount Arapiles the plains consist of fluvial sediments with minor dunes. Most streams in this area reach the Wimmera River, although their courses are often ill-defined.

The Grampians ranges

This physiographic unit comprises the ranges formed from the sediments of the Grampians Group - massive sandstones and conglomerates, siltstones, and mudstones. The unit includes Mount Arapiles, the western Black Range, and the Dundas Range, as well as the Grampians proper. These ranges are characterized by rugged and spectacular rocky escarpments.

The distinctive and striking topography of the Grampians and the other ranges is a result of folding and faulting and the subsequent erosion of the less-resistant sediments by the main streams. This has left a series of strike ridges and valleys. In front of each ridge, a high escarpment exposes bed after bed in cross-section. Behind each ridge is the gentler dip slope, roughly parallel to the direction in which the beds dip away to the west. In addition, many of the tributaries have cut their courses along joint planes.

The Grampians rise to a height of 1,173 m on the Major Mitchell Plateau; this and Mount William (1,168 m) represent preserved remnants of an old land surface or peneplain developed during Early Mesozoic time. Low-dipping (10--30°) strata have been eroded to sparsely vegetated cuesta-type dip-slopes with westerly aspects, such as the Mount William Range. They terminate in steep scarps facing east above high screes. The serrated, hogback-like Serra Range has much steeper dips (30--60°).

In sharp contrast to the Grampians Group of sediments, the granitic rocks intruding the range are less resistant to erosion and therefore have been deeply weathered. They form the low hills between the Victoria and Serra Ranges, and the gentler slopes around Zumsteins. In two other areas, Mafeking and Stony Creek, granodiorites have been eroded out, forming small basins.

Midlands

The Divide traverses this physiographic region of undulating plains and ridges.

Aerial photograph showing the Serra and Mount Difficult Ranges, and the scarp of the Major Mitchell plateau

A continuation of the Central Highlands, the midlands unit separates the Wimmera plains from the volcanic plains of the Western District. The highlands consist of Palaeozoic sedimentary rocks intruded and metamorphosed by granites and granodiorites. The resistant granite of the eastern Black Range south-west of Stawell stands above its surroundings, as do ridges of hornfels such as Mount Ararat.

The Cambrian rocks in the Mount Stavely --Mount Drummond belt protrude as low hills through the Cainozoic sediment that covers the plains east of the Grampians.

Dundas Tablelands

Deeply dissected by streams, the Dundas Tablelands have a characteristic landscape of steep valleys falling away from uniformly flat remnants of the plateau.

Weathering of the Dundas Tablelands probably commenced at the end of the Late Cretaceous, and, after a long period of erosion, a peneplain was formed on the Palaeozoic rocks.

Thin heavily lateritized Mesozoic and Tertiary sediments mask this surface. Late Tertiary block faulting has raised and tilted the Dundas Tablelands in such a way that the present elevation is some 200 m above sea level. Dissection by the Glenelg and Wannon Rivers and their tributaries has exposed inliers of Palaeozoic rocks.

The strata forming the Dundas Tablelands disappear to the north below the Wimmera plains and to the south-east below the basalt plains. In the south-west they grade into the somewhat lower Merino Tablelands.

Merino Dissected Tablelands

The Merino Dissected Tablelands are formed from soft, easily eroded Lower Cretaceous sediments, so they have been weathered to a greater degree than the Dundas Tablelands, from which they slope away southwards.

This unit has a characteristic landscape of rounded, almost pillow-like ridges. A thin cover of Tertiary sediments caps it on the western edge and surface strata have been lateritized throughout, in places to a depth of 10 m.

Volcanic plains

This unit is composed of broad undulating plains; they are interrupted in places by low rounded hills, steep-sided but shallow valleys occupied by swampy watercourses, and patches of broken country where the younger lavas outcrop.

The lavas forming the volcanic plains obstructed the streams that drained the southern parts of the Grampians and the Dundas Tablelands. The headwaters of the Wannon were blocked and diverted westwards to skirt the northern edge of the basalt. As a consequence a chain of marshes developed along the river between Brady Swamp and Cavendish.

Further south, the Eumeralla River was displaced westwards by lava flows from Mount Rouse. On the plains themselves, the drainage system is immature, with ill-defined stream courses and numerous swamps. The older lavas constitute the major part of the plains and the youngest are termed 'stony rises'. There are examples near Mount Napier and Mount Eccles. Eruption points occur at Mount Pierrepoint, Mount Napier, in the Mount Eccles--Macarthur area, and south of Broadwater. Lake Surprise at Mount Eccles is a flooded crater.

Coastal plains

Known as the Tyrendarra plains, the subdivision of the coastal plains within the study area is a low-lying, flat region of Glenelg Group Tertiary sediments overlain in places by sheets of quartz sand.

Recent dunes of uncemented sand mark the coastline; they overlie resistant (that is, consolidated and cemented) Pleistocene calcareous dunes. Sand drifting in continually from the west adds to these dunes, and has caused the mouths of the coastal streams (like the Eumeralla and Fitzroy Rivers) to shift to the east.

Glossary

Aeolian deposits - deposits arranged by the wind

Bedrock - any solid rock exposed at the earth's surface or overlain by unconsolidated material

Dip slope - a sloping land surface that conforms approximately to the dip of the underlying rocks

Dissection - the work of stream erosion on a relatively even surface

Doming - a roughly symmetrical upfolding, the beds dipping in all directions, more or less equally, from a point

Escarpment - a steep slope that terminates high land abruptly

Fluvial - pertaining to rivers; produced by river action

Headward erosion - the extension of a valley at its upper end by stream erosion

Hogback - a ridge produced by highly tilted strata, or a hard stratum of rock dipping steeply downwards

Inlier - a more or less circular or elliptical outcrop of older rocks surrounded by younger strata

Joint planes - lines of fracture in rock, usually perpendicular or transverse to the bedding, along which no movement has occurred

Lunette	- crescent-shaped ridge on the lee shore of a lake or swamp
Peneplain	- a land surface worn down by erosion to a nearly flat or broadly undulating plain
Strike ridge, valley	- a ridge or valley running parallel to the general orientation or the surrounding strata

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7. CLIMATE

Being approximately 170 km from northern to southern boundary, and the same distance across, the study area shows considerable variation in climate.

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; they can be almost stationary for even a week or more at a time.

The climate is mild and the rainfall relatively reliable along the coast and on the higher parts of the Grampians. The Wimmera plains are drier and warmer, but still receive a greater and more assured rainfall than the Mallee region further to the north.

The most detailed analyses of the climate of the study area are contained in the reports issued by the now-defunct Victorian Central Planning Authority on the Glenelg and Wimmera Regions. Much of the present chapter is based on the data the Authority collected, but it has also called on the most recent rainfall and temperature records.

Rainfall

The study area generally, and particularly along the coast, has its highest rainfall in winter. The bulk of the year's rain falls between April and November. Summer rainfall is in the range 18--33 mm per month, and January and March tend to be drier than February, although more in the north than in the south. Table 3 sets out rainfall data at a number of stations, and Map 5 shows the regional isohyets.

Perhaps contrary to expectations, the heaviest downpours occur between December and April. One March at Branxholme, just outside the study area, 209 mm fell in 24 hours, the highest figure ever recorded for south-western Victoria before 1960. Most other stations have had up to 75--100 mm of rain in a day.

Average annual rainfalls are greatest near the coast, and decrease steadily northwards, except for orographic increases in the highlands, especially in the Grampians. (Orographic rain results

Table 3

RAINFALL

A = Mean rainfall in mm
B = Median rainfall in mm
C = Average number of raindays
(A rainday is a day receiving .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 and span of records		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Cavendish	A	33	32	37	53	63	70	69	72	69	62	48	41	649
1884--1975	B	26	21	28	50	59	65	65	70	65	60	44	39	643
	C	6	6	7	11	14	14	17	17	14	14	11	10	141
Coleraine	A	27	30	38	49	60	62	67	71	66	20	46	38	614
1898--1976	B	20	21	26	49	57	61	66	67	62	61	38	32	604
	C	6	5	7	10	14	15	16	16	15	13	10	8	135
Edenhope	A	25	25	29	47	62	68	76	73	65	57	39	33	599
1890--1975	B	18	14	25	42	52	64	68	75	63	53	35	26	593
	C	4	4	5	9	12	12	15	16	12	11	8	6	114
Goroke	A	24	28	24	41	55	60	64	62	56	49	36	28	527
1887--1975	B	15	17	18	37	48	56	64	64	54	45	28	22	513
	C	4	4	4	8	10	11	13	14	11	10	7	6	102
Halls Gap	A	33	40	40	62	97	118	108	118	101	85	65	49	916
1874--1963	B	27	25	32	53	84	114	103	110	98	78	55	39	901
	C	6	6	6	11	13	15	18	18	14	14	11	9	141
Hamilton	A	33	32	43	55	69	71	74	77	72	67	51	46	691
1869--1976	B	27	22	35	52	66	71	70	76	67	66	49	41	676
	C	8	7	10	13	17	18	20	19	17	15	12	10	166

Table 3 (continued)

Station and span of records		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Harrow 1908--75	A	24	33	30	45	62	64	72	74	65	56	38	34	597
	B	18	26	21	37	55	57	67	73	68	53	32	29	605
	C	4	4	5	8	11	12	14	15	11	10	7	6	107
Horsham 1873--1975	A	22	27	25	34	47	50	46	48	45	43	34	28	449
	B	13	17	18	30	42	47	47	47	43	37	28	21	441
	C	4	4	5	7	10	12	13	14	11	10	7	5	102
Macarthur 1936--76	A	38	41	48	63	77	67	88	91	73	72	61	51	770
	B	33	32	32	61	72	61	87	84	73	70	53	51	764
	C	6	7	8	11	15	14	16	17	15	14	11	9	143
Mirranatwa 1901--74	A	29	37	36	54	65	64	73	77	76	63	51	41	666
	B	23	30	30	43	64	57	67	75	70	58	45	36	660
	C	3	4	4	8	9	9	12	12	10	9	7	6	93
Moyston 1886--1975	A	30	36	34	44	53	56	61	65	57	57	45	35	573
	B	22	22	25	40	53	53	59	62	53	55	37	29	577
	C	4	4	5	7	9	11	12	13	10	9	7	5	96
Natimuk 1889--1975	A	23	28	25	33	44	48	51	50	45	41	36	29	453
	B	16	17	21	28	42	45	46	51	42	35	28	22	452
	C	4	4	4	8	10	13	14	15	12	11	8	5	108
Toolondo 1934--46	A	29	17	15	42	35	48	59	58	45	33	38	7	426
	B	17	17	11	43	23	43	51	52	39	34	32	0	371
	C	No records available												
Willaura 1902--75	A	29	38	38	44	50	45	50	56	55	52	48	39	544
	B	22	25	27	39	50	43	48	57	55	52	36	32	546
	C	6	6	7	11	14	13	16	16	14	13	10	8	134
Yambuk 1970--76	A	36	41	54	75	79	69	97	99	76	97	66	36	825
	B	30	41	49	67	91	68	104	99	79	106	60	52	883
	C	7	4	15	15	17	18	23	21	20	18	13	12	183

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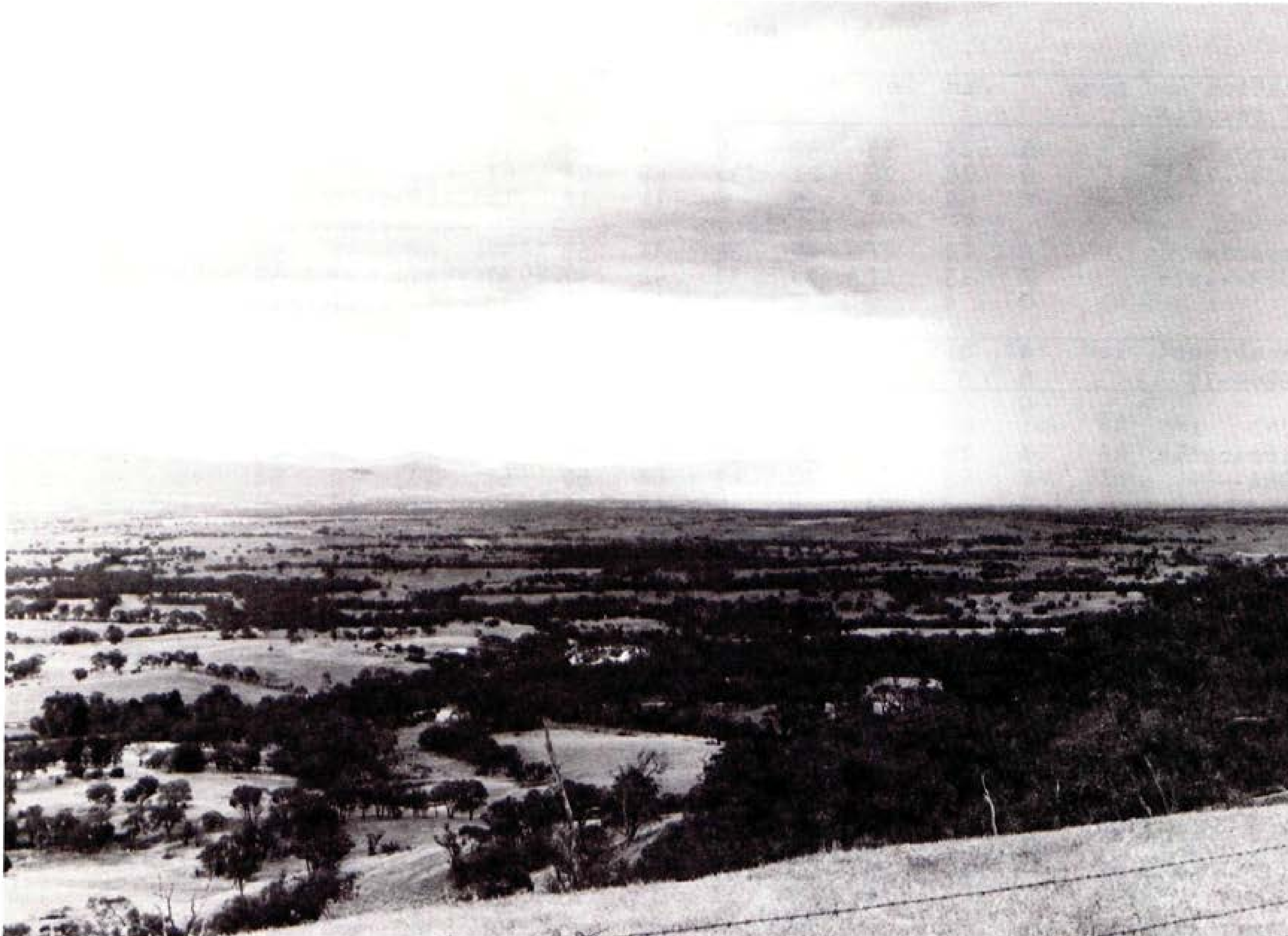

Heavy shower - taken from One Tree Hill, looking west to the Grampians when high land forms lying across the path of the wind force moist air to rise.) There is a corresponding rain-shadow in the midlands, which are to leeward of the Grampians.

Regional rainfalls range as follows:

Coastal plains	750--850 mm
Volcanic plains	750--800 mm
Merino Tablelands) Dundas Tablelands)	600--650 mm
The midlands	500--550 mm
Black Range (western)	625 mm approx.
The Grampians	650--950 mm
Wimmera plains	425--550 mm

Length of growing season

Plant growth depends partly on the soil (drainage, aeration, nutrients, heat transference, depth, texture) and partly on the climate (light, temperature, and distribution of rainfall). The most favourable periods for growth are usually late spring and, to a lesser extent, autumn, because usually rainfall is adequate and temperatures are favourable.

The length of the growing season will therefore vary from year to year, but generalizations can be made.

Statements on the length of growing seasons are based on the criterion of "the month of normally satisfactory rainfall", during which rainfall has a better than 50% chance of exceeding "the effective" amount. The latter quantity is, in simple terms, "the amount of rain necessary to start germination and to maintain growth", and it depends on both rainfall and evaporation. At the end of the total period of effective rainfall the water stored in the soil allows plant growth to continue for some time. Irrigation and fallowing can also extend the length of the growing season. The former provides water in dry months; the latter conserves water in the soil.

Estimates of effective rainfall are useful for agricultural planning, but they do not necessarily indicate the effects of dry spells on deep-rooted plants, which are more able to resist drought.

The growing season in the north of the study area usually lasts for the 7 months from April onwards. Moving south, seasonal length increases and, on the coast, it is normally around 9--10 months.

Low winter temperatures also affect plant growth and interrupt the growing season.

Drought

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

As would be expected, the probability of drought in the study area increases from south to north. Occasionally conditions are severe enough to cause dieback in native vegetation. In the summer of 1967--68, many eucalypts and understorey shrubs lost their leaves - some died. Vegetation here usually recovers rapidly once substantial rain has fallen. Eucalypts develop new crowns from epicormic shoots; many other plant species sprout anew from their base or regenerate from seed. Winter droughts are rare.

Dust storms

Dust storms are a product of drought and of 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, at any time, can lift dust. 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, including the southern part, dust storms now occur only rarely because of pasture improvement and better techniques of cultivation, fallowing, and soil conservation.

Temperature

Few meteorological stations recording temperature exist outside main provincial towns in south-western Victoria. To give a degree of geographical representation, this chapter presents data for three towns - Portland (coast), Hamilton (volcanic plains), and Horsham (Wimmera plains). (Portland lies just outside the study area.) Table 4 summarizes the readings for the three towns.

All stations in the study area have, on occasions, experienced very hot days. All the lowland regions would have had summer temperatures greater than 42°C (108°F). The absolute record is Horsham's 48.5°C (120°F). Days exceeding 38°C (the Fahrenheit "century") may also occur in November and March, except along the coast, and even in October on the inland plains.

Average minimum temperatures remain fairly constant throughout, apart from the coastal belt where winter minimums tend to be higher than inland. The limited data given here illustrate this situation. In July, Portland, Hamilton, and Horsham have had absolute minimums of -2.8°C, -5°C, and -6°C respectively; their average minimums are 6.4, 4.1, and 3.8°C.

The average daily range of temperatures increases from coastal to northern stations. At any time of the year maximum temperatures are likely to be highest and minimum temperatures lowest in the north.

Variation (°C)	Portland	Hamilton	Horsham
Least	Jun 8.6	Jun 8.3	Jun 9.1
Greatest	Jan/Feb 9.1	Jan/Feb 14.8	Feb 16.9

Table 4

TEMPERATURES

PORTLAND (CAPE NELSON) Outside the study area but a typical coastal location for south-western Victoria

Latitude $38^{\circ}26'$ S Longitude $141^{\circ}33'$E Elevation 45 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
9 a.m. mean temperature ($^{\circ}$C) and mean relative humidity (%)													
Dry bulb	17.4	17.4	16.4	14.7	12.3	10.7	9.8	10.2	11.5	13.1	14.3	15.7	13.6
Humidity	78	78	82	81	87	90	86	87	85	80	83	80	83
3 p.m. mean temperature ($^{\circ}$C) and mean relative humidity (%)													
Dry bulb	18.7	19.0	18.4	17.1	14.6	13.3	12.2	12.7	13.7	14.7	15.7	16.7	15.6
Humidity	77	76	79	75	80	84	80	81	80	78	81	80	79
Mean daily maximum ($^{\circ}$C)	20.7	20.8	19.9	18.2	15.3	14.0	13.0	13.6	14.7	16.3	17.5	18.6	16.9
Mean daily minimum ($^{\circ}$C)	13.9	14.4	13.7	12.1	10.0	8.8	7.8	8.0	8.9	10.0	11.1	12.4	10.9

HAMILTON A typical inland location in the south of the study area

Latitude $37^{\circ}45'$ S Longitude $142^{\circ}2'$ E Elevation 186 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
9 a.m. mean temperature ($^{\circ}$C) and mean relative humidity (%)													
Dry bulb	18.9	18.2	16.3	13.1	9.6	7.6	6.9	8.0	10.3	12.8	14.9	16.6	12.8
Humidity	58	64	70	77	86	89	88	85	77	71	66	62	74
3 p.m. mean temperature ($^{\circ}$C) and mean relative humidity (%)													
Dry bulb	25.1	24.7	22.4	18.9	14.5	12.7	11.6	12.7	14.5	17.1	19.2	21.4	17.9
Humidity	37	40	45	52	65	68	69	64	59	53	51	45	54
Mean daily maximum ($^{\circ}$C)	26.4	25.8	23.4	19.8	15.4	13.5	12.4	13.6	15.4	18.1	20.6	22.8	18.9
Mean daily minimum ($^{\circ}$C)	11.8	12.3	10.9	9.1	6.9	5.3	4.7	5.1	6.2	7.4	8.6	10.2	8.2

HORSHAM A typical location in the southern Wimmera

Latitude $36^{\circ}43'$ S Longitude $142^{\circ}12'$ E Elevation 138 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
9 a.m. mean temperature ($^{\circ}$C) and mean relative humidity (%)													
Dry bulb	21.8	20.7	17.8	13.7	9.6	6.9	6.4	7.9	11.0	14.5	17.5	19.5	13.9
Humidity	45	47	58	70	79	87	85	82	72	64	54	49	66
3 p.m. mean temperature ($^{\circ}$C) and mean relative humidity (%)													
Dry bulb	29.4	28.4	25.5	21.2	16.2	13.9	12.7	14.2	16.6	20.2	23.2	25.9	20.6
Humidity	27	31	34	43	55	62	61	56	48	43	37	32	44
Mean daily maximum ($^{\circ}$C)	30.8	29.6	26.6	22.3	17.1	14.6	13.5	15.2	17.7	21.4	24.8	27.3	21.7
Mean daily minimum ($^{\circ}$C)	14.2	14.2	12.1	9.2	6.5	4.5	3.9	4.8	6.0	8.1	10.1	12.2	8.8

Sunshine

The following shows the trend of the changes in monthly totals of hours of sunshine throughout the year.

	Jan	Mar	Jun	Oct
Coastal regions	250	200	125	200
Northern regions	300	240	140	270

Evaporation

Evaporation records are scarce for rural Victoria and estimates must be made from values calculated for saturation deficit, which is a measure of the drying power of the atmosphere.

Annual rates of evaporation probably exceed annual rainfall on all open sites throughout the study area, except perhaps in the higher parts of the Grampians. These rates range from approximately 850 mm on the coast to around 1,150 mm in the north. (Compare these with annual rainfall in each case).

The greatest calculated monthly evaporation is in January - 125 mm in the south and 200 mm in the north.

Frost

Periods of severe frosts and frost-free periods probably range as follows. Exposed coast can expect 1 month of severe frost and up to 9 frost-free months. Most inland locations can expect 2 and 7--8 months respectively, while the highlands may get severe frosts in 3 months, with a frost-free period of only 6 months.

The first screen temperatures under 2°C (this being the highest screen temperature at which a frost will form) occur on average in May throughout the study area except for the highlands, where they may be earlier, and along the coast, where they may be later.

(Screen temperatures are those recorded by meteorological instruments housed in a standard ventilated cabinet known as a "screen". The thermometer is fixed 1 m above ground level, and screen temperature will therefore normally differ from ground temperature.)

Variations occur from year to year. Most stations have experienced frosts as early as March. Severe frosts (with screen temperatures of less than 1°C) start around June and usually number four to twelve a year throughout the study area.

Late frosts can be very damaging to plants and may preclude the cultivation of certain crops, as well as affect the distribution of native vegetation. In general the last severe frosts occur in August--September, and the last light ones in September--October, but Hamilton has experienced severe frosts in early December and light frosts on both December 29 and January 3.

Snow

Snow falls most years on the more elevated parts of the Grampians, but rarely lies there long. It is exceptional in all other inland localities.

Floods

Because of considerable regulation, flooding tends to be only of nuisance proportions in the streams that flow north. The Glenelg, Wannon, and Eumeralla flood more extensively, and mitigation works have been carried out on some stretches of these rivers.

Wind

Broadly speaking, the surface winds blowing from the interior of the continent (north-east to north-west) will normally be warm to hot and very dry throughout summer, while cooler weather is associated with west to south-west winds. During the winter the contrast in temperatures between the two wind streams is less marked.

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8. WATER RESOURCES

The study area is an important source of water for western Victoria. Rainfall in the Grampians far exceeds that on the surrounding plains and the streams flowing from the ranges collectively form the major surface water resource. Those flowing north and west have been tapped to supply water to much of the Wimmera and Mallee. Utilization of the water resources is discussed in Chapter 16.

Surface Water

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 Grampians varies from 700 to more than 900 mm (see Map 5). The elevated parts of the ranges are steep and rocky, and run-off is high. The lower areas, however, consist of broad gently undulating deposits of sand, and the streams that flow across them are swampy and have ill-defined water-courses. Run-off from the lower areas is slight, much water being lost through evaporation and deep seepage, although the latter ultimately contributes to the groundwater.

Average annual discharges from Grampians catchments vary from 560 Ml/km^2 for the MacKenzie River above Lake Wartook to 92 Ml/km^2 for the Glenelg River above Balmoral and 48 Ml/km^2 for the Wannon River above Dunkeld. This variation can be accounted for by the differing proportions of steep rocky land and low swampy land in the catchments.

The Glenelg and Wannon Rivers are the major streams flowing out of the Grampians. They meet near Casterton, and the Glenelg enters the sea at Nelson, near the South Australian border. The Wimmera River rises in the Mount Cole Range and the Pyrenees to the east of the study area, flows along its northern boundary, and drains the eastern flank of the Grampians.

Other main water-courses are:

* those that rise on the Dundas Tablelands, such as Mather Creek, Pigeon Ponds Creek, Chetwynd, Wando, and Dundas Rivers, and Koroite Creek, which flow into the Glenelg or Wannon

Table 5

WATER SALINITY

mg/l T.D.S.	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/l; Adelaide's is 300 mg/l.)
1,000 - 3,000	Brackish water. Maximum salinity humans can normally tolerate is around 2,000 mg/l. The threshold salinity for the growth of most plants is 3,000 mg/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/l), but very limited for use domestically and industrially.
7,000 - 16,000	Salty water. Beef cattle will tolerate up to 10,000 mg/l and sheep on saltbush can utilize water up to 14,000 mg/l. 16,000 mg/l is the maximum for sheep on green pastures.
over 16,000	Unsuitable for livestock.
36,000	Sea water.

* part of the headwaters of the Hopkins River on the plains south-west of Ararat

* the Eumeralla, Moyne, and Shaw Rivers, which are short streams flowing through flattish country to the coast

Catchments of the major streams are shown on Map 5.

Flow in all the streams varies greatly from year to year due to differences in rainfall; for individual years, however, some nine-tenths of the annual discharge is usually in winter and spring.

Water quality

A number of properties affect the suitability of water for domestic, stock, and irrigation use; the most important in this region is the salinity, measured as the total quantity of dissolved solids (T.D.S.). Table 5 illustrates how rising T.D.S. levels limit the uses to which water can be put. In general, 1,000 mg/1 T.D.S. is the upper limit for water for domestic use, 1,000--1,500 mg/1 for irrigation, and 7,000--16,000 mg/1 for cattle and sheep.

When streams are running high, salinities fall because of dilution. When stream flow is low, evaporation tends to increase the concentration of salt. Maximum salinities for streams in the study area tend to range from about 2,000 to 6,000 mg/1 T.D.S. In comparison, the Snowy River at Jarrahmond has a maximum recorded salinity of 120 mg/1, a typical figure for water-courses in the far east of the State.

Table 6 lists some of the stream characteristics in the study area and Figure 3 shows graphically the seasonal variations that typically occur.

Glenelg River

The catchment of the Glenelg River within the study area extends over some 3,100 sq km, taking in the western slopes of the Grampians, portion of the western Black Range, and the northern Dundas Tablelands.

The sole storage on the river is Rocklands Reservoir, above which the catch-

FIGURE 3

STREAM-FLOW VARIABILITY

SOUTH - WESTERN STUDY AREA DISTRICT 2

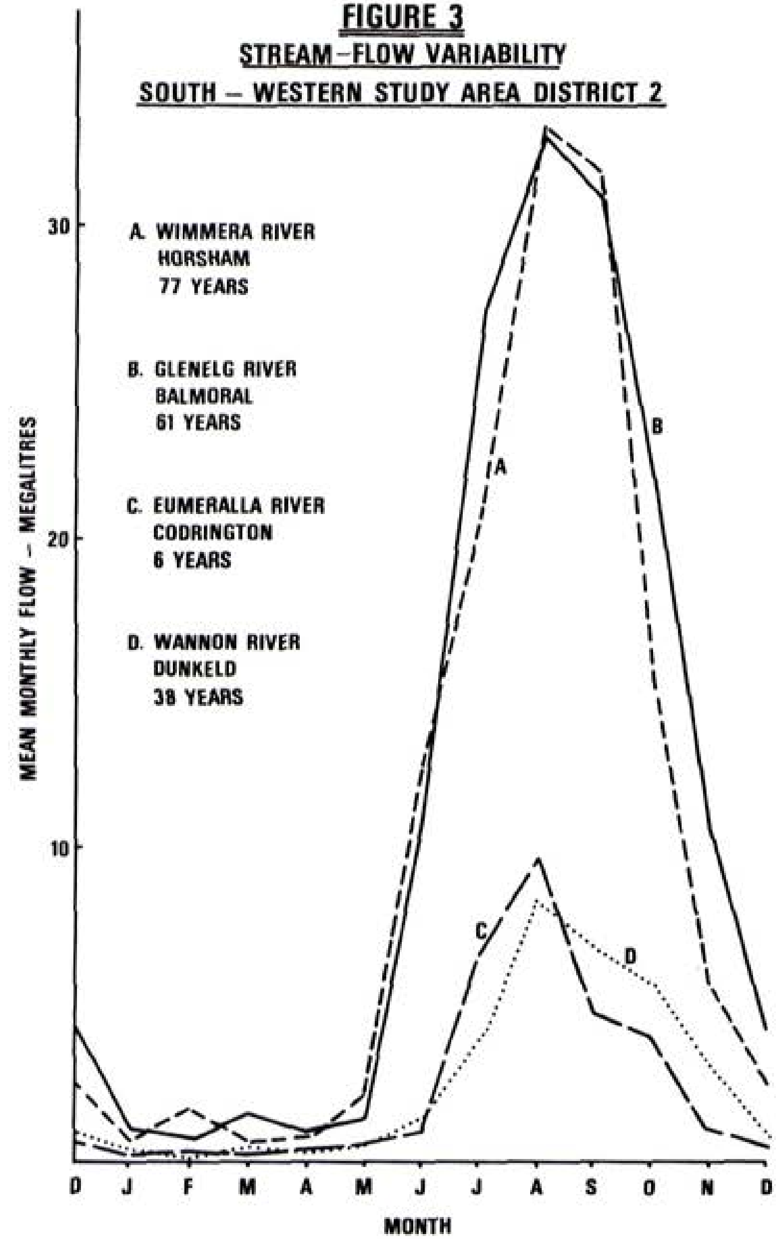


Table 6

STREAM CHARACTERISTICS

Stream system	Seasonal variation in flow	Location of gauging station	Area of catchment (km^2)*	Mean annual discharge (10^3 Ml)	Run-off from unit area Ml/km^2	Flow variability (Ml/day) Max.	Min.	Salinity (mg/l T.D.S.) Max.	Min.
Wimmera River	Winter 52%	Glenorchy	1,950	82	42	44,000	Nil	3,150	150
	Spring 41%	Horsham	4,070	123	31.5	39,000	Nil	2,200	105
MacKenzie River		Lake Wartook	34	18.9	560	12,200	Nil	386	35
Fyans Creek		Lake Bellfield	101	21.7	234	1,200	Nil	250	50 (1960--70)
Mount William Creek		Lake Lonsdale	1,026	63.3	62	26,400	Nil	500	75
Glenelg River	Winter 54% Spring 41%	Balmoral	1,570	144.6	92	31,800	Nil	4,200	312 (1965--70)
Mather Creek	Winter 57% Spring 34%	Pigeon Ponds	150	7.6	50	820	Nil	5,058	566 (1965--70)
Wannon River		Dunkeld	671	32.3	48	5,600	Nil	2,944	145
		Wannon Falls	2,243	123.4	55	8,600	Nil	4,818	252 (1964--70)
Eumeralla River	Winter 60% Spring 30%	Codrington	502	28.8	55	2,400	0.5	2,698	254 (1965--70)

This table gives an indication of the present-day characteristics of the streams in the study area. With the exception of the Eumeralla River, the waters of all streams listed above have been dammed, or are regularly diverted for various purposes. These figures do not take into account losses during storage through evaporation.

Balmoral gauging station - Added to the annual discharge figures measured at Balmoral are estimates of the volume stored in Rocklands Reservoir, and diversions along the Rocklands--Toolondo channel.

*Area above gauging station.

ment is generally forested. Because the stream bed is swampy, however, water quality is only moderate. Virtually all of the flow is impounded. Below the dam the Glenelg is fed mainly by tributaries draining agricultural land; the bulk of the discharge occurs in winter and spring, so the river usually ceases to run for much of the summer and autumn. (Small releases may be made from Rocklands during these months to ensure that water in the pools is not too saline for stock.)

Flow varies greatly from year to year. The maximum annual discharge recorded at Balmoral was the 1906--07 flow of 543,000 Ml; in severe contrast, the Glenelg carried a mere 3,100 Ml in 1914--15.

The main problems in the Glenelg system below Rocklands are flooding and salinity. Serious floods in the system appear to originate in the Dundas Tablelands because of the somewhat higher rainfall there. Most streams are very salty. Water in Mather Creek had a salinity of 5,058 mg/l T.D.S. when flow was around 5 Ml/day. Even during high floods salinity has been recorded at around 555 mg/l.

A small portion of the catchment of the Crawford River (some 100 sq km in extent) lies within the study area to the south-west of Hamilton. This stream flows south-west and joins the Glenelg River at Dartmoor.

Wannon River

The study area includes almost the entire catchment of the Wannon River. Covering some 2,900 sq km, the catchment embraces the southern Dundas Tablelands and portion of the volcanic plains (both of which are agricultural), and the forested southern slopes of the Grampians.

There are no major storages on the Wannon, although a tributary - Den Hills Creek - has been dammed. As with the Glenelg, the bulk of the Wannon's flow occurs in winter and spring. Maximum and minimum annual discharges recorded over 38 water years at Dunkeld are respectively 119,000 Ml in 1960--61 and 37 Ml during 1967--68.

The river's narrow upper valley is swampy, but water quality is high. Below the Grampians the swamps broaden and continue to Cavendish. The river loses water through evaporation and normally does not flow along this section in summer. Below Cavendish tributaries ensure perennial flow but they are brackish, particularly the Dundas River, so water quality is low.

Wimmera River

Some 2,900 sq km of the catchment of the Wimmera River is located within the study area. This system drains the eastern and northern Grampians, the northern half of the western Black Range, and the northern slopes of the midlands.

The steeper portions of the catchments are generally forested; most of the flatter country is agricultural.

Several storages dam the Wimmera and its tributaries, and others were constructed by extending natural swamps.

Three substantial tributaries of the Wimmera River are the MacKenzie River, Mount William Creek, and Norton Creek, all of which rise in the Grampians.

Flowing over the flat plains of the eastern Wimmera the river forms effluent streams (or distributaries); a complex drainage pattern results. The Wimmera does not flow to the sea but terminates in Lake Hindmarsh, north of the study area. Before regulation, flood flows discharged along effluents such as Outlet, Dunmunkle, and Yarriambiack Creeks to other inland lakes. This is much rarer today because of the number of large storages built on the Wimmera River system.

In common with the other large streams, the river has more than nine-tenths of its flow in winter and spring. Total annual discharge has varied greatly - from 591,700 Ml in 1956--57 to none at all in 1943--44 - since recording began at Horsham.

Water in the headwaters is of high quality. Salinity increases in the northern reaches, and the maximum recorded values at Glenorchy and Horsham are respectively 3,150 mg/l and 2,200 mg/l T.D.S. (The Horsham reading is lower because the several Grampians streams that enter the Wimmera River below Glenorchy dilute its brackish water.)

Hopkins River

The plains to the south-east of the Serra and Mount William Ranges form an inland drainage basin around Lake Muirhead, and portion of the catchment of the Hopkins, another river with variable flow and high salinity. This catchment is almost entirely agricultural land.

At Wickliffe, just outside the study area, the maximum recorded annual discharge of this stream was 127,000 Ml in 1956--57; the minimum figure was 500 Ml

The MacKenzie River at Zumsteins

Mount William Creek in the Grampians

in 1967--68. The highest salinity reading reached 9,396 mg/l when flow was 22 Ml/day.

No storages have been constructed on the Hopkins River.

Coastal streams

Coastal streams with catchments located fully or partly in the study area include the Moyne, Shaw, and Eumeralla Rivers and Darlot Creek. These short streams have marshy valleys through which drains have been cut to facilitate agricultural usage of the surrounding land. Their catchments cover the following approximate areas within the study district:

Moyne River	100 sq km
Shaw River	150 sq km
Eumeralla River	525 sq km
Darlot Creek	400 sq km

In each case the catchments are mostly agricultural land. Despite the greater reliability of rainfall in the coastal regions, these streams exhibit the same seasonal patterns of flow as the water-courses discussed above, although they rarely cease to run. For instance in 1967--68, a year of severe drought, the following total discharges were recorded:

Darlot Creek	2,600 Ml
Eumeralla River	13,400 Ml
Moyne River	2,400 Ml

In contrast, the maximum annual discharges recorded are:

1968--69	Darlot Creek	88,000 Ml
1964--65	Eumeralla River	72,000 Ml
1960--61	Moyne River	96,000 Ml

These streams have only been gauged during the last two decades. The coastal water-courses are brackish in their middle reaches when flows are low. The highest values recorded for Darlot Creek are in the range 1,900--2,800 mg/l T.D.S. In winter these streams are prone to nuisance flooding. No coastal streams have been dammed to serve as water storages.

South-western Wimmera plains

North of the Divide, the streams west of the Wimmera River catchment on the plains between Natimuk and Apsley are all non-perennial. Drainage lines parallel the sand ridges, and small swamps and lakes of varying salinity are common wherever local topography restricts overland flow or intersects the water table. In consequence water-courses are restricted in length, although some swamps and lakes are connected.

The Apsley--Langkoop district has somewhat higher rainfall than elsewhere on the plains, and the streams there (including Koijak and Mosquito Creeks), although still non-perennial, are more substantial. These creeks flow into Bool Lagoon, South Australia.

Table 7

NATURAL LAKES AND SWAMPS

Name	Water quality	Location	Approx. area (ha)
Lake Muirhead	F	10 km NW of Willaura	810
White Lake	S	16 km NE of Harrow	560
Booroopki Swamp	F	30 km N of Edenhope	420
Lake Kanagulk	S	14 km N of Balmoral	350
Lake Yallakar	F	13 km NE of Edenhope	350
Centre Lake	S	19 km NE of Harrow	260
Brady Swamp	B	27 km NW of Wickliffe	240
Lake Bow	S	18 km S of Mt. Arapiles	200
North Lake	S	21 km NE of Harrow	200
Lake Wallace	F	Edenhope	180
Lake Buninjon	F	24 km SW of Ararat	170
Winter Lake	F	16 km NW of Edenhope	140
Lake Kemi Kemi	F	3 km S of Edenhope	130
Lake Karnak	B	30 km N of Edenhope	120
Clear Lake	F	19 km S of Mt. Arapiles	120
Unnamed	S	22 km S of Mt. Arapiles	120
Unnamed	S	6 km S of Mt. Arapiles	120
Unnamed	F	17 km N of Harrow	100
Boundary Swamp	F	9 km SE of Mt. Arapiles	100
Lake Bringalbert	F	16 km NE of Apsley	100
Lake Carchap	S	14 km S of Mt. Arapiles	90
Miga Lake	F	26 km N of Harrow	90
St. Mary's Lake	F	6 km W of Mt. Arapiles	90
Lake Yambuk	T	Yambuk - junction of Eumeralla and Shaw Rivers	80
Unnamed	F	26 km S of Mt. Arapiles	80
Pine Hut Lake	F	25 km SW of Mt. Arapiles	80
Lake Mullancoree	B	11 km N of Harrow	80
Lake Koynock	F	32 km NE of Edenhope	80
Unnamed	S	11 km S of Mt. Arapiles	70
Lake Morea	F	21 km N of Edenhope	70
Lake Cooper	F	32 km NE of Edenhope	60

Table 7 (contd.)

Lake Yampitcha	F	5 km N of Edenhope	60
Unnamed	F	8 km N of Harrow	50
Lake Awonga	F	11 km NE of Edenhope	50
Pine Hill Lake	F	8 km N of Harrow	40
Lake Dollanoke	F	14 km N of Harrow	40
Lake Jaracteer	F	12 km N of Harrow	40
Lake Cogumbul	F	13 km NE of Edenhope	40
Lake Charlegrark	F	Booroopki	40
Lake Carpolac	F	21 km N of Edenhope	40
Lake Jingeel	F	3 km W of Toolondo Reservoir	35
Lake Moinmuick	F	14 km NE of Edenhope	35
White Lake	S	24 km N of Harrow	35
Lake Moinalwar	F	16 km NE of Edenhope	20
Lake Doling Doling	F	5 km NE of Hamilton	20

F = Freshwater
B = Brackish
S = Salty
T = Tidal

Most of the lakes (and swamps) are on the Wimmera plains, between Horsham and the South Australian border. The others are on the plains east of the Grampians, both north and south of the Divide. Table 7 lists these bodies of water.

A line drawn through Kanagulk--Harrow--Edenhope--Minimay--Natimuk and back to Kanagulk encloses the belt containing the most saline lakes, the most extensive of which are Centre and White Lakes. The larger lakes throughout the south-western Wimmera plains only dry up during extremely severe droughts. The smaller swamps are more frequently dry.

The catchments of the swamps and lakes in this region are both agricultural and forested. Water quality is low to moderate with typical salinities of about 1,000 mg/l T.D.S. or more.

Certain natural swamps, whose capacities have been enlarged by engineering works, are important water storages. These are described in the chapter on water utilization.

Groundwater

Groundwater is found underground in porous and permeable strata known as aquifers. Substantial reserves of groundwater of varying salinities are present

Kangawall Lagoon, south of Goroke

throughout the study area in both confined and unconfined aquifers.

Confined aquifers occur in sedimentary basins and consist of porous formations that are partially sealed by impervious formations. Recharge takes place by deep seepage where the porous formation outcrops, usually in higher land towards the margin of the basin, and this continual addition to the aquifer increases the hydrostatic pressure of the water being stored.

When the water is under sufficient pressure in the aquifer to rise up a bore to the surface it is said to be "artesian". "Sub-artesian" water only rises part of the way up the bore and must be pumped from there to the surface.

In unconfined aquifers - shallow formations in which the upper surface of the water forms the regional water table - the water is stored under normal hydrostatic pressure. These aquifers are recharged by rain falling locally and infiltrating downwards into the porous formations directly beneath the surface.

The Murray Basin

Groundwater saturates the Tertiary and Quaternary sediments of the basin - from the surface near lakes and streams, and elsewhere from a depth of about 50 m down to the pre-Tertiary basement. The groundwater has originated in two main ways - from rainwater seeping down through the sediments and from sea water trapped in them when they were laid down. The main recharge zone lies to the north of the Dundas Tablelands on the southern edge of the basin.

The southern part of the Murray Basin contains four main aquifers or aquifer systems. They are, from deepest to shallowest, the sands of the Renmark

Group, the Duddo Limestone--Winnambool Formation (the Murray Group), the Par-illa Sand, and the Wunghnu Group.

Renmark Group

The Renmark Group is a widespread unit within the Murray Basin. As it does not outcrop, recharge must pass through younger marine deposits. Although data are limited, salinity readings of around 1,000--2,000 mg/l have been recorded in the Renmark Group between Edenhope and Gymbowen. North of the study area, in the Mallee, discharges of up to 38 litres per second have been pumped from screened bores.

The Renmark Group sands in the recharge zone have not been fully explored but offer potential for groundwater develop-ment.

To the east of that zone, groundwater salinities increase rapidly until at Horsham the readings exceed 10,000 mg/l. To the west, in a bore near Langkoop, a sample of groundwater from the Renmark Group had a salinity of 4,298 mg/l.

Duddo Limestone--Winnambool Formation

The Duddo Limestone is the most product-ive source of groundwater in the Murray Basin, and provides water for town, in-dustrial, irrigation, and stock purposes in the north-west of the study area. Its permeability is relatively high, giving it good properties as an aquifer. Bores do not require casing, as the rock will not crumble into the borehole.

The recharge zone, and consequently the area of lowest salinity in the lime-stones, is centred on the plains between Apsley, Goroke, and Natimuk, where sal-inity readings of 720--1,240 mg/l are common. Yields range from 8 to 50 l/sec; the latter rate is high enough for irrigation.

Water movement in the aquifer is gener-ally towards the north and north-west. Northwards, away from the recharge zone, the aquifer becomes confined and water movement is mainly horizontal, with water entering the system from other units in only a few places.

Southwards, towards the Dundas Table-lands, and eastwards, the limestones thin and become discontinuous on app-roaching the edge of the Murray Basin, and lenses of limestone are surrounded by marls of relatively low hydraulic conductivity. This is reflected in falling water quality - salinity south-west of Edenhope is 2,000--8,600 mg/l.

East of Natimuk the unit changes and be-comes thinner, more clayey, and much less permeable. It is known here as the Winnambool Formation. The difference in permeability is reflected in greater salinities, which rise to more than 9,000 mg/l near Horsham, with maximum discharge of 6.3 l/sec through a 15-cm bore.

Parilla Sand

The Parilla Sand, an unconfined aquifer, outcrops at the surface or occurs at shallow depth over much of the Wimmera plains. The lowest-salinity groundwater in this formation occurs in the country between Apsley, Goroke, and Natimuk, which is the recharge zone of the Duddo Limestone. Here the salinity falls below 1,000 mg/l.

Away from the recharge zone, the salinities increase. At Edenhope, they vary from 930 to 6,120 mg/l. East of Edenhope, salinity reaches 4,517 mg/l and near Arapiles it is 3,100 mg/l. Further east, at Horsham, salinities rise to 7,000 mg/l, and at Glenorchy to 15,000 mg/l.

Wunghnu Group

The Wunghnu Group consists of fluvial sediments and some lacustrine deposits, which occur extensively within the study area north of the Grampians and Dundas Tablelands. The group is characterized by rapid changes in lithology and hence in hydraulic conductivity. It includes the Calivil Formation and younger deposits.

The Calivil Formation is a hydrologically important unit that may occur beneath the Wimmera plains. Its constituents range from fine sand to cobble-sized material and the formation represents infilled Middle Tertiary valleys. This old trunk drainage system interfingered with, and was eventually buried by, the Parilla Sand and later alluvial sediments. The deposits of the formation are more commonly known as "deep leads" and last century were extensively mined for gold at the foot of the highlands, and for a short distance out beneath the plains. The deep leads formed dendritic drainage patterns, whose trunk streams occupied a similar position in plan to those of the present.

Lead material was intersected from 64 m to 77 m in the Marma No. 1 bore just outside the study area, near Lubeck, hinting at a continuation beneath the present Wimmera River drainage system heading towards Horsham. A bore near Lah-arum intersected the Calivil Formation from 79 m to 93 m beneath the MacKenzie River system and yielded groundwater containing 247 mg/l T.D.S. Further drilling would be necessary to explore these lead systems.

The Loddon deep lead is the only one that has been investigated in great detail and provides the best data for comparison. Close to the highlands, bores near Bridgewater showed that deep lead to be 2.4--3.2 km wide, 75 m thick, and incised 60 m into bedrock. Salinities were of the order of 1,000 mg/l.

Covering the Calivil Formation are younger alluvial sediments of the Wunghnu Group. Shallow beds of sand and gravel acting as confined and unconfined

Table 8

AQUIFER CHARACTERISTICS IN DIFFERENT PHYSIOGRAPHIC AREAS

Aquifer name	Rock type	Depth struck m	Salinity range mg/l T.D.S.	Typical yield litres/sec
	Wimmera plains (north of Edenhope and west of Natimuk)			
Parilla Sand	Sandstone	0--60	335--1,500	less than 14
Duddo Limestone	Limestone	16--95	640--1,200	less than 19
Renmark Group	Sand	44--153	1,129--3,200	3.5
	Wimmera plains (south of Edenhope and east of Natimuk)			
Calivil Formation	Gravel			
	a) beneath Wimmera River system	67	5,700--6,200	less than 9.5
	b) beneath MacKenzie River	64--85	197--1,400	less than 15
Parilla Sand	Sandstone	0--20	930--17,000	4
Duddo Limestone--Winnambool Formation	Limestone and marl	15--87	640--8,600	8.5
Renmark Group	Sand	15--119	1,800--8,700	5
	Grampians, western Black Range, and associated screes and alluvials			
Scree	Sands, gravels	0	50--500	less than 11
Glenelg River alluvials	Fine sands	0	100	less than 11
Colluvium--alluvium masking Victoria Valley and Mafeking granitic rocks	Sand and gravel	0	3,000--4,000	2.5
Grampians Group	Quartzite (fractured)	0	100	less than 8.0
Cainozoic alluvials	Sand, gravel	0--30	4,000--5,000	less than 15
Colluvium--alluvium	Sand, gravel	0--15	5,500	5
Cambrian--Ordovician sediments	Sandstone--siltstone	0--30	4,000--13,000	1.2
	Dundas Tablelands			
Rocklands Rhyolites	Acid volcanics	0--30	1,000--5,500	less than 19
	Western District basaltic plains			
Newer Volcanics	a) Stony rises and scoriaceous basalt	0--60	0--1,000	0.6--6.3
	b) Weathered basalt	0--60	4,000--6,000	0.6--6.3
	Otway Basin			
Bridgewater Formation and younger dunes	Cemented calcareous dune limestone, siliceous dunes	0--48	700--900	less than 1.2
Heytesbury Group	Limestone	0--183	500--1,500	less than 25
Dilwyn Formation	Well-sorted quartz sand	400	500--3,000	less than 125

aquifers are scattered among silts and clays. Salinity can vary greatly within separate aquifers in any vertical section of the group. It is generally very low close to the highlands, but increases into the basin.

Summary

In general, the highest-quality water in the aquifers of the Murray Basin comes from bores on the plains of the south-western Wimmera in the Apsley--Goroke--Natimuk belt. Further south-west beyond Edenhope, salinity of the groundwater tends to be higher, and it rises markedly east of the Wimmera River with typical values of more than 10,000 mg/l T.D.S. in some formations.

Grampians

Massive quartzites in the Grampians contain large quantities of high-quality water. Groundwater flows along fractures, but these are rare in such tight rock as quartzite. A technique of pulse hydraulic fracturing (to create fissures by means of explosions down the bore) has been highly successful, with yields of up to 8.7 l/sec from the fractured quartzites. Salinity in these rocks is always less than 100 mg/l, so they are an excellent source of water for all uses.

Drilling in the alluvial deposits of the Glenelg River north of Mount Thackeray shows that salinities are less than 100 mg/l and yields average 11.4 l/sec. Good-quality groundwater can also be obtained from the scree slopes flanking much of the ranges.

Groundwater for town supplies is obtained from the quartzites and their screes near Mount William, at Dunkeld, and at Bullawin on the west of the Victoria Range. Hamilton derives part of its water from these bores. Willaura, Glenthompson, and Moyston are supplied with water from Mount William Creek during winter, and from bores during summer.

Once off the scree slopes, groundwater salinities increase sharply in most of the rock types surrounding the Grampians. In the alluvial sediments south of Lake Fyans, they range from 1,444 mg/l to 4,750 mg/l. West of the Mount Difficult Range, those in other alluvial deposits are high. Readings of 2,591 mg/l, from a bore north of Lah-arum, and of 4,580 mg/l, from another west of Wartook, are typical. In the Victoria valley, readings in the groundwater associated with alluvial sediments at Mirranatwa and west of Mount Abrupt were around 3,800 mg/l.

Drilling in the granites that intrude the Grampians Group sediments has shown the jointing systems to be clogged with clays produced by weathering. As salinities are higher and yields lower than in the nearby sandstones, the groundwater potential of these granitic rocks is regarded as low.

Dundas Tablelands

In the Glenisla--Woohlpooer area, on the eastern margin of the Tablelands, salinity readings from a limited number of bores ranged from 1,000 to 2,300 mg/l.

The rhyolites and trachytes here, and further west, may contain better water locally where the rocks are less weathered or are subject to periodic recharge from good-quality surface water. Three bores near Telangatuk and Kanagulk exhibited wide variation - from 683 mg/l (parish of Daahl) to 3,865 mg/l and 16,700 mg/l (parish of Telangatuk).

On the extreme western edge of the Dundas Tablelands lenses of limestone can supply water, but the distribution of limestone is complex and varies sharply from place to place.

The Otway Basin

South of Hamilton, drilling by the Department of Minerals and Energy has revealed good reserves of groundwater in aquifers contained within two different sedimentary formations that lap onto the Dundas Tablelands and thicken towards the south into the Otway Basin proper.

Well-sorted quartz sands (see glossary) from Lower Tertiary sediments within the Wangerrip Group were struck at 300 m near Codrington. The water ranged from 500 to 1,000 mg/l and was suitable for town supply. This aquifer is high-yielding, with bores producing more than 63 l/sec.

The Middle Tertiary Heytesbury Group, which overlies the Wangerrip Group, also contains high-yielding limestone aquifers, giving up to 38 l/sec, with salinity varying between 500 and 1,500 mg/l. This water is used extensively for stock bores, and some is suitable for irrigation.

Near the coast, porous dune limestone of the Bridgewater Formation and Recent unconsolidated calcareous dune sands contain shallow groundwater. The water is "hard", but salinities are low and range from 700 to 900 mg/l with typical yields around 12 l/sec. The water is suitable for most uses.

Volcanic Plains

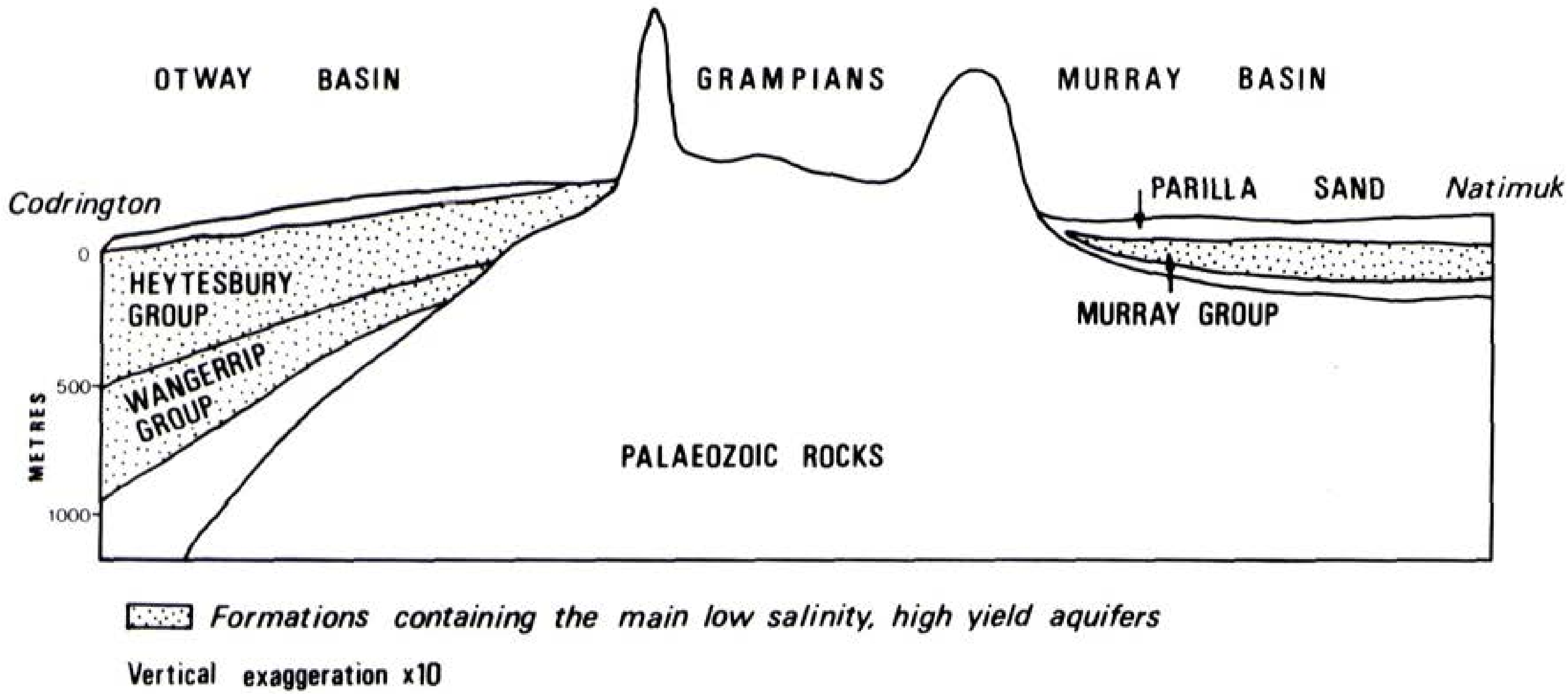
The quality of water contained within the basalts varies in relation to the degree of weathering of the rock itself.

The areas of stony rises, and the basalts and pyroclastic rocks associated with the young scoria cones (e.g., Mount Eccles) yield water of around 55 mg/l. Typical yields are about 0.6--6.3 l/sec. Springs on Mount Rouse, just outside the study area, supply water for Penshurst. The groundwater from these younger volcanics is used extensively for stock and has a potential for irrigation in places.

FIG. 4

SOUTH-WESTERN STUDY AREA, DISTRICT 2

DIAGRAMMATIC CROSS SECTION THROUGH THE OTWAY BASIN, GRAMPIANS AND MURRAY BASIN



The older phases of the New Volcanics are more deeply weathered and contain the more saline groundwater - salinities range from 4,000 to 6,000 mg/l. This water has no potential for irrigation, but is used widely for stock.

Cambrian--Ordovician Sediments

In the Cambrian--Ordovician sediments around Moyston, water from bores contains from 4,000 to 13,000 mg/l T.D.S. and averages about 8,000 mg/l. The groundwater in the Cambrian--Ordovician hills north of Rocklands Reservoir is expected to be of similar quality.

Granitic rocks intrude these sediments east of Moyston. During summer, the water in streams there is derived largely from the regional groundwater and contains 3,500--8,000 mg/l T.D.S.

Merino Dissected Tablelands

The edge of the Merino Dissected Tablelands lies in the study area. Small volumes of poor-quality water (with salinities around 3,000 mg/l) are present in the limited sandstone aquifers in the Otway Group sediments. Both confined and unconfined aquifers occur.

Table 8 lists characteristics of aquifers. It is divided into areas, within which the aquifers are placed in order of geological age from youngest to oldest.

Figure 4 depicts the most useful aquifers in the Murray and Otway Basins.

Glossary

Dendritic	- shaped like the trunk and branches of a tree.
Hardness (in water)	- refers to the difficulty in lathering with soap and the tendency to deposit fatty scum on baths and fabrics; caused by the presence of calcium and magnesium bicarbonates in the water.
Permeability	- the capacity of a rock to allow fluids to pass through it.
Well-sorted quartz sands	- deposits of sand that have been stratified by natural processes; individual layers have uniform texture.

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9. SOILS

Soil is formed by a complex process involving interactions between climate, parent materials, topography, and plants and animals.

Variations in these factors lead to variations in the physical and chemical properties of the soil. The length of time over which these interactions take place also affects soil properties.

The type of soil formed has a large influence on the uses to which land can be put. Agriculture, forestry, engineering activities, water harvesting, and many other uses are strongly dependent on the nature of the soil.

Soil Properties and Plant Growth

The growth of plants depends primarily upon the amount of light received, the temperature, and the quantities of water and plant nutrients available in the soil.

The physical properties of soil, in conjunction with climate and topography, affect the amount and availability of water, while the supply of plant nutrients is determined by the soil's chemical properties.

The physical properties include texture, structure, permeability, and shrinking and swelling characteristics. They are interrelated and affect the way the soil behaves in response to mechanical disturbance when wet and dry, its susceptibility to erosion, its capacity to store moisture, and its degree of aeration. Water-storage capacity and aeration are especially important to plant growth.

Sands are permeable and are therefore well drained, but retain little water for use by plants during the dry season. Many clay soils, however, can store large amounts of water and, in the climatic conditions of the study area, are generally more productive, except where they are poorly drained.

Horizons of clay or "coffee rock" may impede the movement of water and roots. On the other hand, water trapped above a layer of "coffee rock" at depth may form an important reservoir for deep-rooted plants at times when the surface soil layers have dried out.

The most important chemical properties are the quantities of nutrients available to plants, the amounts of clay minerals and organic matter, the degree of acidity or alkalinity, and the presence of any toxic concentrations of chemicals such as salt.

Classification

Northcote (1971) evolved a system of classifying Australian soils, with four primary divisions:

- organic soils; all soils containing more than 20% organic matter
- uniform soils; the texture changes little down the profile
- gradational soils; those that have no sharp changes down the profile, but gradually become more clayey with depth
- duplex soils; these show a sharp change of texture between the surface horizons and the subsoil

Table 9 shows the soil groups in the study area. The list is largely derived from the work of soil scientists in the CSIRO and the Soil Conservation Authority of Victoria (see references).

The most widespread soils are listed below.

Organic Soils

Peaty soils

Peats are formed in environments of low biological and chemical activity where the rate of accumulation of organic matter exceeds the rate of decomposition. The study area has no pure peats, because additions of non-organic matter are far greater in every soil-forming situation there.

Peaty soils, however, have been formed in many of the swamps of the coastal and volcanic plains.

Where the inorganic portion of the accumulating material has been at least partly derived from basalt, such as at Condah Swamp and along the Eumeralla River, peaty soils are very fertile. Many of these areas have been drained and used for dairy-farming and growing crops. Peaty soils also occur in the estuarine swamps behind the coastal dunes. Here the addition of phosphate, copper, zinc, and manganese would be necessary for agriculture to succeed.

After drainage, the organic matter in these soils begins to decompose and the subsequent changes in their structure may lower productivity.

Uniform Soils

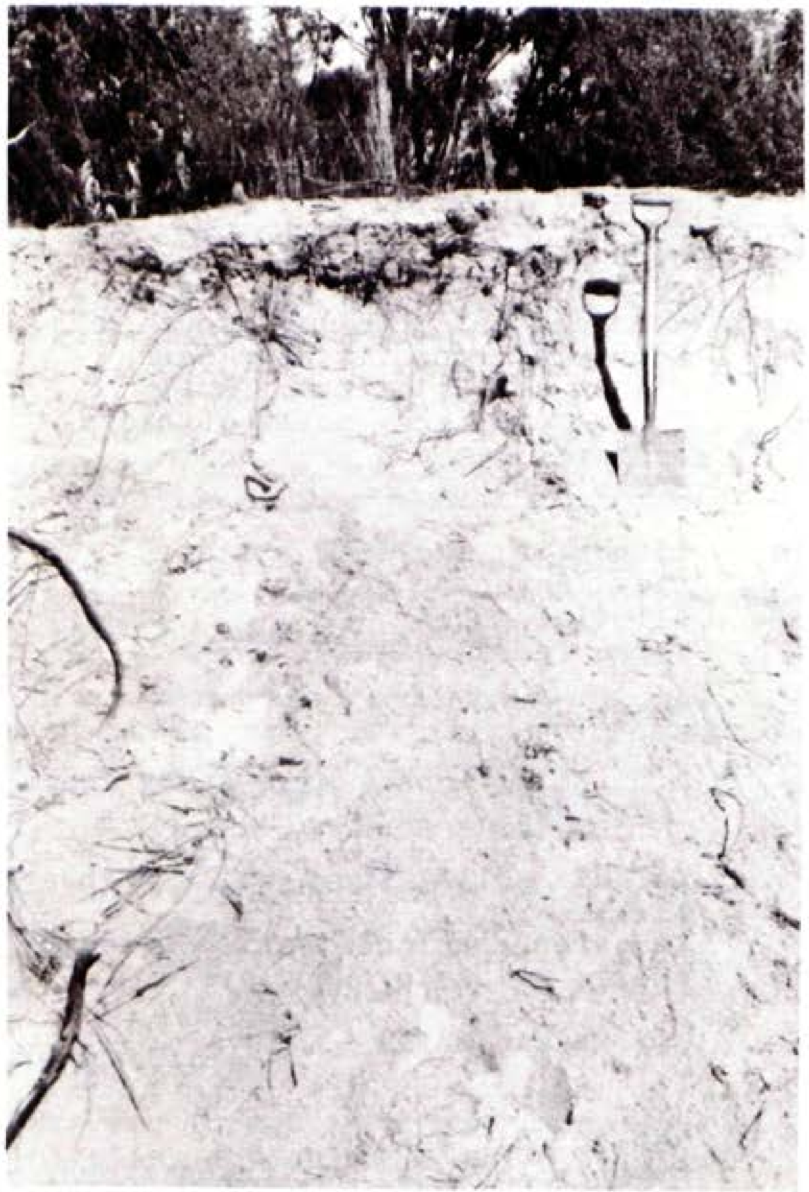
Leached sands

These soils are formed on deep deposits of quartz sand. In general, the surface horizon is darkened by organic matter, and overlies up to 1 m of grey sand. A

Table 9

SOILS - CLASSIFICATION AND NOMENCLATURE

Soil division	Soil group	Equivalent names - as used in other literature
Organic soils	Peaty soils	Carr peats
Uniform soils	Leached sands	Nomopodzols; iron leptopodzols
	Weakly differentiated pale sands	Regosols; podzolic deep sands
	Grey clays	Meadow soils; alluvial soils
	Black cracking clays	Chernozems; grey soils of heavy texture; Wimmera grey soils; prairie soils
Gradational soils	Shallow stony gradational soils	Lithosols; skeletal soils
	Yellow gradational soils	Clay leptopodzols
	Grey-brown gradational soils	Alluvial soils
	Red gradational soils on limestone	Terra rossa soils
	Black gradational soils on limestone	Rendzinas
	Red-brown shallow stony gradational soils	Lithosols; Corangamite stony loams; chocolate soils
Duplex soils	Yellow sodic duplex soils	Solodic soils; brown soils of heavy texture
	Yellow-brown calcareous sodic duplex soils (of the basalt plains)	Calcareous solodic soils; solodic soils; acidic brown clays
	Calcareous sodic duplex soils (of the plains west of the western Black Range)	Solonetzic soils
	Red duplex soils	Red solodic soils
	Mottled soils with ironstone	Brown solodic soils; transitional krasnozems



Profile of a weakly differentiated pale sand

cemented layer, formed by the precipitation of iron and its interaction with organic matter, is sometimes found at the base of the grey sand layer. Where this "coffee rock" is well developed, impeded drainage may result. Yellowish-brown clayey sands are often found at depth.

Leached sands are found on many of the sandy lunettes and ridges throughout the area, on some of the older sand dunes near the coast, and on the outwash slopes of the Grampians.

They are highly acidic and very low in plant nutrients - such as potassium, calcium, magnesium, copper, zinc, phosphorus, and nitrogen. In many areas they remain under native vegetation, but where they have been cleared they usually carry unimproved pastures and provide rough grazing.

Weakly differentiated pale sands

These are also formed on deep deposits of sand and have very little profile development. Apart from some surface accumulation of organic matter, they consist only of pale brown sand, and have no leached horizons or layers of "coffee rock". They are found both on coastal dunes and on some inland dunes in the lower-rainfall areas.

The soils are usually calcareous near the coast, where shell fragments constitute a large percentage of the soil-forming material, but mildly acidic or neutral on the inland dunes. They are infertile and support low vegetation only. If the vegetation is removed, they are highly susceptible to wind erosion. Being incapable of supporting any economic production, they have largely been left uncleared.

Grey clays occur throughout the study area in situations where the water table is close to the surface for most of the year, especially near the edges of swamps. The lack of aeration in the subsoil commonly causes the development of orange, brown, grey, and blue mottling referred to as gley horizons. Because of their poor structure, these soils have a low agricultural potential.

Black cracking clays

Formed by the weathering of parent material with a high feldspar content, these heavy soils are well known for their excellent structure. In particular, the surface soil dries out to form fine crumbs that, to some extent, protect the subsoil from further moisture loss (hence the popular term "self-mulching"). The texture grades from a clay loam or light clay at the surface to a heavy clay with free lime present in the deep subsoil. Nutrient levels are mostly high except for phosphorus and sometimes nitrogen.

Black cracking clays are found on the plains between Horsham and Natimuk, where they are grey in colour, gilgaied (locally known as "crab-holey"), and extensively used for growing cereals. They also occur in the Merino Tablelands and in the lower positions of the basaltic landscapes - in both situations they grow high-quality pasture.

Gradational Soils

Shallow stony gradational soils

Being usually very shallow (bedrock is often at less than 0.3 m), such soils are almost invariably non-arable. Angular pieces of rock are found throughout the profiles. Natural fertility is very low because of the siliceous nature of most of the parent material.

Stony gradational soils are found on steep slopes in the Grampians, in the western and eastern Black Range, and on the higher hills of the midlands west and north-west of Ararat.

Some areas have been cleared and support low-quality pastures, although the erosion hazard on cleared slopes is very high. These soils mostly occur in areas used as water-supply catchments, but their general low water-holding capacity means that stream flows are uneven.

Yellow gradational soils

These soils are formed on unconsolidated deposits containing both clay and sand. Textures change down the profile from a sand near the surface to a light clay in the deep subsoil. Nutrient levels are usually very low. Free drainage and a low water-holding capacity lead to moisture stress in plants growing on them in the dry months of the year.

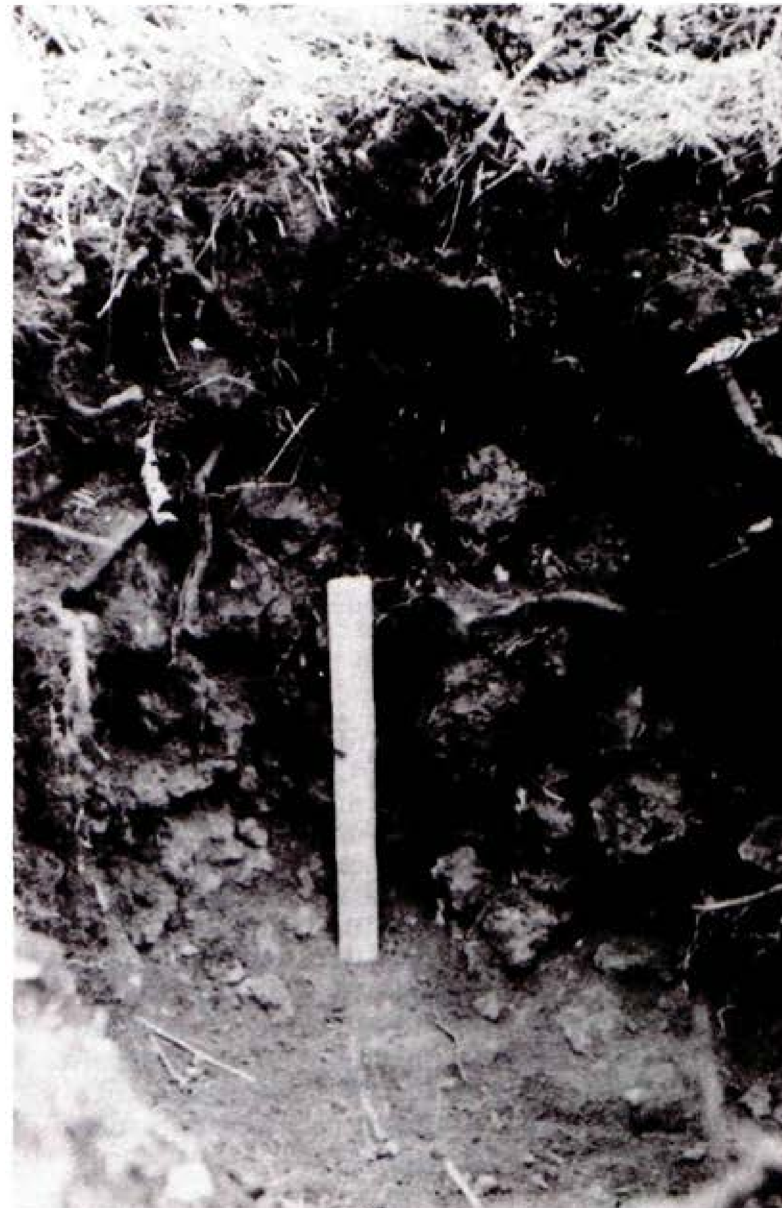
Yellow gradational soils occur on some of the outwash slopes of the Grampians, on the Tertiary sands and gravels near Stawell, and on the coastal plain south of Bessiebelle. Where rainfall is moderately high and evenly distributed, they will support useful pastures. In many areas, however, the soils remain under their natural vegetative cover of eucalypt forest.

Grey-brown gradational soils

Typical of the flood plains of the Glenelg and Wannon River systems, these fertile soils frequently owe their stratification and variability of texture to depositional phases rather than gradual differentiation of horizons in the profile with time. Despite their free drainage, they may still develop mottled subsoils where the water table is locally high. They are frequently used for irrigated cropping and dairy-farming.

Red and black gradational soils on limestone

Both soil types have sandy loam surface horizons, drain freely, and are highly calcareous. Profiles are shallow, with "floaters" of rock present throughout.



Red-brown stony gradational soil

The soils are restricted to coastal outcrops of indurated dune limestone. The black type is more common near the sea, while the red type predominates further inland. Generally fertile, these soils are used mainly for grazing, and some cropping. Their low water-holding capacity may limit plant growth.

Red-brown shallow stony gradational soils

Highly fertile soils derived from basalt are found on stony rises and scarps. The commonest colour is reddish-brown, but darker colours result where drainage is somewhat impeded. On sites where deeper soils have developed, the profile grades from a stony loam to a clay at about 0.5 m with basalt "floaters" present throughout. Water-holding capacity of the soils is low because of their shallowness.

The soils are particularly common around Mount Eccles and Mount Napier. They support reasonable pastures, but are subject to moisture stress in the dry months.

Duplex Soils

Yellow sodic duplex soils

Soils with relatively high concentrations of sodium are termed "sodic". They are common in the study area, and are found on a wide range of sedimentary parent material - the main environmental

Yellow sodic duplex soil

features are long gentle or flat slopes in areas of moderate rainfall. The surface texture is often a fine sandy loam, overlying a sharply contrasting heavy clay at about 0.3 m. Permeability of the soils is low, but they are moderately fertile.

Ironstone gravel, also known as "buckshot", is commonly found at the base of the topsoil where a perched water table promotes its formation. The colour of the subsoil varies from grey to brown or yellow, with yellowish-brown being the commonest shade. Gilgais are a common feature on the flat plains.

Yellow sodic duplex soils are naturally prone to erosion because of their poor structure and permeability, especially where they carry grassland and the climate is wet in winter and dry in summer.

Contributing further to this hazard is the salinity of the local groundwater, the result of annual additions of cyclic salt to the soil, mainly dissolved in the rain or contained in atmospheric dust. Under native forest the levels of these water tables stay low - the deep-rooted trees draw large quantities of water from the soil, which they lose to the atmosphere by transpiration.

If the forest is cleared and the land used for pasture, the level of the water table rises because the shallower-rooted grasses transpire much less than trees. Often the groundwater will be in direct contact with the roots of the pasture plants. Where it is salty enough to be toxic to plants they die, and the soil erodes.

Yellow-brown calcareous
sodic duplex soils

Structural and other properties resemble those of the previous group. "Buckshot" gravel is found where the surface horizon meets the heavy clay subsoil; but, generally, the nutrient status of these soils is higher, due to the influence of weathering basalt. Phosphate is the only nutrient likely to be in low supply.

The soils are invariably endowed with tough and cloddy subsoils, which are only slowly permeable to water. They are also distinguished by the tendency of the subsoil to form columns of clay with regular vertical cracks between them. Gilgais are common. The surface horizon is often a fine sandy loam, with "buckshot" gravel usually present at its base.

The main occurrence of such soils is on the plains between the western Black Range and the Victoria--South Australia border. They support grazing of sheep and cattle on improved pasture.

Red duplex soils

Compared with the previous groups, red duplex soils occupy steeper slopes. As well, they were formed under conditions of freer drainage. Their fertility is low, as they are deficient in phosphorus, nitrogen, and sometimes molybdenum and potassium. They occur on Cambrian--Ordovician sediments near Ararat, and on Cambrian cherts and shales. Their major use is for the growth of improved pastures for grazing cattle and sheep.

Mottled duplex soils with ironstone

A range of parent materials produces such soils, which occur on the Dundas Tablelands, on areas of granite near Mirranatwa and Great Western, and on the oldest surfaces of the Hamilton basalts. They differ from one area to another, and further subdivision of the group would be warranted in a more intense study. All, however, have in common the property of being "relict" - that is, belonging to a former climatic period, which was probably much wetter than the present. Most of the soils formed at that time have since been eroded away by the natural downcutting of streams and other modifications to the surface - these scattered formations remain.

The iron and aluminium minerals they contain strongly fix phosphorus in a form unavailable to plants, so they are usually relatively lacking in this nutrient. The soils are likely to have other deficiencies because of the long period of leaching that they have undergone. Those on the basalt are better endowed with nutrients than the others; they are influenced by the presence of weathered rock at depths of about 1.5 m.

Salting is a problem on the Dundas Tablelands, not only because of changes in the level of the groundwater following clearing, but because of the high salt content of the Palaeozoic bedrock. Where streams have cut below the level of the laterite capping, groundwater seepage has often caused severe salting in the surrounding land. This has resulted in management problems for farmers, a loss of productive land, and increased salinities of streams.

Glossary

Coffee rock - in certain highly weathered soils, minerals and organic matter leached from the upper horizons concentrate at depth and combine to form a dark layer, crumbly to quite compact in texture, and colloquially known as "coffee rock".

Gilgai - an uneven surface of numerous small distinct mounds of soil (approximately 1 m across) separated by depressions; common in the Wimmera and parts of western Victoria: the local difference in elevation between the tops of the mounds and the bottom of the depressions is generally 0.6--0.9 m but occasionally exceeds 1.5 m.

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10. VEGETATION

The native vegetation in the study area varies greatly, reflecting the diversity of climate, soil, and topography. In particular the Grampians are outstanding for the variety of vegetation types and for the large number of species, including many that are rare and significant, growing there.

Originally, woodlands covered most of the Wimmera plains, Dundas Tablelands, and volcanic plains - red gum occurred in all areas, while yellow gum, buloke, yellow box, and grey box were most common in the north and manna gum and swamp gum were most common in the south.

Most of the woodlands have been cleared or altered for agriculture, although many farms still carry large numbers of trees, mainly red gums, in their paddocks. Many areas of woodland remain on public land, often occurring as small remnants. Restricted areas of native grassland occurred north of Hamilton and Willaura - these are now greatly altered by agriculture.

Forests grew near the coast, in the midlands near Ararat and Stawell, in the Grampians, and on the sandy rises on the Wimmera plains. While examples of these forests remain on public land, those near the coast and in the midlands have been much reduced in area.

The Grampians contain a varied and very rich native flora, most of which remains in a natural condition despite the logging, grazing, burning, and roading activities of European Man over the last 130 years. Vegetation formations found in the Grampians include tall wet forests with tree-fern understorey, dry forests, heathy and grassy woodlands, wet and dry scrubs, and heaths. Some 1,000 species of vascular plants (about one-third of the State's indigenous flora) have been recorded in the Grampians, while three genera and 30 species are not found elsewhere in Victoria, and 26 species are endemic there.

Significance of vegetation

Native vegetation is important to land conservation for several broad reasons. Firstly, plants possess intrinsic interest and beauty; they also have great economic and scientific value and make an important contribution to landscape. Vegetation is important for the conservation of most animals, as these depend directly or indirectly on plants for

Table 10

VEGETATION

Structural form	Major spp. of tallest stratum	Associated tree or shrub species	Nature of the lower strata
Open forest II (>20 m height)	messmate--brown stringybark	mountain grey gum blackwood black wattle manna gum swamp gum	Tall scrub of wattles, tea-trees and bush-peas, with bracken, grasses, and sedges; in sheltered sites tree ferns and moisture-loving plants
Open forest I to shrubby woodland (5--20 m)	brown stringybark--messmate	long-leaf box shining peppermint	Dense heathy understorey, rich in species from the following genera: *Acacia, Banksia, Brachyloma, Calytrix, Dillwynia, Epacris, Grevillea, Hakea, Hibbertia, Leptospermum, Leucopogon, Platylobium, Pultenaea*
	messmate--scent-bark	shining peppermint swamp gum	
	brown stringybark	manna gum swamp gum scent-bark	
	messmate--red stringybark	long-leaf box	Open understorey of golden wattle, hedge acacia, tea-tree, with grassy areas
Woodland	red gum	very sparse golden wattle, hedge acacia	Grasses and herbs
	yellow gum	brown stringybark, yellow box, long-leaf box, drooping she-oak	As for red gum, but with more shrubs
	grey box buloke	black box, grey box, yellow gum	Grassy, with sparse rushes and sedges
	manna gum	blackwood, tree violet, tree everlasting	Dense bracken with grassy patches, and many small herbaceous plants

Table 10 (continued)

Closed scrub (2--8 m)	cross-leaf honeymyrtle		Tangled sedges
Open scrub (2--8 m)	Grampians gum--long-leaf box	Oyster Bay pine, brown stringybark	Dense community of heathy plants
	brown stringybark	long-leaf box, Oyster Bay pine, messmate	
	bull mallee--dumosa mallee, peppermint box	broom honeymyrtle, broom baeckea, quandong	Guinea flowers
Heath (0--2 m)	prickly tea-tree--silver banksia, shining tea-tree --Grampians fringe-myrtle		Numerous species of the genera listed under open forest I, above
	desert banksia	brown stringybark, silky tea-tree	Beard-heaths, guinea flowers
	mallee honeymyrtle--desert hakea		
Low open shrub-land	Grampians gum--brown stringybark--long-leaf box	Oyster Bay pine	Dense heath community
Swamp and lake communities	various rushes and sedges		
Coastal commun-ities	coast beard-heath	club rush, marram grass, saltbush	
Grassland, fern-land	speargrass, kangaroo grass and introduced grasses, bracken		
Softwood plant-ations	radiata pine		

food, and often for shelter, protection, and nesting places. Since the physical features of the site - climate, topography, and soils - largely determine the natural vegetation, the nature of the physical environment can often be judged by the type of vegetation present. Plants are also important in protecting soils from erosion by wind or water.

Classification

The classification of the vegetation on the public land of the study area is used both as a scheme for description and as a legend for mapping. Because the vegetation is so diverse, only a broad description is given here, and the vegetation map, at a scale of 1:250,000, is generalized. More detailed accounts of vegetation are given in the block descriptions. The aim of the classification is to facilitate description of the vegetation, and to assist in land use planning for the area. The classification is shown in Table 10.

The vegetation map (Map 6) was compiled from maps supplied by the Forests Commission. These maps use a variety of legends and scales, and the form of this material influenced the classification adopted here.

Structure

The major units of classification of the vegetation are the structural forms, which are based on the height and crown

Table 11

STRUCTURAL FORMS OF VEGETATION

Form and height of tallest stratum		Projective foliage cover of tallest stratum		
		Dense (70--100%)	Mid dense (30--70%)	Sparse (10--30%)
Trees	>20 m		Open forest II	Woodland
Trees	5--20 m		Open forest I	
Shrubs	2--8 m	Closed scrub	Open scrub	Low open shrubland
Shrubs	0--2 m		Heath	
Grasses	0--2 m		Grassland	

density of the tallest stratum. The forms follow the scheme proposed by R. L. Specht, although the height classes have been altered to better suit the vegetation being studied, and to fit in with existing mapping and descriptive work. The structural forms are shown in Table 11.

Floristics

Within each structural form, commonly occurring combinations of species have been defined. These have been chosen subjectively and, while not based on detailed studies of species relations, they are readily recognizable in the field and indicate certain sets of environmental conditions.

In addition to the forms defined under the Specht system of classification, two categories - swamp and lake communities and coastal communities - are used to accommodate special habitats.

Open forest II

The tall, relatively dense forests comprise messmate and brown stringybark, with an understorey of scrub 2--3 m high. Other tree species growing in this formation are mountain grey gum, swamp gum, manna gum, and black wattle. The scrubby understorey is usually dominated by prickly moses, narrow-leaf wattle, bush-pea, prickly tea-tree, and spyridium, over bracken, sedges, and grasses.

Open forest II near Mafeking

The formation grows on shallow gradational soils in sheltered parts of the Grampians where the rainfall exceeds 700 mm. Its main occurrences are on the eastern slopes of the Victoria and Serra Ranges, and near Mafeking, Mount Victory, and the Wartook Reservoir.

It also occurs on mottled duplex soils with ironstone on the coastal plain near Tyrendarra. Here messmate is the most common species, with manna gum, swamp gum, and brown stringybark also occurring.

All of these forests, except for a few areas on steep or rocky sites, have been used for timber production for many years. As a consequence, they tend to contain old branchy trees unsuitable for sawlog production, and areas of regrowth. This vegetation type has often been burnt by wildfires.

In the most sheltered sites - the heads of gullies draining the eastern fall of the Victoria Range, Dairy Creek near Halls Gap, and near the Major Mitchell Plateau - messmate and mountain grey gum form a very tall forest (greater than 30 m high in some places). Here the lower strata contain tree-ferns, hazel pomaderris, and blackwood, with moisture-loving plants such as clematis and other ferns on the gully bottoms. The total area of this vegetation type is small.

Open forest I to shrubby woodland

This formation, which is shorter and less dense than open forest II, is widespread in the study area. Brown stringybark is the most common species, and messmate, shining peppermint, swamp gum, manna gum, scent-bark, and long-leaf box also grow in the formation.

In the Grampians these forests occur on shallow stony gradational soils, and on the leached sands of the outwash slopes and the sandy ridges of the south-western Wimmera plains.

The understorey is heathy - communities of heathy plants are widespread in the study area, and may occur as an understorey or as the major formation. They usually contain many species, the most common being in the genera shown in Table 12.

Near Ararat, low forests of messmate and red stringybark occur on red duplex soils. Associated species are long-leaf box, with occasional native cherry, over a ground flora of grasses and scattered low heathy shrubs.

Brown stringybark is the dominant tree species over very large areas of sandy soils in the Grampians and extending to the South Australian border. On better sites it forms tall forests (20 m high), but, as the moisture status and natural fertility fall, the forests are shorter and less dense, and then become shrubby woodlands. These latter are common on the public lands on the Wimmera plains. The understorey is always heathy, and is dense with taller shrubs in and around the Grampians, while elsewhere it is lower and more open, and contains fewer species. Daphne heath often dominates the understorey of this formation on the Wimmera plains.

Messmate and scent-bark grow on the sandy outwash slopes, over a dense

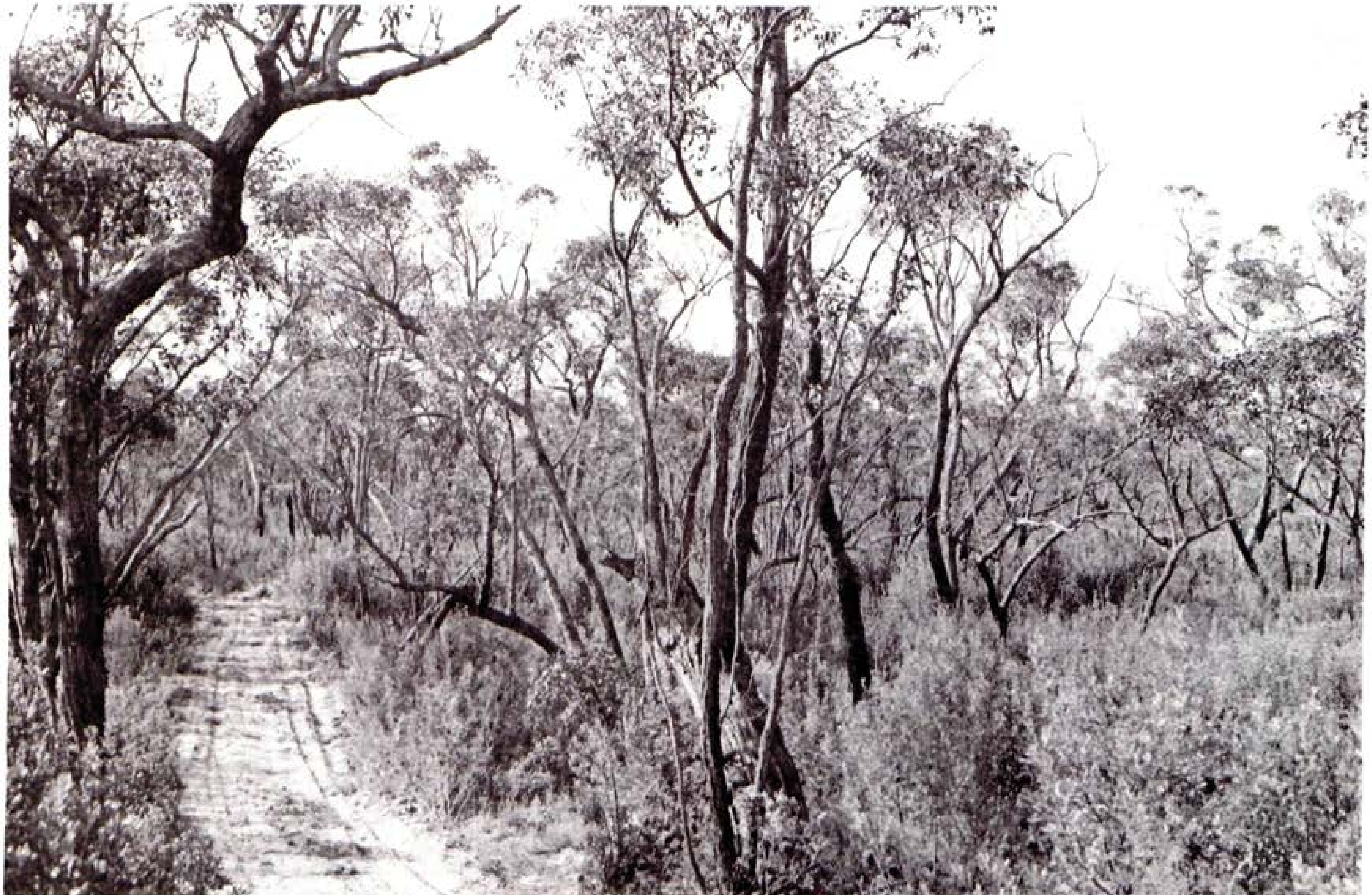
Table 12

GENERA COMMON IN HEATHS

Genus	Common name
Acacia	Wattles
Astroloma	Heaths
Banksia	Banksias
Bauera	Baueras
Baumea	Twig-rushes
Boronia	Boronias
Brachyloma	Heaths
Calytrix	Fringe-myrtles
Casuarina	She-oaks
Correa	Correas
Dillwynia	Parrot-peas
Drosera	Sundews
Epacris	Heaths
Grevillea	Grevilleas
Gahnia	Saw-sedges
Hakea	Hakeas
Hibbertia	Guinea flowers
Hovea	Hoveas
Juncus	Rushes
Lepidosperma	Sword-sedges
Leptorhynchos	Buttons
Leptospermum	Tea-trees
Leucopogon	Beard-heaths
Lomandra	Mat-rushes
Melaleuca	Honeymyrtles/paperbarks
Platylobium	Flat-peas
Pultenaea	Bush-peas
Schoenus	Bog-rushes
Xanthorrhoea	Grass-trees

heathy understorey. On the upper slopes the trees form a forest, but on the lower slopes they thin out to form a heathy woodland, with brown stringybark, shining peppermint, and sometimes yellow gum becoming common.

All the vegetation types described above have been burnt by periodic wildfires.



Open forest I--shrubby woodland

Woodland

Woodland vegetation is characterized by trees for which the depth of the crown is greater than the length of the trunk, and which grow openly spaced.

Although the formation is widespread on public land in the study area, it occurs in small patches, often on the edge of the public land, apart from large areas around the western Black Range, Mount Napier, and Mount Eccles. This is because the woodlands, which originally covered vast areas of western Victoria, grow on land that is, in general, well suited for agriculture. Mount Eccles and Mount Napier consist of "stony rises" country, and are exceptions to this. The large areas of red gum and yellow gum around Woohlpooer and the red gum stands at Kadnook and Connewirrecoo are growing on land that was selected and cleared for agriculture, but has now reverted or been brought back to public ownership.

Woodlands containing red gum, yellow gum, and yellow box occur on yellow sodic duplex soils or heavy grey clays, and usually have a grassy floor with sparse shrubs. Red gum grows in pure stands at the lower elevations with an understorey of grasses and herbs. Yellow gum and yellow box occupy higher sites, and may have an understorey of sparse shrubs.

Areas of grey box and buloke are scattered through the public land of the south-western Wimmera plains, usually on calcareous sodic duplex soils. Black box grows in depressions in a few places in the north-west of the study area. In most cases the understorey consists of sparse shrubs over low grasses.

Woodland of grey box and buloke on the south-western Wimmera plains

Manna gum, with some blackwood, forms a floristically uniform vegetation over the stony rises around Mount Napier and Mount Eccles. Fire has reduced the density of these stands so there are now large treeless areas, especially at Mount Napier, although in some places the trees are denser and form open forest II. Sparse shrubs - tree violet and tree everlasting - grow above a ground layer of dense bracken, grasses, and small herbaceous plants. The Byaduk Caves, in the stony rises to the west of Mount Napier, contain a rich fern flora.

Closed scrub

Dense thickets of cross-leaf honeymyrtle grow on wet sites in the swampy head-waters of the Glenelg and Wannon Rivers. The canopy is usually 3--4 m high, and tangled sedges grow beneath it.

Open scrub

This formation consists of shrubs (a shrub is a woody plant less than 8 m tall, frequently with many stems arising at or near the base), which are widely spaced, with an understorey of heathy plants. Grampians gum, long-leaf box, and brown stringybark are the most comm-on where the formation occurs on rocky sites in the Grampians. Brown stringy-

Heath and woodland in the Wannon valley bark is common on poor sandy outwash slopes.

In the north-west of the study area - at Mount Arapiles and on the public land immediately to the west - small areas of mallee occupy dry shallow soils on exposed sites. Species present are dumosa mallee, yellow mallee, and slender-leaf mallee. Peppermint box also grows at Mount Arapiles and at Lower Norton, with Kamarooka mallee and bull mallee. The understorey is dominated by broom honey-myrtle and broom baeckea.

Heath

Heath consists of low plants with hard small leaves, and is found on very infertile sites that are often waterlogged in winter or extremely dry in summer. Clumps of low trees may occur in and around the heaths. They are very rich in species, and although individual examples may differ significantly, species from the genera listed in Table 12 occur in heaths throughout the study area.

Extensive areas of wet heath occur in the Victoria valley, and smaller areas are scattered through the public land on the Wimmera plains. The most commonly occurring species varies widely from heath to heath. In the Grampians, scrub and dwarf she-oak, prickly tea-tree, silver banksia, and austral grass-tree are common dominants. On the Wimmera plains, mallee honeymyrtle and desert hakea often form the tallest stratum, although beaked hakea and broom honey-myrtle are also common.

Dry heaths occur on the slopes of the Grampians where the soil is too shallow and dry for trees (shiny tea-tree--Grampians fringe-myrtle), and on deep sands on the south-western Wimmera plains (desert banksia). A dwarf mallee-like form of brown stringybark is associated with desert banksia on the driest sites.

The heaths burn readily, but have great regenerative capacity from rootstocks and seed.

Low open shrubland

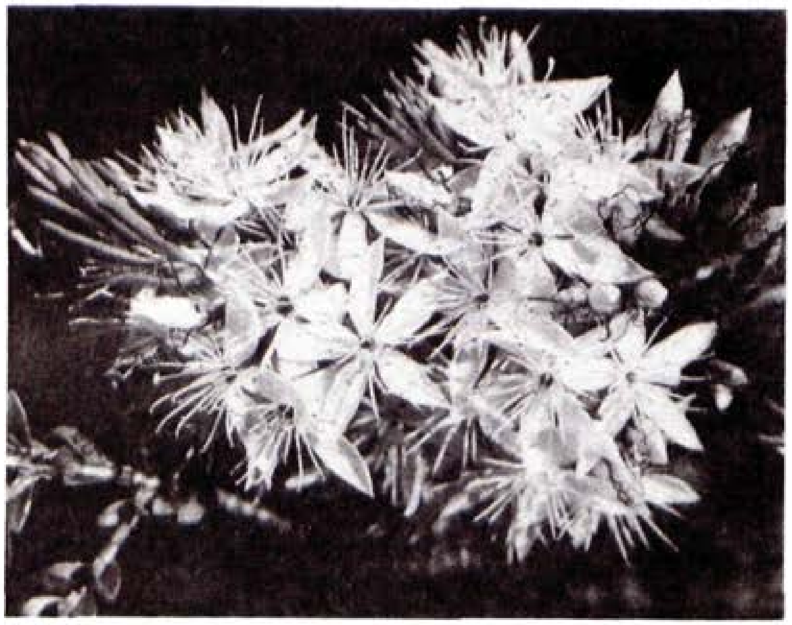
The vegetation that grows in and around the large areas of exposed rock in the Grampians and Mount Arapiles is often referred to as "rock communities". It consists of heath, scrub, and low trees that grow on small pockets of soil in holes and crevices in the rock. Grampians gum, brown stringybark, and long-leaf box are the most common scrub and tree species. Oyster Bay pine is also frequent. Fringe-myrtle is often prominent in the heath understorey.

The vegetation on Mount William and the Major Mitchell plateau has been placed in this grouping, although it has been referred to in the past as "sub-alpine". It is low and wind-pruned, but lacks a distinctive alpine element although snow gum growing over snow grass occurs in a few places in the south of the plateau. A large proportion of the surface area is rock. Grampians gum and coast banksia are common dominants.

Swamp and lake communities

About 150 swamps and lakes have been identified on the public land of the study area. While most contain fresh water, the water in some ranges from brackish to very saline.

The fresh-water lakes are usually fringed by red gum or black box, and contain some areas of sedgeland. These vary from a few clumps at the water's edge to extensive stretches completely covering the wetland.



Fringe-myrtle, common in the heaths of the study area

In addition, fully aquatic vegetation - such as pond weed, water-milfoil, bladderwort, and marsh flower - is often present. In summer the beds of dried-out swamps may carry grasses, or herbs such as water buttons.

Many of the saline wetlands were originally fringed with salt paperbark, and some stands of this species remain. Glassworts are common shoreline species. Sea tassel, which forms thick mats under the water, is the most common plant found in saline wetlands, although often the beds of saline wetlands carry very little vegetation.

Coastal communities

These communities have a very limited occurrence in the study area. Much of the coastal public land consists of sand dunes, with some coast wattle and coast beard-heath, and a low cover of hairy spinifex, coast spear-grass, and knobby club-rush.

Grassland and fernland

Grassland occurs in only a few places, and is usually the result of clearing the original woodland or forest. It contains a mixture of the native spear, wallaby, and kangaroo grasses, and introduced pasture species.

Fernland occurs on the stony rises country at Mount Eccles and Mount Napier. It has resulted from the repeated intensive fires that have burnt through these areas since European settlement. Austral bracken is the dominant species. Sparse grasses and herbs grow among the rocks beneath the bracken.

Significant Species

Twenty-six species of plants are endemic to the Grampians (that is, they occur nowhere else). A further six occur in only one or two localities outside the study area, and another 19 have their only Victorian records in the study area. These species, and a further 60 isolated records, are listed in Appendix 2B.

Plant geography

Geologically the Grampians have been stable for a long time, and some plants may have existed continuously there from mid Tertiary times (20 million years ago).

Several species in the study area, especially in the Grampians, are some distance from their main range.

Several Tasmanian plants grow in the Grampians but nowhere else in Victoria - for example *Pomaderris apetala* and *Leptospermum nitidum* (although the latter has recently been recorded at nearby Mount Cole). Similarly, a number of plants in the Grampians otherwise occur only in East Gippsland and New South Wales - for example, *Bertya findlayi*, *Pultenaea benthamii*, *Swainsona brachycarpa*, and *Hibbertia cistiflora*.

Another group of plants there has definite affinities with the flora of southern Western Australia - for example, *Conospermum mitchellii*, *Sphaerolobium daviesioides*, and the rare *Borya nitida*.

A number of species in south-eastern and south-western Australia have similar connected distributions. The explanation for some such occurrences may be that a relatively uniform (pan-Australian) flora extended across southern Australia in mid Tertiary times. This may have been broken into segments by the invasion of the sea (the Nullarbor and Murravian gulfs) in Miocene times. The Grampians formed a promontory in the Miocene sea. (The presence of coast banksia *(Banksia integrifolia)* on the Victoria Range, on Mount Rosea, and in the Mount William--Major Mitchell Plateau area may date from that time.)

An alternative explanation is that a period or periods of aridity occurred during Quaternary times, reducing the range of much of the flora. Many plants may have survived in the diverse environments provided by the Grampians (and other mountain areas), and recolonization may have taken place from these refuges.

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11. FAUNA

Although much of the natural vegetation has been cleared for agriculture, the study area is noteworthy for its fauna. In particular, many species of wildlife are abundant and readily observed in the forests, woodlands, and heaths of the Grampians, and on wetlands throughout the study area.

More than 350 vertebrate animal species have been recorded in the district. This total comprises around 230 birds, more than 50 mammals, 41 reptiles, 13 amphibians, and 26 fresh-water fish - about half of the Victorian aggregate of around 650 vertebrate land and fresh-water species.

Little is known of the invertebrate animals here. The total number of species greatly exceeds the vertebrates, but most have scarcely been studied, making a comprehensive discussion impossible here. Appendix 3F lists the fresh-water crayfish recorded in the study area.

Most of the information on which this chapter is based was supplied by the Fisheries and Wildlife Division, the National Museum of Victoria, and local naturalists.

Habitats

Animal communities are usually linked to particular plant formations, and the specific requirements of the various species for food, shelter, and breeding sites are supplied by the structure of the vegetation and the plant species that comprise it. Chapter 10 classified the vegetation in terms of structural and floristic variations. These major vegetation types can also be used to describe the distribution of animals.

Thus, the study district includes the following habitats:

* Wetlands (swamps and lakes)
* Agricultural land (grasslands and associated belts of trees)
* Forests
* Woodlands
* Open scrub (including rock communities)
* Heath and closed scrub
* Coastal dunes and beaches (coastal communities)
* Aerial habitats

For information on the coastal fauna and the marine animals found offshore, the reader should refer to the Land Conservation Council's reports on other study areas (South-western area, District 1, and Corangamite, Melbourne, and East Gippsland areas).

Birds and Mammals

Full lists of the birds and mammals of the study district are found in Appendices 3A and 3B.

Wetlands

The study area contains a variety of wetland habitats. Lakes and swamps range from fresh-water to very saline, some are transient and others seldom dry up. There are several large water storages, and numerous rivers and creeks.

Australian waterfowl tend to be erratic in their movement and breeding. Both of these activities are controlled by the availability of food, which is ultimately determined by rainfall. This ability to take advantage of favourable conditions is an adaption to the uncertain Australian climate.

If the conditions appear to ensure production of sufficient food for the survival of the existing population of water-birds and offspring, then breeding will occur. Species vary greatly in their ecological needs, however. Some will not breed unless flood-plains are inundated; others will mate and produce eggs within a few days of the water level starting to rise.

During seasons of heavy rainfall, water lies on flood-plains, around the margins of overflowing swamps, and in shallow depressions throughout agricultural land. Large numbers of waterfowl breed in the study district at these times. Large waders such as great egrets and pacific herons, diving water-birds such as hoary-headed and Australian grebes, and many species of duck utilize these flooded areas.

Pastures and grassland exposed as the water recedes support abundant growth, which is grazed by maned duck, Australian shelduck, and black swan. The birds feeding on the numerous invertebrates in this vegetation include straw-necked and sacred ibis and white-faced herons.

Saline lakes support a variety of waders as well as black swans and various species of ducks. Populations vary from year to year. Up to 10,000 red-necked avocets, 10,000 banded stilts, and 100 black-winged stilts have been observed on the salt lakes near Douglas. The birds feed on brine shrimp.

Other major aquatic habitats are the man-made reservoirs, with their relatively large areas of still water and (in many localities) innumerable dead trees. Although the banks of these storages are often too steep, and the waters too deep, for many species of waterfowl to feed, reservoirs still provide breeding sites along their margins, or refuges during drought.

Trees that have died from permanent inundation are used for nesting by a further range of species including parrots, cockatoos, and the white-bellied sea eagle (which, contrary to its name, inhabits inland lakes and river systems as well as the coast). Ultimately all of these dead trees will decay and fall and a very useful source of shelter and breeding sites will be lost.

The permanent swamps adjacent to the Grampians (such as Bryan, Marney, and Brady Swamps) are also important. One year, Bryan Swamp was host to 500 pacific herons, 1,000 white-faced herons, a small flock of royal spoonbills, 45 glossy ibis, and a number of whiskered terns. Straw-necked and sacred ibis are reported to have bred there.

The major aquatic habitats found on the volcanic plains are the Eumeralla and Wannon Rivers and the multitude of farm dams. A few natural lakes remain, but farmers have drained most of the swamps.

Of the mammals typical of wetland habitats, the platypus is found in most streams, including the Wimmera River system, and the eastern water-rat is common in swamps and lakes as well as water-courses. Short-nosed bandicoots and eastern swamp-rats may be found on the margins of wetlands that have dense thickets of tea-tree or paperbark.

Because of the increase in the extent of permanent bodies of water since settlement (i.e., channels, storages, agricultural dams, irrigation farming), it is possible that populations of the species able to utilize such habitats have also grown.

The water rat, a widespread native mammal

Appendix 4 summarizes the results of a survey of the district's wetlands, which was commissioned by the Council. The survey gives each wetland a rating for its value for conserving water-birds.

Agricultural land

Bird and mammal populations on agricultural land are governed by the availability of food (from crops, unimproved or improved pasture, and trees), shelter and nesting sites (on the ground, in residual native trees, and in plantations), and the degree of predation.

Most of the grassy woodlands of the Dundas Tablelands and Wimmera plains have been alienated because of the suitability of the clay soils for agriculture. Restricted stands of the native vegetation occur on public land and some agricultural properties are relatively uncleared, as are many roadside reserves.

As far as is known, no species of birds have become extinct because of changes in the regional vegetation induced by European settlement, but many have been reduced in number, and local extinction could occur if certain remnant stands were to be felled.

On the other hand, some species have probably increased in number, particularly those able to live and forage on open grasslands, such as sulphur-crested cockatoos, masked lapwing, and certain hawks.

Huge flocks of long-billed corellas are found throughout the Wimmera plains and Dundas Tablelands, and around Hamilton where they are locally a pest in oat crops. Elsewhere in Australia this species is rare and appears to be declining in numbers and range.

Some of the conspicuous species on the Wimmera plains are the brolga, wedge-tailed eagle, emu, cattle egret (a recent immigrant from northern Australia), and red-tailed black cockatoo. The last-named species feeds on stringybark and she-oak seeds, so the brown stringybark open forests and woodlands of the south-western Wimmera plains may well be essential for its survival in western Victoria.

The region most thoroughly cleared for agriculture is the volcanic plain. Rare species occasionally seen on farms there are the Cape Barren goose and the plains-wanderer. (The latter has also been recorded around Edenhope and Stawell.)

The agricultural environment supports few native mammals. The fat-tailed dunnart has been able to adapt to farmlands, and other species - such as the echidna, western grey kangaroo, and red-necked wallaby - may be present where farms abut uncleared country. Wherever stands of trees have been retained the brush-tailed possum is common. Eastern swamp-rats may be present in marshy pockets on farmland. The common dunnart has been recorded in pastoral country north-west of Hamilton, and Gunn's bandicoot is a rare inhabitant of thickly grassed country between Wannon and Penshurst (and beyond to Port Fairy in the Corangamite study area).

Several alien species are widespread - the fox, feral cat, hare, rabbit, and house mouse.

Brolgas

Forests

Forests greater than 20 m in height (open forest II) are not widespread in the study district, the major occurrence being in the wetter parts of the Grampians. This vegetation presents a variety of habitats for animals, including deep soils, thick ground cover, scrubby understorey, dense tree canopies, perennial streams, and, in older unlogged stands, hollow trunks and branches.

It is thought that, of the fauna populations in the study area, those of the Grampians have been affected the least since European settlement began. It is difficult, however, to assess the consequences of introductions like those of the rabbit and the cat.

Little was published on the birds of the Grampians until late in the 19th Century so we have no real basis for comparison with the bird life today. In 1891 (as recorded in *Victorian Naturalist*, Vol. 8), 88 species were observed around Halls Gap, although this probably included the plains to the east of the town. All of these species are still present in substantial numbers.

The Grampians are an important refuge and transit route for forest-dwelling migrants, including the satin flycatcher, rose robin, pink robin, olive-backed oriole, and rufous fantail. The uncommon powerful owl is found in the forests of the Grampians.

The eastern swamp-rat, red-necked wallaby, echidna, and smoky mouse are found below tall forest, although the smoky mouse is uncommon. (See also under "Open scrub".) Where the understorey consists of dense tall shrubs, the ring-tailed possum is common; feathertail and sugar gliders occupy the hollows in over-mature and damaged trees.

The forest floor on drier sites is likely to be occupied by yellow-footed and brown antechinus and heath-rat as well as the ground species mentioned above. Swainson's antechinus occupies wet situations with dense ground cover. The arboreal fauna probably resembles that of the tall forest on wetter sites.

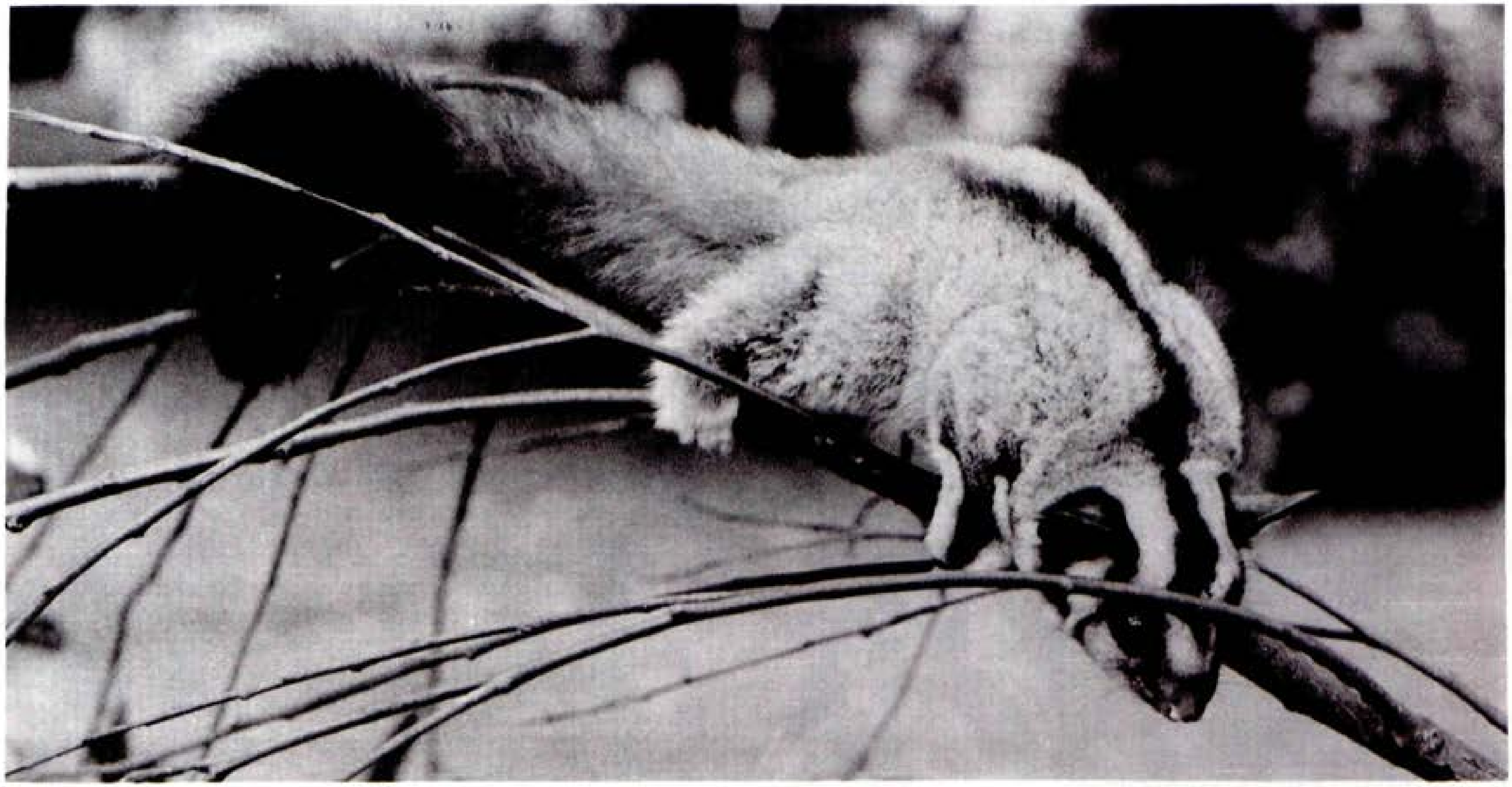
Koalas, released in the Grampians two decades ago, inhabit forest (and woodland). For food, they prefer the eucalypts, manna gum, messmate, swamp gum, mountain grey gum, and narrow-leaf peppermint, but are also known to feed on red gum and yellow gum. Disease apparently wiped out most of the indigenous koala populations in the Grampians early this century. (As far as is known the wombat never lived in the Grampians, although Major Mitchell reported wombat burrows in the banks of water-courses east of Mount Arapiles.)

Shorter forests (5--20 m in height) merging into shrubby woodlands are widespread on the outwash slopes of the Grampians and on the sands of the south-western Wimmera plains.

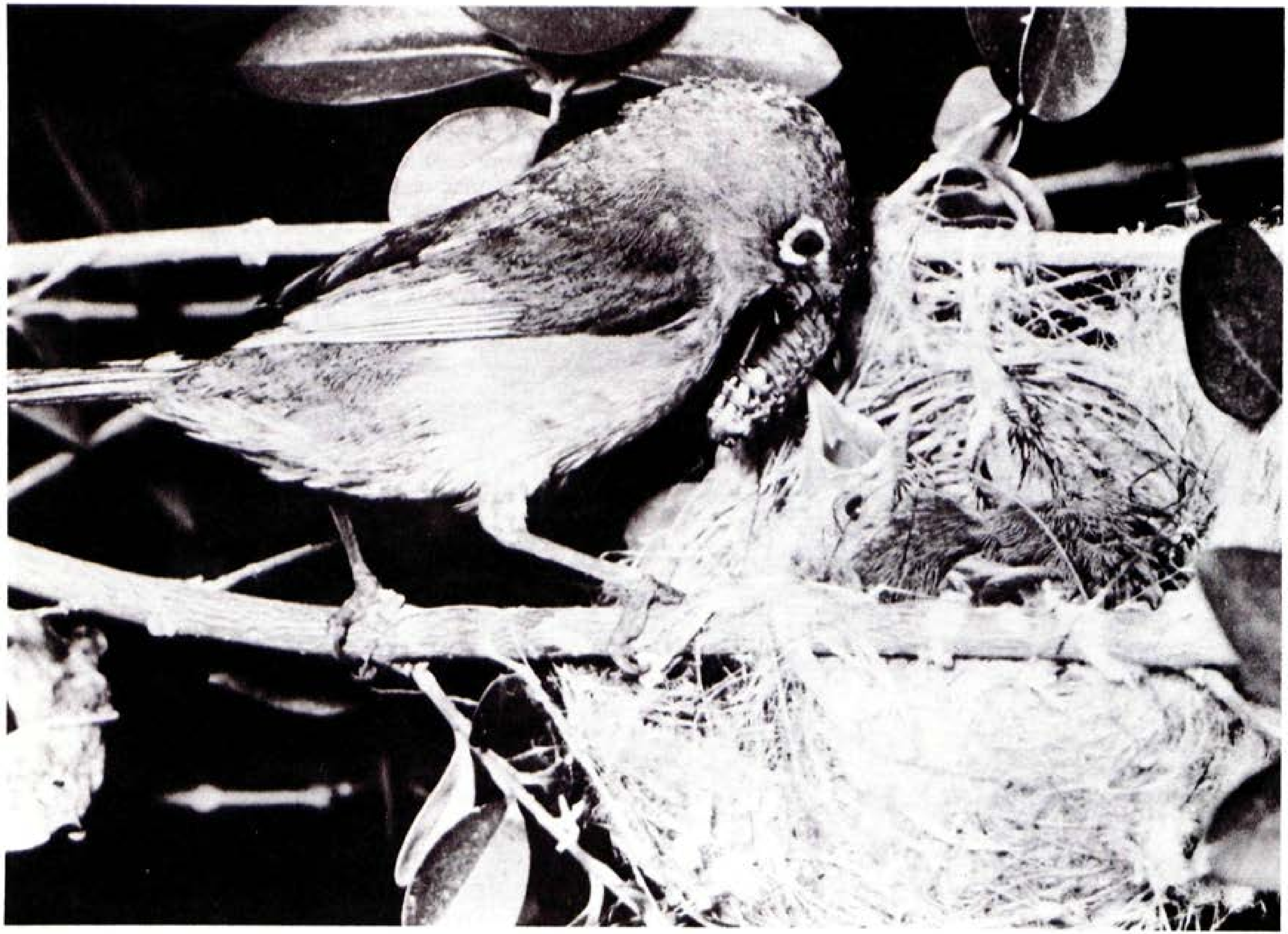
The silky desert mouse is found on the more-densely vegetated high sand ridges (that is, ridges neither recently burnt nor heavily grazed) on the south-western Wimmera plains. The common dunnart is probably widespread, but the western pigmy possum, which inhabits tall undergrowth and has been collected at Edenhope, is probably less common. Other species occurring in this sandy country are the echidna and red-necked wallaby.

Woodland

A great proportion of the woodland has been at least partially cleared for agriculture. Remnants of this vegetation on both private and public land are



Sugar glider



Silver-eye, a widespread species in the study area therefore important for the conservation of a range of birds, and further clearing of woodland would affect many species.

Mammals found in the woodlands of the south-western Wimmera include the echidna, yellow-footed antechinus, tuan, fat-tailed dunnart, brush-tailed possum, sugar glider, feathertail glider, and, within the large tracts of uncleared land on the edges of cleared country (including the largely freehold Dundas Tablelands), the western grey kangaroo and red-necked wallaby.

The yellow-footed antechinus is found in the grassy woodlands of the Grampians. The echidna, eastern grey kangaroo, and red-necked wallaby are common, and the western grey kangaroo grazes grasslands close to areas of heathy woodlands. Red deer are present in some areas. (Sambar and chital deer have been liberated in the vicinity of the Grampians, but have not been definitely sighted in recent years.)

Besides feathertail and sugar gliders and brush-tailed possums, which are known in this forest type, the ring-tailed possum and eastern pigmy possum are likely to be resident where the woodland has a dense shrubby understorey along water-courses.

The fauna of the shrubby woodland characteristic of the stony ridges of the midlands is probably much reduced because of the present fragmented distribution of this vegetation and the heavy grazing to which it has been subjected. Likely ground residents are the echidna, short-nosed bandicoot, yellow-footed antechinus, and eastern grey kangaroo, with feathertail gliders, sugar gliders, and brush-tailed possums in the trees. Koalas are increasing in numbers throughout the region.

A few stands of uncleared or lightly cleared open woodland remain on the plains and creek flats in the lower parts of the region and along roadsides. The ground fauna includes the swamp-rat in marshy habitats, as well as the species listed above for the shrubby woodland. A colony of potoroos is known at Pomonal. Squirrel gliders live in grey box woodland north-west of Stawell, but apparently not elsewhere in the study area.

The manna gum woodlands of the stony rises south-east of Mount Eccles support a wide range of mammals. Native ground mammals present are the tiger cat, brown antechinus, Swainson's antechinus, red-necked wallaby, eastern grey kangaroo, and bush-rat. The arboreal fauna includes the yellow-bellied glider and sugar glider.

The bush-rat, swamp-rat, brown antechinus, tuan, brush-tailed possum, eastern grey kangaroo, echidna, koala, and Swainson's antechinus have been recorded in the Mount Napier woodlands.

Open scrub

Open scrub is found on sandy outwash slopes and rocky sites in the Grampians and on Mount Arapiles. Grampians gum, brown stringybark, and long-leaf box are the most common dominants.

More than 80 species of birds have been observed at Mount Arapiles. (This area contains extensive woodland stands in addition to open-scrub.) Interesting sightings include Gilbert's whistler, the black-chinned honeyeater, southern scrub-robin, and black-winged currawong.

White-browed scrubwren, flame robin, silver-eye, white-eared honeyeater, crescent honeyeater, and New Holland honeyeater are common in low open scrub of Grampians gum.

The eastern grey kangaroo, yellow-footed antechinus, fat-tailed dunnart, echidna, brush-tailed possum, and ring-tailed possum have all been recorded at Mount Arapiles. Ring-tailed possums live in colonies on the cliffs, in sharp contrast to the species' typical forest habitat. A colony of brush-tailed rock wallabies once lived here, perhaps as recently as 50 years ago, but is now extinct.

In the Grampians - on exposed sites with low, wind-contorted vegetation - the most-commonly trapped mammal in a recent survey was the smoky mouse. This animal was discovered in 1933 and, until the survey in 1975, had been rarely trapped for examination. The open scrub of Grampians gum seems to be the species' stronghold. The brown antechinus is also common, with apparently lesser populations of Swainson's antechinus, echidnas, and eastern swamp-rats.

The habitat has no arboreal fauna, although the eastern pigmy possum (which normally lives in the canopy) is found among the rocks at higher altitudes. A colony of brush-tailed rock wallabies occupies steep cliffs in the Victoria Range.

In less-elevated situations, open scrub is often heathy. Heath rats are common here, and short-nosed bandicoots if the ground cover is dense enough. The arboreal fauna includes brush-tailed possums, ring-tailed possums, sugar gliders, and feathertail gliders. Echidnas, western and eastern grey kangaroos, and the red-necked wallaby are also widespread.

Heath

The main occurrences of heath are in the Grampians. Among the common birds in this environment are the rufous-crowned emu-wren, New Holland honeyeater, and calamanthus. The heath rat is common, and the short-nosed bandicoot is sometimes present in dense vegetation. The echidna, eastern and western grey kangaroos, and the red-necked wallaby are widespread in heath.

Aerial habitat

Some 15 species of hawks and eagles found in the study area prey on animals in various vegetation types. Insect-eating birds that seek food on the wing are the rainbow bee-eater, white-throated needletail, fork-tailed swift, various swallows and martins, and the nocturnal Australian owlet-nightjar and tawny frogmouth.

Strictly speaking, however, the only truly aerial species are a swift, a needletail, and the various bats, because they forage exclusively in the air.

Feral Mammals

In almost every terrestrial environment in the study district one is likely to encounter rabbits, foxes, feral cats, and the house mouse.

Black rats are widespread in the Grampians and in agricultural country. The hare is common on farmlands, and red deer occur throughout the Grampians. Probably this region has a few feral dogs. The Vermin and Noxious Weeds Destruction Board has attempted to eradicate a colony of feral pigs from the Grampians. Feral goats on certain cliff faces probably descend from animals kept by miners and settlers decades ago for milk and meat. As well, goats and sheep from surrounding farms have gone wild into The Stones State Faunal Reserve - a few remain there (see the chapter on hazards).

History of Mammal Populations

Prehistory

Wakefield carried out the most thorough analyses made so far of the prehistoric fauna of western Victoria, studying fossils and sub-fossils from various cave deposits. His results indicate that a number of mammals not found in western Victoria today (although usually remaining elsewhere in Australia) lived in the region during the last 10,000--15,000 years. In addition, several large herbivorous mammals became extinct around the end of the Pleistocene, about 10,000 years ago. Among these were *Thylacoleo carnifex*, the so-called "marsupial lion", diprotodons, and various kangaroos, including the ancestors of present-day species.

The carnivorous thylacine (Tasmanian tiger) and the Tasmanian devil were present in south-western Victoria about 3,800 years ago. The oldest remains of the dingo known in the region are some 3,000 years old. It has therefore been surmised that the advent of the dingo was at least partly responsible for the disappearance of the two carnivorous marsupials, due to the competition the dingo posed.

Table 13 lists species recorded by Wakefield from fossil deposits in local caves, that are no longer found in the region. The main localities are Mount Hamilton, near Lake Bolac; the Grampians; Byaduk; Mount Arapiles; and McEachern Cave and other caves along the lower Glenelg River.

Table 14 shows the animals identified from bone fragments in Aboriginal middens at Koroit beach, just east of the study area. The age of these remains has not been definitely established, but tentative dates are 1,800--2,800 years.

It is always possible that a species thought extinct in south-western Victoria will be rediscovered there. *Pipistrellus tasmaniensis*, the Tasmanian

Table 13

MAMMALS IDENTIFIED IN FOSSIL DEPOSITS OF RECENT AGE IN SOUTH-WESTERN VICTORIA

Sarcophilus harrisii	Tasmanian devil
Thylacinus cynocephalus	Thylacine
Perameles bougainvillei	Marl
Bettongia gaimardi[1]	Southern bettong
B. lesueur	Boodie
Aepyprymnus rufescens	Red-bellied rat kangaroo
Lagorchestes leporides[2]	Brown hare wallaby
Onychogalea unguifera	Northern nail-tailed wallaby
O. fraenata	Bridle nail-tailed wallaby
Macropus greyi[3]	Toolache wallaby
Megaleia rufa	Red kangaroo
Pseudomys sp.	Unnamed
P. australis	Plains rat
P. gracilicaudatus	Chestnut mouse
P. novaehollandiae	New Holland mouse
Rattus tunneyi	Tunney's rat
Conilurus albipes[4]	White-footed tree rat

1. Reported in Grampians 1910 (Ride, 1970)
2. Not collected anywhere in Australia since 1890 (Ride, 1970)
3. Considered extinct
4. Known only from 19th Century collections elsewhere in Australia - not seen since then

Table 14

SUB-FOSSIL REMAINS FOUND AT KOROIT BEACH, SOUTH-WESTERN VICTORIA

Macropus giganteus	Eastern grey kangaroo
M. rufogriseus	Red-necked wallaby
M. greyi	Toolache wallaby
Wallabia bicolor	Black wallaby
Thylogale billardierii	Red-bellied wallaby
Aepyprymnus rufescens	Rufous rat-kangaroo
Bettongia penicillata	Woylie
Potorous tridactylus	Potoroo
Trichosurus vulpecula	Brush possum
Pseudocheirus peregrinus	Common ringtail
Petaurus breviceps	Sugar glider
Isoodon obesulus	Short-nosed bandicoot
Perameles nasuta	Long-nosed bandicoot
P. gunnii	Gunn's bandicoot
Dasyurus maculatus	Tiger cat
D. viverrinus	Quoll
Sarchophilus harrisii	Tasmanian devil
Antechinus minimus	Swamp antechinus
Rattus lutreolus	Eastern swamp-rat
Hydromys chrysogaster	Water-rat
Mastacomys fuscus	Broad-tooth rat
Pseudomys australis	Plains rat
Pseudomys sp.	Unnamed
Arctocephalus pusillus	Australian fur seal

From C.R. Campbell (1967), as quoted in Dorward (1976).

pipistrelle, was formerly only known in south-western Victoria from sub-fossil deposits near Portland. A live specimen was collected in the Grampians in 1977. As zoological knowledge consolidates through field and laboratory investigations, new species may also be distinguished. (This applies to all other vertebrates, as well as to mammals.)

Changes since settlement

At present, more than 50 species of mammals are found in the study area but, as noted, the number was once greater. Reasons vary for these extinctions.

Many districts were never visited by zoologists before agricultural settlement brought its changes to the landscape. Comprehensive museum collections were first assembled in the 19th Century, but none were made from within the study area, although numerous individual specimens originated there.

Of the terrestrial mammals recorded with certainty as having been, at some time, resident in south-western Victoria, only three species apparently now absent are actually known to have been present when European settlement began. These are the quoll, red-bellied pademelon, and dingo (although a dingo was recently killed on the southern edge of the Little Desert, so the species may still extend into the study area).

It seems likely, however, that some of the animals listed in Table 14 may also have been present in the region early last century. European settlement may have caused their extinction by:

* elimination of habitat by clearing, grazing, and the introduction of alien pasture species and, later, fertilizers
* competition from the introduced rabbit, black rat, and house mouse
* predation by the fox, feral dog, and feral cat; hunting by man
* introduction of diseases

Reptiles

The study area comprises parts of three major zoogeographic zones, which are often used to describe the distribution of reptiles.

* Cool temperate Bassian (i.e., the moist uplands of south-eastern Australia and Tasmania)
* Warm temperate Bassian (i.e., the warmer areas of southern Australia with moderate rainfall)
* Eyrean (i.e., the arid inland)

The district has Eyrean conditions in a small pocket in the north-west. Warm temperate Bassian conditions apply in most of it, while the higher parts of the Grampians are cool temperate Bassina. In Victoria, more species of reptiles occur in the warm to hot Eyrian than in the Bassian regions.

Out of a Victoria total of about 100 species, 41 reptiles have been recorded in the study area. These are listed in Appendix 3C.

Dundas Tablelands--Wimmera plains

Representatives of both the Bassian reptilian fauna characteristic of southern and eastern Victoria and the arid-adapted Eyrean reptilian fauna of inland Australia co-exist in this region. The greatest diversity of reptiles is found where the vegetation types of both zones intermingle.

Tiger snake

Typical Eyrean species include the painted dragon, ocellated skink, and wall skink; representative species from more-temperate climates include the delicate skink, Bougainville's skink, black rock skink, and tiger snake.

Grampians ranges

The Grampians themselves have a classic Bassian reptilian fauna, with both warm and cool temperate affinities recognizable. The former group is usually found in the lower foothills, valleys, and plains - typical species are the bearded dragon, marbled gecko, striped skink, and brown snake. The latter group is restricted to the high ranges (for example, Mount William, the Major Mitchell Plateau, and the Serra and Victoria Ranges) and includes McCoy's skink and the copperhead.

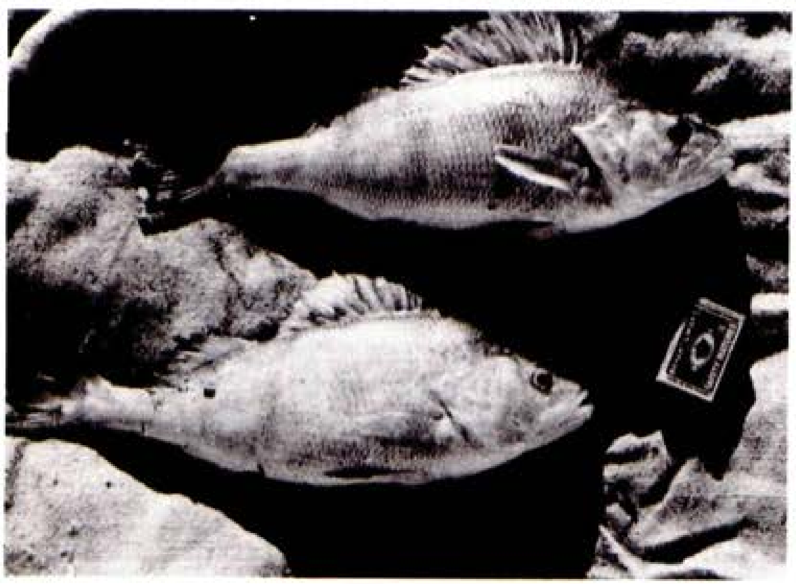
Mount Arapiles is an interface for the Bassian and Eyrean species, and, with its range of environments, including rocky outcrops, has a rich reptilian fauna.

Midlands

This region supports a typical Bassian warm temperate plains community, which includes such species as the bearded dragon, Boulenger's skink, and brown snake. The warm temperate form of the Eastern water skink has only been recorded in the study area near Great Western. Large tree goannas can be observed in some of the more extensive blocks of public land and on the roadside reserves.

Volcanic and coastal plains

This region has a mixture of Bassian influences, with species from both the warm temperate and cool temperate zones. Typical warm temperate species include the bearded dragon, common bluetongue, and brown snake; the cool temperate fauna is represented by the grass



English perch

skink, southern bluetongue, and lowlands copperhead. Tiger snakes are common in the stony rises country.

Amphibians

With several exceptions, the 13 species of frog found in the study area can utilize temporary bodies of standing water as breeding places. Some of these species have adapted to survive drought. A few lay their eggs in the ground prior to flooding and one species - *Nebotrachus centralis*, the trilling frog - is able to survive long droughts by burrowing into moist ground and forming a small chamber. As the ground dries out, the animal seals the walls with a secretion from its skin and awaits, in a state of aestivation (summer torpor), the next substantial rains.

Appendix 3D gives an annotated list of the amphibians of South-western area, District 2.

Fish

The wide range of aquatic habitats in the study area varies from fresh-water mountain streams to brackish estuaries and swamps and highly saline inland lakes. The range of fishes is not so wide, although it has been supplemented by introduction of alien and other Australian species. Several indigenous species, however, are very adaptable and are found throughout the study area in different aquatic environments.

Whereas some of the smaller native species are common, two larger ones - blackfish and Macquarie perch - that are important to anglers have become very rare. The main reasons for their decline are changes in habitat through siltation, water utilization, pollution, and engineering activities, including flood-mitigation works.

Appendix 3E gives an annotated list of the fish species in the study area.

Fire and the Fauna

Animals are linked to vegetation types, in some cases quite rigidly, so any changes in the structure and composition of the vegetation, such as those caused by burning, will be followed by changes in the animal populations. Some species thrive after fire; others decline. These effects may be immediately manifested or may take years to become obvious. A rare species could also be very vulnerable to the effects of wildfire if its distribution was restricted.

Authorities generally agree that the frequency and typical severity of fires has changed since European settlement began in Australia. Prior to this, Aborigines burnt their tribal lands to drive animals during hunting and to encourage game to the new growth. Lightning also started fires in the warmer months. Since European settlement began there have probably been more summer fires than formerly, except that the past decade has seen the official acceptance of protection-burning programmes to lower fuel build-up and minimize the damage caused by wildfires.

Recent studies of the heath rat in the Grampians appear to underline the role of fire in the maintenance of this species in heathland, its preferred habitat. Heathland is perpetuated by fire. The absence of fire means an increasing shortage of food for this mammal as the older heath plants progressively deplete the soil of nutrients and suppress the growth of regeneration and other food plants by competing with them for light and moisture. The heath rat was found exclusively in 5- to 10-year-old heath during this survey.

This has implications for management, particularly in small areas of heath. To conserve the heath rat a mosaic of regular low-intensity fires would be required, with each stand of heath being burnt every decade or thereabouts. It appears that, in the case of a small isolated block of heath harbouring the heath rat, completely burning the vegetation would cause the species to die out - it cannot occupy heath much younger than 5 years in age and there are no adjacent suitable habitats into which it can migrate.

Other species of animals frequenting the heaths of the Grampians may, however, have quite different requirements and therefore a different reliance on fire.

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12. LAND SYSTEMS

The preceding sections of this report have described the features of the land in the study area - geology, land forms, climate, soils, and vegetation.

These features are not distributed at random, nor do they occur completely independently. Rather, distinct environments consisting of characteristic patterns of land forms, soils, and vegetation can be recognized. These patterns often occur over large areas within a given range of climate as part of a broader pattern, thus allowing large areas of land to be described in terms of units, each with a particular range of climate, topography, parent materials, and sometimes vegetation.

In this method of characterizing the land, each feature of the environment is considered in relation to the others, instead of separately as in a soil or vegetation survey. The approach allows other attributes of the land - such as problems of development, erosion hazard, and potential productivity - to be used with the physical features of the environment in defining units.

An understanding of the nature of such areas, 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 materials, soil, and vegetation are uniform within close limits. Components usually occur in a limited number in a consistent repetitive sequence, and an area containing such a sequence is termed a LAND SYSTEM.

Land systems are broad-scale mapping units, which may be delineated as the first stage in the characterization of land for land use and management planning, and are therefore valuable where integrated information is required for large areas on a relatively broad scale.

The South-western (District 2) study area contains 42 land systems, as mapped and described by the Soil Conservation Authority. For this report, these land systems have been placed into 13 groups based on similarities of land form, land use, and hazards. They are shown on Map 7, and Table 15 sets out the sequences of soils, land forms, vegetation, and so forth for each group.

Table 15

SOUTH-WESTERN AREA, DISTRICT 2

LAND SYSTEMS

Land system group	Land systems	Average annual rainfall (mm)	Landscape	Geology	Soils	Native vegetation	Hazards
	Discovery Bay	725--850	Undulating stable and unstable sand dunes	Pleistocene and Recent calcareous sands	Weakly differentiated pale sands	Open grassland of hairy spinifex with an open scrub of sallow wattle, drooping she-oak, and moonah in sheltered sites	Severe hazard of wind erosion on the sand dunes
Coastal Dunes	Long Swamp	725--850	Swamp and dune complex	Recent swamp deposits with some calcareous dunes	Mainly peaty soils with some grey clays near the edge of the swamps; weakly differentiated pale sands on dunes	Open scrub of moonah, drooping she-oak, and paperbark, with sedgeland areas of reeds and rushes	Moderate hazard of wind erosion, humification of peats when drained
	Nelson	725--850	Complex of limestone dunes and sand sheets	Pleistocene dune limestone and Recent siliceous sands	Red gradational and black gradational soils on limestone; leached sands elsewhere	Woodland of manna gum, swamp gum, moonah, shining peppermint, and brown stringybark	Moderate to low hazard of sheet and wind erosion
Coastal Plains	Heywood	700--850	Undulating plains	Tertiary limestone and Quaternary alluvium	Yellow gradational soils are dominant, with many other soil groups occurring, including leached sands and grey clays	Woodland of swamp gum, snow gum, manna gum, she-oaks, and shining peppermint with an open forest of messmate, manna gum, and brown stringybark on the dunes and rises	Low erosion hazard
	Eccles	675--750	Stony rises	Holocene basalt	Red-brown shallow stony gradational soils	Woodland of manna gum, blackwood, and wild cherry	Moderate hazard of sheet erosion on the stony rises, severe humification losses when swamps are drained
Stony Rises	Condah Swamp	650--750	Swamp with some stony rises	Recent swamp deposits, some Holocene basalt	Mainly peaty soils, with grey clays near the edge of the swamps; red-brown shallow stony gradational soils on the stony rises	Closed scrub of woolly tea-tree, and tussock grasses	

Table 15 (continued)

Land system group	Land systems	Average annual rainfall (mm)	Landscape	Geology	Soils	Native vegetation	Hazards
	Dunkeld	625--750	Undulating plains	Pliocene & Pleistocene basalt	Yellow-brown calcareous sodic duplex soils are dominant; grey clays occur in low positions		
Volcanic Plains	Hamilton	625--750	Undulating plains	Pliocene & Pleistocene basalt	Mottled duplex soils with ironstone	Woodlands of swamp gum, blackwood, lightwood, she-oak, and open woodland of red gum near Dunkeld	Generally low to moderate hazard of sheet erosion and salting - salting hazard is severe in drainage lines around Willaura
	Branxholme	650--750	Rolling hills	Tertiary limestone and marl	Red duplex soils are dominant; black cracking clays and mottled duplex soils with ironstone are common		
	Dundas	600--750	Flat plateau	Lateritized material of various ages and types	Mottled duplex soils with ironstone, grey clays in shallow depressions	Open woodland of red gum, manna gum, swamp gum, peppermint, and messmate	Low to moderate erosion and salting hazards
Lateritized Tablelands and Plains	Brimpaen	600--750	Flat to undulating plain with low scarps	Lateritized Pliocene sediments	Yellow sodic duplex soils and calcareous sodic duplex soils	Woodland of red gum, yellow box, grey box, and yellow gum	
	Glenelg	600--750	Deeply cut valleys below the plateau	Palaeozoic sedimentary, igneous, and metamorphic rocks	Yellow sodic duplex soils are most common with leached sands on acid igneous outcrops and grey-brown gradational soils on alluvial flats	Woodland of red gum and manna gum with tussock grassland of wallaby grass and spear grass on the lower slopes	Severe hazard of salting and of sheet and gully erosion

(Names given to some of the land systems in the Table, especially those in the Coastal Dunes and Coastal Plains groups, refer to localities well outside the study area. This has been done because these systems were first described and named by Gibbons and Downes in studying land to the west. To avoid confusion, the same names have been used to describe them in the study area.)

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PART III

LAND USE

13. HAZARDS

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. This chapter deals with the hazards of soil erosion, salting, fire, weeds, vermin, and fungi.

At the time of European settlement, a balance existed between the soils, vegetation, climate, fauna, and Aborigines of the study area. The activities of the European settlers have resulted in major alterations to the environment, the main ones being removal of the native vegetation and fauna, cultivation of the soils, and the introduction of rabbits, stock, and exotic plants.

While some land deterioration occurred during the early years of settlement, especially on land types in which stability was naturally precarious, land management practices on the agricultural land have improved considerably over the last three decades. The present pattern of land use is, however, perpetuating erosion in many places, even if at a slower rate. In addition, any major changes in land use, such as large-scale clearing of forested land, could initiate new erosion problems.

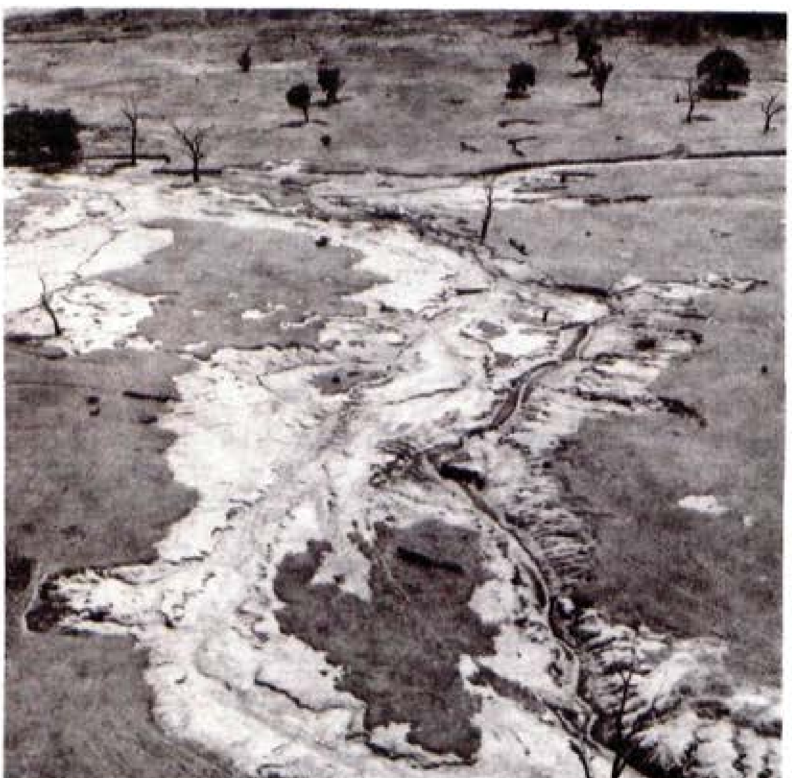
On the public land changes have been wrought by logging, roading, burning, construction of water storages, and recreation use, as well as the introduction of exotic plants and animals.

In a number of places in the study area these changes have resulted in deterioration of the land and land-based resources. In general, this deterioration is far greater on the freehold than on the public land.

Land Deterioration

Land deterioration can be divided into forms that occur on-site and those that occur off-site. On-site deterioration includes loss of soil material, loss of soil structure and porosity, loss of nutrients such as phosphorus and nitrogen, increases in toxic chemicals in the soil (such as salt), problems of access and trafficability, reduction of water-holding capacity, and loss of aesthetic appeal. Off-site deterioration includes reduced perenniality of streams, increased higher peak flows and incidence of flooding, increased sedimentation of land and utilities, and increased salinity and turbidity of streams.

The different land systems vary in the extent to which they will deteriorate, depending on factors such as climate, topography, soil properties, and management. The previous chapter outlined the susceptibility to deterioration of the various land systems in the study area. The types of deterioration are water



Erosion following salting on farmland near Ararat

erosion, wind erosion, salting, and mass movement.

Water erosion

The most obvious form of deterioration caused by the action of water is gully erosion, and numerous examples of this can be seen in the dissected tablelands, lateritized tablelands, and midland hills.

In the worst-affected areas, most creeks and drainage lines have become deep broad gullies. In addition, severe rills and gullies have developed in many places away from natural drainage systems such as along tracks, plough lines, and roadside table drains.

Less obvious is the deterioration of land caused by sheet erosion, which removes successive layers of soil from the surface of the land. The worst-affected areas are parts of the midland plains, inland plains, and midland hills, particularly where soil salting occurs. Most sloping land can become sheet-eroded if the protective cover of vegetation is removed and heavy rain falls.

In badly sheet-eroded areas the surface soil has been removed progressively over a period of years. This seriously affects the productive potential of the land, because the surface soil contains most of the plant nutrients and provides the best medium for germination. Removal of the surface soil also results in lower infiltration rates, which increases run-off and leads to gullying and flooding. Sheet erosion also leads to siltation and turbidity of streams and reservoirs.

Wind erosion

In the north-west, the study area contains many sand ridges and lunettes where the surface soils have a very weak structure. If these soils are denuded of their protective cover of vegetation, particularly during the drier months, they are easily wind-eroded.

The inland sand sheets and dunes and parts of the inland plains show evidence of blow-outs and scalding on sand dunes. The damage done by wind erosion on inland dunes in the study area is limited.

Along the coast, the dunes of the Discovery Bay land system have a high erosion hazard. Some wind erosion occurs in the thin strip of public land on the foreshore, as well as on the adjoining freehold within this land system.

Seaside development and overgrazing rapidly destroy the protective vegetation covering the dunes and they become highly vulnerable to erosion. Considerable planning of public access - together with constant care and maintenance - is essential to preserve the vegetative cover, otherwise the resource can rapidly degenerate, and remedial works are very expensive.

Mass movement

Landslides and mudflows are common all through the Casterton and Glenelg land systems around the edge of the Dundas Tableland. Geological dissection has exposed areas of soft sediments that are prone to mass movement when saturated.

Although mass movement occurred before settlement, Man's activities have increased its incidence and severity. Clearing of red gum from the tableland has increased the flow of sub-surface seepage, which saturates and lubricates the upper areas of the long slopes below the laterite capping.

Gullyside slumping frequently occurs in the Casterton land system, where gullies often exceed 10 metres deep. These spectacular scours undermine the adjacent land, causing it to collapse.

Mass movement is naturally accelerated during wet years, particularly following abnormally dry periods.

This category of land deterioration is most unpredictable and difficult to control. Although the loss of productivity is low, landslides are a constant concern to road construction authorities, and gullyside slumping disrupts access and fencing on farms. It is also a major source of siltation in streams.

Pasture improvement and tree-planting, which increase water usage throughout the landscape, reduce the incidence and severity of mass movement.

Deterioration on public land

Public land in the study area has suffered very little deterioration.

In the Grampians, some minor gullying has occurred along the edges of roads and tracks built on the outwash slopes, especially on roads after very wet winters. Very minor erosion occurs on walking tracks. This deterioration can be readily controlled by good design and adequate maintenance of roads and tracks. There is no deterioration in areas of undisturbed native vegetation.

Salting

High levels of soluble salts in soils and streams are a serious problem on the lateritized tablelands and parts of the midland plains. Soil salting occurs in the drainage lines and the lower slopes. It is a significant hazard because it reduces plant productivity. Germination rates and growth rates decrease until eventually the high salt concentration prevents all plant growth. The land is then susceptible to sheet and gully erosion.

Incipient salting may also be a problem. Although it has few obvious signs, it reduces production of crops and pastures. Eventually such areas are likely to become unproductive.

Streams flowing from the salt-affected areas are also saline - in some cases too much so for domestic or stock use. This is particularly serious when the streams flow into reservoirs. A number of streams draining the Dundas Tablelands carry large quantities of salt into Rocklands Reservoir, where the salinity causes concern, especially during dry spells. (For example, in August 1968 it reached 910 p.p.m.)

Salting in the study district is due to changes in the movement of water in the soil and groundwater, which have been brought about by clearing the native vegetation and replacing it with grassland.

The major source of salt is the regional groundwater, which tests on bore water show to be very saline in the rocks beneath affected areas. This salt has originated as either connate salt, trapped in the sedimentary rocks at the time of their deposition beneath the sea, or salt produced by weathering of rocks, particularly igneous rocks. In the Cambro-Ordovician sediments salinity ranges from 4,000 to 13,000 p.p.m. T.D.S.. Values of 5,500--10,600 p.p.m. have been recorded in granite, and 1,000--5,500 p.p.m. in the groundwater in the Rocklands Rhyolite. (Groundwater was intersected at depths of 0--30 m in these rock types.) In contrast, the groundwater in the Grampians sandstones and their adjacent scree deposits generally contains less than 100 p.p.m.

A salted drainage line on the Dundas Tablelands

A second source of salt is cyclic salt - carried inland from the ocean and deposited in rain. While this form has accumulated in the subsoils in some areas, the total amount of salt in the regional groundwater is much greater than the reserves in the soils. This suggests that the cyclic salt is a less-important factor influencing stream and storage salinity.

Under natural conditions, the areas now affected by salting carried a woodland of deep-rooted eucalypts, which took up and transpired most of the rain that fell - a small surplus in the winter months percolated down through the soil to the groundwater, and emerged as stream flow.

Following settlement, many of the trees were cleared and replaced by grassland, which uses much less water than the original vegetation. As a result more water now percolates down through the soil to the groundwater. The groundwater, which is saline, has risen in level and flows into the creeks and drainage lines, where it has weakened and killed the vegetation, and the streams now carry increased volumes of saline water.

While the symptoms of soil salting may be treated by agricultural techniques such as mulching and planting of salt-tolerant pasture species, the cause of the problem must be treated by increasing the amount of water transpired by the vegetation, thus preventing further large additions to the groundwater. This can be done by establishing deep-rooted pasture species and by planting or permitting regeneration of the native eucalypts.

Government schemes to encourage farmers to do this are now in operation in the eastern part of the Dundas Tablelands.

Rocklands Reservoir

Prior to settlement the Glenelg River at Rocklands was probably less saline than at present. Most of the river's flow would have originated in the Grampians, where the relatively high rainfall greatly exceeds the water used by the vegetation. Consequently large volumes are added to the groundwater, and then flow into the streams. As this groundwater is of low salinity, the streams contain good-quality water. This would have diluted the relatively small quantities of lower-quality water flowing from areas overlying saline groundwater.

Since settlement, however, both the volume of water flowing from the cleared areas and its salinity have increased, resulting in the relatively high salinities now recorded in Rocklands Reservoir.

Substantial areas of public land in the Rocklands catchment overlie saline groundwater. In general these are the areas of gum and box woodlands around

Woohlpooer and to the south and east of the western Black Range. They are similar to many areas that have been cleared, and are capable of growing fair-quality pastures, although the costs of development would be very high.

Current evidence indicates that any additional clearing of the native eucalypt woodlands in these areas would substantially increase the quantity of salt moving into Rocklands Reservoir. As this storage normally contributes more than half the water supplied by the Wimmera--Mallee Stock and Domestic System, it is clearly most important to safeguard the quality of the water flowing into the reservoir, and to avoid any further clearing in salt-susceptible parts of the catchment.

Summary

Expensive soil conservation programmes have been implemented to control gullying, salting, mass movement, and sheet erosion on freehold land.

Deterioration through the public land in the study area is generally insignificant because most of it remains uncleared. Thus any development of public land that could destroy the existing tree cover should be discouraged.

This applies particularly to the remaining areas of red gum in the catchment of Rocklands Reservoir, where soil salting is a major hazard.

Throughout the other public land in the study area, careful planning, construction, and maintenance of roads and tracks is essential in several land systems.

The outwash slopes of the Grampians, and soils derived from granites, and the midland plains and hills are particularly vulnerable to roadside gullying.

Along the coast, careful planning and implementation of any development, and prevention of overgrazing, are essential to prevent wind erosion on the foreshore reserve.

Fire

The forests and scrubby woodlands of the study area burn readily, and the effects of fire on vegetation can be observed over the greater part of the public land. The repeated incidence of wildfires occurring over the centuries as a result of lightning and the hunting techniques of Aborigines has certainly affected the evolution of the forest plant and animal communities. The vegetation has been drastically modified by the severity of wildfire since European settlement.

Major Mitchell, who travelled through the area in 1836 prior to European settlement, refers to 'the marks of fire' even on 'the highest mountains and places most remote and desolate', and he ascribed these findings to 'conflagrations which take place in the woods in summer'. Robertson refers to a fire sweeping the 'whole of the Wannon' in the summer before he took up his station at Wando Vale in 1840.

Hamilton describes the conditions of the country in the north-western corner of the study district when he first saw it in 1846 and refers to the 'indiscreet use of fire' as a factor in changing the conditions of the countryside. He provides brief details of the use of fire by the early pastoralists to create refuge areas in grassland and in the 'burning of all rubbishy (stringybark) country in the autumn' as a means of reducing losses from summer wildfires. He also refers to the loss of log and brush fences due to fires, indicating that wildfires were often a problem to the early settlers.

Although comprehensive fire records prior to 1939 are unavailable, these and other extracts from literature and reports indicate that the early settlers were the cause of frequent, widespread, and often high-intensity wildfires.

Those of disastrous intensity caused serious deterioration in the general condition of forest areas by reducing vegetation cover and damaging timber stands. After settlement, many areas changed from open parkland with large trees to forests with younger trees and thick scrub. This was due at least partly to damaging wildfires promoted by land clearing and grazing practices.

Since 1939, fire-protection measures have become widely enforced and accepted. The situation in relation to wildfires and illegal burning operations has changed to a large extent. The occurrence of wildfire has greatly declined, which reflects improved detection, more-efficient suppression capability, more-effective law enforcement, and management of fuel quantities.

Public co-operation in the detection and suppression of wildfire has increased. Access and equipment for fire protection have been improved. Grazing rights have been cancelled on all but the red gum and yellow gum woodlands, and the development of private land to improve stocking rates has reduced the requirement for rough bush grazing. As a result the incidence of wildfires resulting from fires used to promote new pasture growth has decreased.

Fires still occur, however. Statistics reveal that lightning is the main cause of forest fires here (see Table 16) and accounts for more than 40% of all those started. In general, such fires are now rapidly extinguished, and those started by people are responsible for most of the area burnt.

The Grampians

The fire history of the Grampians shows that large-scale fires are likely to occur there over much of the year, that lightning is a prominent cause, and

Table 16

RECORDED CAUSES OF WILDFIRE

	1972/73	1973/74	1974/75	1975/76	1976/77
Lightning	9	1	6	13	21
Deliberate lighting	7	-	1	7	3
Land-owners burning	6	-	3	4	1
Other causes	8	7	10	7	9
Unknown	1	1	-	2	1
	31	9	20	33	35

that those due to human agency, including deliberate lighting, occur periodically.

The local vegetation and topography is such that successful control of wildfire depends on early detection, rapid mobilization of men and equipment, good access, and efficient initial attack.

Considerable expenditure by the Forests Commission on fire protection has resulted in the development of 1,400 km of forest roads, 20 helipads, 3 fire lookouts, a comprehensive communications network, water storages, fire-breaks, an airstrip equipped with fire-bombing facilities, and a large fleet of fire-fighting vehicles. Extensive research into fire behaviour is carried out.

Fuel-reduction burning - carried out over broad areas or undertaken to remove localized hazards - is a vital component of protection policy. The current annual target is 6,000 ha, spread over zones chosen for their strategic value in protecting life and safeguarding public and private assets. The aim is to reduce fuel levels by the use of low-intensity fire in any area every 5--7 years.

A large proportion of fuel-reduction burning is undertaken in heathlands and low-quality eucalypt forest (scrub and open forest I). Research has indicated that such fires have helped to diversify the heath communities by creating a range of post-fire successional stages. The interaction of fuel, weather, and topography governs the nature of results achieved, and burning patterns are extremely complex.

Large numbers of people visit the forest area each year - with peaks at Christmas and Easter, when the danger of spread of fire is very high. Public education programmes are undertaken to minimize the number of fires arising from recreation use.

Aircraft play an important role. Aerial reconnaissance is undertaken after widespread lightning storms, retardants are applied from the air in remote locations, and helicopters are used to ferry men to inaccessible areas and to carry out surveillance of going fires. Nevertheless, the use of bulldozers and hand-trailing are the basic techniques applied in creating a mineral earth-break around going fires.

Open forest I--shrubby woodland after fire

The fire danger is lower in the grassy red gum forests in and around the Grampians than in the forest and scrub areas. Grazing by domestic stock is used to remove much of the grassy fuel. This reduces the need for ploughed or graded fire-breaks.

South-western Wimmera plains

Fire history here, also, reveals a much-reduced incidence of wildfire in recent years. Substantial areas of public land have been burnt, however. The last large-scale outbreak occurred in spring 1967, when many burns on private property spread into public lands. The latter are widely dispersed among agricultural land. Much of the forest area is scrubby brown stringybark country that is highly flammable. The remnants of gum and box woodland present a much-reduced fire problem.

Access tracks for fire protection have been constructed in the larger units of public land, some water storages provided, and protective burning carried out. Fire look-out towers are located at Mount Arapiles and north-east of Chetwynd. Local rural fire brigades give considerable assistance in fire-control work, and access to most of these areas is good.

Other public land

The two areas of stony rises country at Mount Napier and Mount Eccles have traditionally been burnt either to encourage fresh growth of grass or, especially in recent years, to reduce the hazard of fires spreading from the bush onto adjacent farms. Access within the stony rises is very difficult, and many of the existing tracks can only be travelled at very slow speeds. Additional access is required for effective protection.

Fire-fighting in these areas poses special problems, as the use of mechanical equipment is impossible and any work on fire edges away from existing tracks must be done by hand.

The incidence of fire in the Dundas Ranges is low, although fires burnt much of the forest in spring 1967. Local land-owners regard the area as a fire danger to their properties, because of the broken nature of the topography and the difficulties of access.

A fire look-out located at Mount Dundas forms an important part of the fire-protection system for the Grampians and southern blocks of public land in the study area.

Cinnamon Fungus

A number of root-rot fungi can cause defoliation and death of eucalypts in Victoria. The most significant pathogen in the group is the cinnamon fungus, *Phytophthora cinnamomi*, which has caused decline and death of trees in some mixed eucalypt forests in Victoria. This fungus is widely distributed in the soils of coastal eastern and southern Gippsland and is also found in south-central and western Victoria, extending to the South Australian border.

Convenient methods for isolating the fungus were only developed during the 1960s. In Victoria *P. cinnamomi* was not linked to decline and death of eucalypts until it was identified in forest soil in 1969, although previous reports of patches of defoliation and scattered deaths of trees suggest that in some localities it has been present for three or four decades.

The fungus is usually associated with poorly drained sites and with soils that have an impeding horizon at shallow depth. Its spread is limited during periods when the soil is dry and cool, and is most rapid after heavy rainfall during late spring and summer.

P. cinnamomi rots the fine roots of susceptible plants. This reduces the plant's ability to absorb water from the soil, and dieback or death of the plant occurs during hot, dry periods when the roots are unable to supply sufficient water to the foliage, even though the soil may be moist. The effects of the disease vary from rapid death of all susceptible vegetation to chronic chlor-

Vegetation affected by cinnamon fungus

osis and fluctuating dieback and partial recovery.

The only detailed investigation of the decline and death of flora in the study district has been in the Grampians, where the fungus is widespread. Most of the affected areas adjoin roads and tracks, although the fungus has been isolated in remote areas in the Victoria and Mount Difficult Ranges.

Soil tests for the fungus have shown that it is the major factor in the decline and death of eucalypts, particularly brown stringybark and messmate, and of many understorey species. Severely affected areas are colonized by grasses and sedges. The fungus has also been found in soils from apparently healthy forest.

Examination of past aerial photographs has shown that severe crown decline and mortality started during the 1950s. Aerial and ground surveys during 1976 have indicated these effects in approximately 2,500 ha (1.2%) of the forest. The areas most severely affected are the shorter dry forests and low heathy woodlands on poorly drained flat to gently sloping areas with northerly to easterly aspects. Commercial timber stands have not yet been affected.

The severity of attack and the degree of infestation are greater on those areas burnt after the onset of attack than on unburnt sites, or on sites burnt before the onset of dieback. An examination of weather patterns also indicates that severe dieback associated with high *P. cinnamomi* activity probably occurs when summer--autumn drought follows above-average spring--summer rainfall. Such conditions appear to occur every 13--14 years. The disease spread rapidly during the dry period in 1976 following the exceptionally wet years of 1974--75. It is expected to continue to spread, at a rate determined by climatic conditions.

Quarantine measures to limit the spread of the disease within the Grampians by means of vehicles and machinery have not been introduced, because no large uninfected areas remain. All infected gravel pits have been closed, however.

Forests Commission scientists, in co-operation with Melbourne University, are studying the impact of *P. cinnamomi* on a range of plant communities with a view to ameliorating its adverse effects.

Pest Plants and Animals

While pest plants and animals are best known for the losses they cause in agricultural land, they also have considerable impact on public land.

Pest species of animals present problems in its use and management. For example, rabbits compete with native fauna and feed voraciously on the vegetation, thus leading to soil erosion and the elimination of some plant species. Control by poisoning may kill some native animals and this may conflict with some of the aims of management.

The presence of weeds on public land causes concern for several reasons. On recreation areas they may be aesthetically displeasing, cause discomfort due to the presence of prickles or thorns, or have poisonous properties. In nature conservation areas they compete with native plants and are aesthetically undesirable, and measures to control them may be incompatible with management goals. In some situations weeds on public land may spread to adjacent land.

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

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

Most pest plants and animals are proclaimed noxious weeds or vermin, and their control is required by legislation. A major cost associated with vermin and noxious weeds on public land is that of control measures.

Problem Animals

Animals found in the study district that have been declared vermin under the *Vermin and Noxious Weeds Act* are rabbits, foxes, hares, sparrows, and starlings. Feral cats are pests throughout the area.

Pigs run wild and have caused some damage to pastures, but now appear to be under control. In addition, house mice, kangaroos, emus, sulphur-crested cockatoos, and long-billed corellas are considered to be pests in some circumstances.

Rabbits

Rabbits are found throughout. They are most common on farms, where they compete with stock for pasture, and are normally found on the fringes of the public land adjacent to pasture, their main food. Rabbit numbers in forest are generally very low. They may graze selectively and thus change the composition of the vegetation - and, if infestations become severe, they may render the land susceptible to soil erosion.

Rabbits were a problem during the establishment of the Billywing pine plantation. Aerial baiting with carrots and 1080 was carried out before planting.

Aerial baiting is also carried out from time to time around the edges of the inaccessible stony rises country at Mount Napier, in a joint programme with adjoining freehold areas. The programme treats a total of about 5,000 ha, and is the only satisfactory method of control for this type of land.

Ground methods are used to poison rabbits on public land when necessary, especially in the fringes of scrub country when it harbours rabbits feeding on adjacent farms.

As well as poisoning, other methods of control are fumigation and ripping of warrens, and inoculation with myxoma virus. To assist the spread of myxomatosis, rabbit-flea releases have been made in the northern and north-eastern parts of the study area.

Foxes

Foxes are found throughout. They are opportunist feeders and mainly live on rabbits, mice, and carrion sheep, but can be a threat to smaller native fauna and birds where carrion sheep are not readily available.

The main methods of control are spotlight shooting, fumigation, and poisoning. Poisoning on public land is occasionally carried out, and secondary poisoning from rabbits assists with control, particularly around fringes of scrub and on public land. At present foxes are sought as game animals, as their pelts are valuable.

Hares

Hares cause little damage to land, as their population densities are not normally very great. They only become a problem when a large colony forms. They can compete for food with livestock on agricultural land and occasionally damage bark of fruit trees. Control, if necessary, is chiefly by shooting.

Wild pigs

Wild pigs, or pigs run wild, appeared in the south-east of the Grampians in 1973 and damaged a small area of pasture. Pigs are ominivorous and can root up

Foxes are found throught the study area

large areas while searching for food. Control by poisoning appears to have been successful over the last 3 years, and there is no evidence of pigs at present.

Goats

Feral goats have been seen throughout the southern Grampians. Their stronghold appears to be the Victoria Range, including the Chimney Pots area. No estimates of the population are available, and no work has been done to control the animals. If numbers increase, goats could have a serious impact on the vegetation in the Grampians.

Other pests

The noxious birds, sparrows and starlings, are found in the study district. Agriculturally they can damage seed crops and carry diseases but they are of little importance on public land. They compete with native birds for food and nesting sites.

House mice are present at times in cropping areas and are generally not regarded as pests. If they do reach plague proportions, however, control is difficult. Poisoning can be used, but usually natural causes reduce the numbers to normal levels. House mice compete with native mammals for food and living space.

Feral cats are not declared vermin, but they are a threat to native fauna - particularly in forest areas. They occur in a wide variety of habitats and, as opportunist predators, their diet depends upon the availability of prey species.

Emus, kangaroos, sulphur-crested cockatoos, and long-billed corellas can become pests in some situations, particularly on the farm lands adjacent to the Grampians, Black Range, and scrub lands. They can create serious problems on farms by damaging crops, pastures, and fences.

It is sometimes necessary to issue permits under the *Wildlife Act* to destroy limited numbers of these species.

Weeds

A survey carried out here in 1970 showed that 65 species of noxious weeds were present. Generally, noxious weeds only colonize areas of native vegetation that have suffered some soil disturbance such as quarrying, mining, or logging. They are also found along creek or river frontages, on road reserves, in grazed areas, or at sites of abandoned farms and camps.

The principal noxious weeds in the study district are the annuals, of which spear thistle, slender thistle, saffron thistle, spotted or variegated thistle, stinkwort, and bathurst burr are the most prevalent. The most-common perennials are one-leaf cape tulip, horehound, blackberry, spiny rush, hoary cress, furze, sweet briar, and hedge acacia. These plants occur on much of the public land, including roadside reserves, creek and river frontages, and land held under grazing licence.

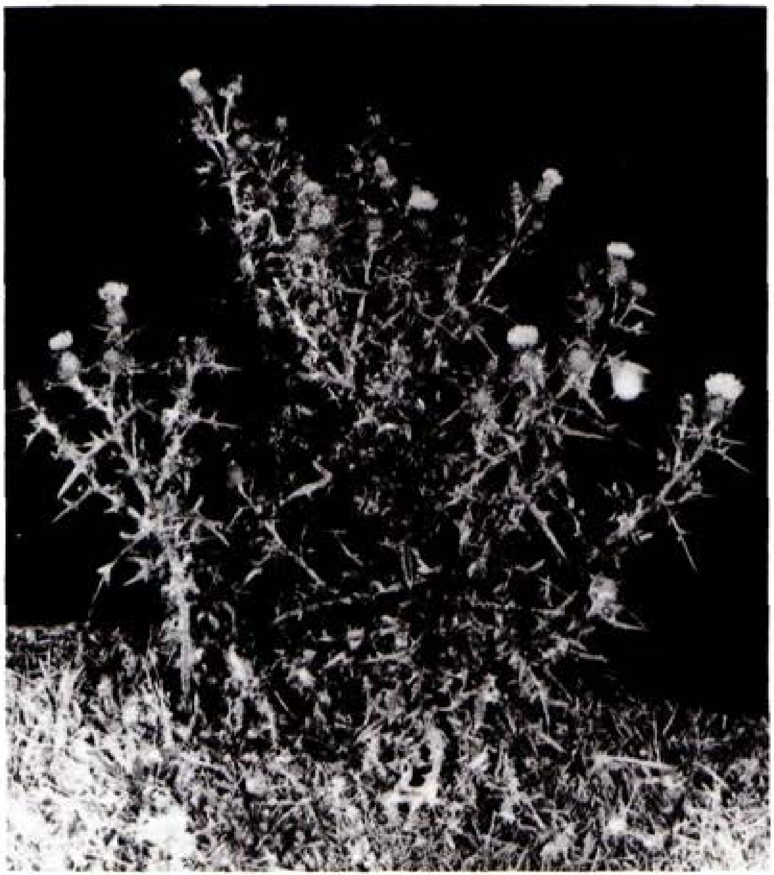
One perennial not common in the southern portion is skeleton-weed. A small area has been found on Bryan Swamp State Game Reserve since grazing there ceased. With treatment, it is under control.

Thistles

Spear thistle, also commonly known as black thistle, is often incorrectly called scotch thistle. Slender thistle and shore thistle are often difficult to distinguish from one another. These three are weeds, because they often occupy grazing land that could be producing pasture more acceptable to stock.

They will readily become established in soils of high fertility that are bare of vegetation at the end of summer.

Dense patches of spear thistle reduce carrying capacity and their spiny nature deters animals from grazing close to the patches. The spear thistle head that



Spear thistle, found on farms and on public land

contaminates wool is objectionable to shearers and wool handlers.

Variegated thistle (alternative name, spotted thistle) occurs in a number of places. It grows best on soils of high fertility and is confined mainly to those of alluvial or volcanic origin. It is very competitive and when firmly established will eliminate most other plants by shading and competition for moisture and nutrients. If grazed under certain conditions, it can cause nitrate poisoning in stock, particularly cattle.

One-leaf cape tulip

This weed is found widely on public-land creek and river frontages (e.g., Mather Creek, Glenelg River), on road reserves at Apsley and Edenhope, and also on some agricultural land. It will poison stock under certain conditions, particularly animals introduced from an area free of the weed. If it occurs densely in a pasture it will replace many desirable plants; grazing animals generally avoid it, and the usable pasture can thus be considerably reduced.

Control methods are spraying with 2,4-D, and cultivation, where possible, over a period of at least 4 years to exhaust the dormant seeds and corms in the soil.

Blackberry

Blackberry grows in various situations, but is mainly confined to streams and

Table 17

NOXIOUS WEEDS

Noxious weed	Presence (No. of Parishes)
Spear thistle - *Cirsium vulgare* (Savi) Ten.	156
Slender thistle - *Carduus tenuiflorus* Curt. and *C. pycnocephalus* L.	151
Sweet briar - *Rosa rubiginosa* L.	113
Stinkwort - *Inula graveolens* (L.) Desf.	108
One-leaf cape tulip - *Homeria breyniana* (L.) G.J. Lewis	79
Horehound - *Marrubium vulgare* L.	75
Saffron thistle - *Carthamus lantus* L.	65
Spotted or variegated thistle - *Silybum marianum* (L.) J. Gaertn.	57
Furze - *Ulex europaeus* L.	53
Boxthorn - *Lycium ferocissimum* Miers	46
Blackberry - *Rubus fruticosus* L. agg.	40
Bathurst burr - *Xanthium spinosum* L.	39
Paterson's curse - *Echium plantagineum* L.	36
Soursob - *Oxalis pes-caprae* L.	31
Cape broom - *Genista monspessulana* (L.) L.A.S. Johnson (syn.: *Teline monspessulana* (L.) C. Koch)	30
Spiny rush - *Juncus acutus* L.	28
Hoary cress - *Cardaria draba* (L.) Desv. (syn.: *Lepidium draba* L.)	26
Skeleton-weed - *Chondrilla juncea* L.	24
Caltrop - *Tribulus terrestris* L.	16
St. John's wort - *Hypericum perforatum* L.	14
Bindweed - *Convolvulus arvensis* L.	13
Thorn apple - *Datura* spp.	13
Wild watsonia - *Watsonia bulbillifera* J.W. Mathews et L. Bolus	13
Boneseed - *Chrysanthemoides monilifera* (L.) T. Norlindh	12
Great mullein - *Verbascum thapsus* L.	11
Hemlock - *Conium maculatum* L.	11
Tree of heaven - *Ailanthus altissima* (Mill.) Swingle	10
Fennel - *Foeniculum vulgare* Mill.	8
Amsinckia - *Amsinckia* spp.	8
Hawthorn - *Crataegus monogyna* N.J. Jacq. - and its hybrids *laevigata* DC. (syn.: *C. oxyacanthoides* - Thuill.) - and its hybrids	8
Pampas lily-of-the-valley - *Salpichroa origanifolia* (Lam.) Baill.	8

Stemless thistle - *Onopordum acaulon* L.	8
Erect prickly pear - *Opuntia stricta* (Haw.) Haw.	7
Sand mustard or sand rocket - *Diplotaxis tenuifolia* (L.) DC.	7
Star thistle - *Centaurea calcitrapa* L.	6
African feather grass - *Pennisetum macrourum* Trin.	5
Two-leaf cape tulip - *Homeria miniata* (Andr.) Sweet	5
Wild teasel - *Dipsacus fullonum* L. ssp. *fullonum*	5
Apple of Sodom - *Solanum sodomeum* L.	4
Prairie ground cherry - *Physalis viscosa* L.	4
Topped lavender - *Lavendula stoechas* L.	4
Dodder - *Cuscuta* spp.	3
Flax-leaved broom - *Genista linifolia* L. (syn.: *Teline linifolia* (L.) Webb et Berth.)	3
Spiny broom - *Calicotome spinosa* Link	3
Spiny burr grass - *Cenchrus longispinus* (Hack.) Fern.	3
Tufted honeyflower - *Melianthus comosus* Vahl	3
White horsenettle or silver-leaf nightshade - *Solanum elaeagnifolium* Cav.	3
Wild mignonette - *Reseda luteola* L.	3
Chinese scrub - *Cassinia arcuata* R.Br.	2
Five-spined saltbush - *Bassia quinquecuspis* (F. Muell.) F. Muell	2
Illyrian thistle - *Onopordum illyricum* L.	2
Italian or cut-leaf blackberry - *Rubus laciniatus* Willd.	2
Khaki weed - *Alternanthera pungens* Humb. et al (syn.: *A. repens* (L.) Link)	2
Noogoora burr - *Xanthium pungens* Wallr.	2
Onion weed - *Asphodelus fistulosus* L.	2
Spiny emex or three-cornered Jack - *Emex australis* Steinh.	2
Artichoke thistle - *Cynara cardunculus* L.	1
English broom - *Cytisus scoparius* (L.) Link (syn.: *Sarothamnus scoparius* (L.) W. Koch)	1
Hard-head thistle - *Centaurea repens* L.	1
Nut grass - *Cyperus rotundus* L.	1
Serrated tussock - *Nassella trichotoma* (Nees.) Hack. ex Arech.	1
Tutsan - *Hypericum androsaemum* L.	1
Wheel cactus - *Opuntia robusta* Wendl.	1
Wild garlic - *Allium vineale* L.	1

Acacia hedge (*Acacia armata* R.Br.), although not listed above, was proclaimed a Noxious Weed in 1974 and is found in various Parishes in the study area.

roadsides, and around townships. A few small patches occur in the north-east of the Grampians. It is very hard to eradicate, especially where access is difficult. Its persistence is due to its efficient reproduction. The seed can spread for some distance via creeks and rivers, and birds and foxes (which are fond of the succulent fruit) can distribute the seeds over a wide area.

Other plants

Many land-owners consider bracken fern to be a problem in pastures of low productivity. It occupies a number of areas on both public and private land, and provides additional harbour for rabbits in stony areas and scrubs.

Arum lily occurs near the Mount Difficult pine plantation and at Zumsteins and could be a potential danger, especially in view of its poisonous content. Bridal creeper is found in scattered locations on the south-western Wimmera plains, and could also be a potential danger if it continue to spread to other areas.

Table 17 lists 65 weeds found during a survey in 1971. This covered 173 parishes in the study area; those parishes with less than a tenth of their full extent inside the study area were excluded.

14. CONSERVATION

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

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

Use of Conservation Areas

Reference

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

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

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

Although all land types need to be represented in reference areas, the need is most urgent in those that have been extensively developed for uses such as agriculture. Few, if any, areas suitable for reference remain for some land types in the study area. Conscious effort must be made to retain reference areas in suitable remnants to represent all land types.

Conservation of species

Each species of plant and animal makes a unique contribution to the richness and diversity of the environment. Each is an essential part of Man's natural

The Asses Ears, Grampians

heritage and, to many people, there is a moral responsibility to ensure that none of them should knowingly be lost or endangered.

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

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

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

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

Special natural values

Particular areas of land are often needed to preserve significant natural values such as distinctive geological features. Many of these have important scientific value, while others are valuable in education. Most of the more accessible and spectacular features also attract tourists.

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

As described in chapter 3, the study area contains a number of Aboriginal relics. Since many of these sites are culturally and scientifically important, some of the more significant sites on public land may need special protection.

Buildings or structures on Crown land or on land vested in any Minister are not listed in the Register under the *Historic Buildings Act* 1974. The National Trust of Australia (Victoria), however, records or classifies all historic buildings, landscapes, areas, objects, and sites that members consider worthy of preservation.

Recreation

Most Australians live in the artificial environment of large cities and towns, and many find that their lives are enriched by renewed contact with the natural world. Chapter 15 discusses the requirements of natural surroundings for many forms of outdoor recreation. Birdwatching, nature study, hunting, and bushwalking all require conservation of the native plants and animals; picnicking and driving simply require a background of trees or shrubs in the recreation areas. These requirements can all be filled in the study area.

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

Education

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

Productive uses

Some productive and commercial uses of land are achieved by conserving the natural ecosystems in varying degrees. The commercial product is obtained by harvesting a proportion of the population of a species or group of species at a controlled rate, which the ecosystem can sustain. Examples include the sustained yield of hardwood timber and the conservation of wetlands to produce game birds. The continued success of such uses depends on maintaining many of the natural features of the ecosystem. Land under such management can also be used for education, recreation, and scientific purposes, and it may form a protective buffer around small areas specifically devoted to nature conservation.

Viability

The viability and effectiveness of conservation areas depend on a number of factors, including the size of the area, the type of community, ecosystem, or feature to be conserved, and the degree

The Glenelg River in the Victoria valley to which the area can be managed to control influences that tend to upset the natural balance.

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

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

Narrow strips of native vegetation are valuable for migratory and nomadic birds and as wildlife "corridors" for small animals. These are particularly so in the study area because the areas of natural landscape are so fragmented.

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

Types of Reserves

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

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

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

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

15. RECREATION

Recreation is any activity freely undertaken for personal pleasure. Outdoor recreation, which includes a wide range of activities, is an important use of public land, and is a major reason for the retention of natural areas.

Recreation is an important form of use in much of the public land in the study area, which contains diverse features and environments, used for a wide variety of activities. In particular, the Grampians are a recreational resource of national significance.

The district is traversed by the highway linking Adelaide and Melbourne, and also by the coastal highway, 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.

The Grampians in particular have been extensively developed for recreation, with roads, look-outs, and picnic and camping spots. The populations of the local towns are relatively low, and the majority of the estimated 450,000 visitors to the area each year come from Melbourne and other parts of Victoria, with a significant percentage from South Australia.

Recreational attractions on public land are supplemented by a variety of attractions on private land - vineyards, farms, historic buildings, and museums.

Map 8 shows the main natural and historic features of interest, and where facilities have been developed.

Recreation Resources

Recreation resources of the area include the rugged and diverse Grampians ranges, the man-made and natural wetlands and lakes, the volcanic features on public land south of Hamilton, and the beauty of the Western District--Wimmera landscapes and towns, and the history associated with them.

The Grampians

The Grampians dominate any discussion of recreation resources on public land.

They rise dramatically in steep rocky cliffs from the surrounding plains to a maximum elevation of 1,160 m at Mount

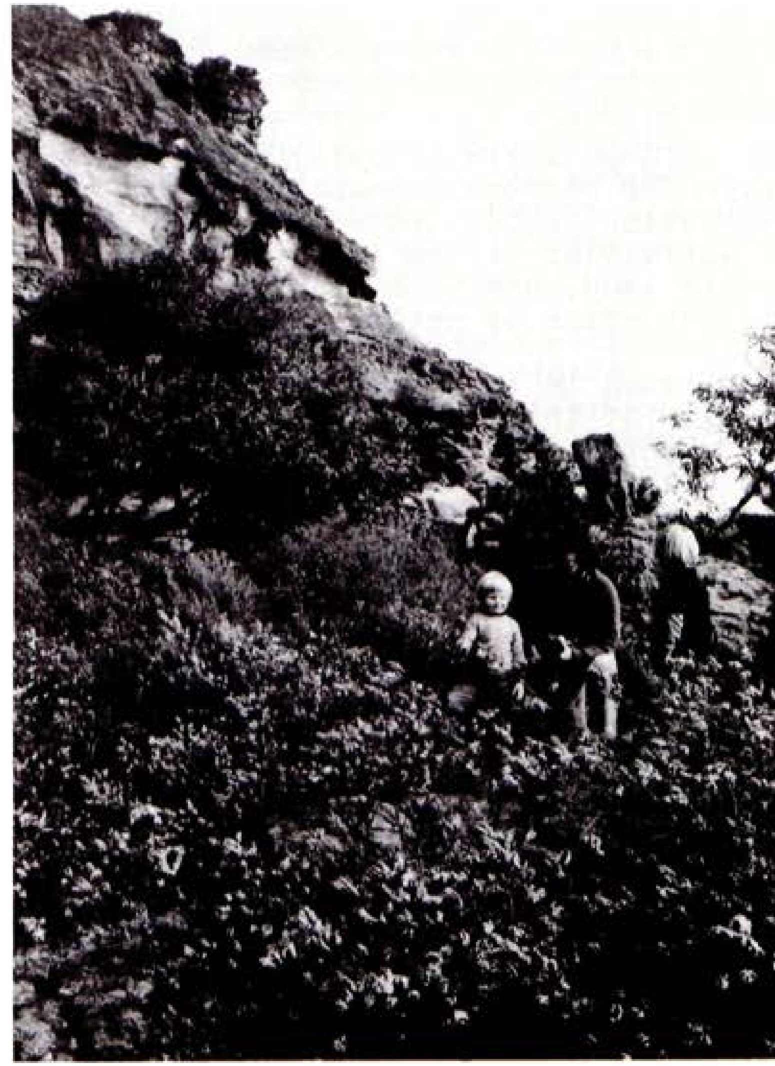
William. Rugged ranges contrast with gently sloping to flat areas in the Victoria valley, Wartook basin, and around western Black Range. They cover a total of about 180,000 ha.

The steep slopes, diversity, and scale of the Grampians give the region great scenic grandeur. Vegetation varies from tall forests to woodlands, scrubs, and heaths. The area is renowned for its diversity of native plants, and its wildflower displays in spring. Wildlife displays, look-outs, water storages, waterfalls, and rock formations are additional features.

The Grampians are easily reached from the Western Highway linking Melbourne and Adelaide. Access is good, via several major tourist roads that are sealed, and an extensive system of well-signposted gravel roads. About 40 picnic grounds have been established, and camping is permitted at 15 of these. The main tourist centre, Halls Gap, offers a wide range of accommodation. Stawell, Horsham, Hamilton, Dunkeld, and Ararat also offer accommodation and other facilities for tourists.

Most tourist use is concentrated on the parts of the Grampians served by sealed roads. These are the townships of Halls Gap, the camping and picnic area at Zumsteins, Reid and Boroka Look-outs, Lake Wartook, the Dunkeld--Halls Gap road, and the road to the turntable on Mount William.

An extensive system of well-signposted gravel roads provides access to the rest of the Grampians, including some rugged



Among the wildflowers in the Grampians areas in the Victoria Range. This system is used by a relatively small number of visitors, who are seeking to get away from the well-used areas and see more natural isolated ones.

Many walking tracks leading to lookouts, waterfalls, or other features have been built. For the more serious bushwalker there are large areas, especially on the Major Mitchell Plateau and the Victoria Range, that have no vehicular or walking tracks.

About 15 of the 40 known sites carrying Aboriginal cave paintings are regularly visited by tourists and walkers. Protective screens have been built at 12 of these sites.

Visitor surveys

The Forests Commission has carried out surveys in the Grampians to find out the number of people using the area, where they come from, what activities they undertake, where they stay, and what they think of the area. Data were collected from a sample of the people visiting the Grampians by means of roadside interviews and mail-back questionnaires.

The latest survey, carried out between April 1977 and April 1978, estimates the total number of visitors to the Grampians to be 425,000. Of these, 68,000 were day-trippers and 357,000 were holiday-makers who spent an average of 2 days in the area. Thus the total number of visitor-days during the survey period was 930,000.

The last comparable survey was carried out in 1970--71. At that time the estimated total numbers of visitors and visitor-days were 124,000 and 352,000 respectively. Thus the number of visitors to the Grampians has increased by 240%, or 34% per year, and the number of visitor-days by 165%, or 24% per year over the 7-year period.

The 1977-78 survey indicated that 63% of day-trippers lived within 80 km of Halls Gap, and 90% lived within 160 km. Of the visitors who stayed for more than one day, 49% lived in Melbourne, 27% in other parts of Victoria, and 18% in South Australia. Of those who stayed overnight, 42% stayed in commercial places in the Grampians (caravan parks, flats, etc.) and 6% stayed in Forests Commission areas (camping grounds).

Among the respondents to the survey, the most popular activities were pleasure driving and "relaxing", followed by camping and walking on tracks. Picnicking/barbecuing was the next most popular. The survey shows that the frequency of participation in all other activities - fishing, hiking, photography, rock scrambling, nature study, painting, and visiting caves - is very low compared to the five listed above.

The survey showed that most visitors to the Grampians did not think the area was overcrowded, although a substantial minority thought that the presence of more people in the area would have spoilt their stay.

Mount Eccles

Mount Eccles National Park (390 ha) contains Lake Surprise, a crater lake surrounded by high basalt cliffs; Mount Eccles, a scoria mound; and other volcanic features - lava canals, tunnels, caves, and stony rises. These features are well preserved, as the last eruption at Mount Eccles occurred only 6,500 years ago.

Pleasant picnic facilities have been developed in the tall manna gum woodland above the lake, and a camping area with 30 unpowered sites is available.

Access to Mount Eccles is good, although it is not on a through road or near a major highway. The estimated numbers of visitors to the park over the last 5 years are set out in Table 18. Reasons for the fluctuations in the numbers of visitors are not known. Some 13% of visitors arrive by bus.

Park records for 1977 show that, of the 212 groups that camped in the Park, 6% came from within 50 km, 56% from Melbourne, 14% from other parts of Victoria, 23% from interstate, and 1% from overseas.

The major activities undertaken in Mount Eccles National Park are picnicking, walking, nature study, and photography. Large numbers of school students come on excursions to study the volcanic land forms: 48 such groups visited the Park in 1977.

Mount Napier, 20 km north of Mount Eccles, also contains volcanic land

Table 18

NUMBERS OF VISITORS TO MOUNT ECCLES NATIONAL PARK

Year	Day visitors	Camp groups
1972--73	8,644*	77*
1973--74	8,894*	88*
1974--75	10,033	124
1975--76	11,658	160
1976--77	11,189	212

forms and features, including the Byaduk Caves. This area is visited mainly by field naturalists, although the Caves attract some tourists. It has not been developed for recreation, and access within the public land is poor.

South-western Wimmera plains

Lakes and swamps are the features of recreational interest in the areas of public land scattered across the south-western Wimmera plains.

About 40 major lakes or swamps on public land are permanent or hold water for most of the year - a few of these are saline. Some are surrounded by public land and others by private property. Another 50 or so lakes and swamps dry out each year or fill occasionally.

The standard of access to the lakes varies widely. Many of those in large blocks of public land can be reached by means of sandy tracks, which may become impassable in very wet or very dry weather. Some of those surrounded by private property have no developed access.

Only a few of the lakes have developed facilities for picnicking and camping. Duck-shooting is the most widespread activity here - in a good season almost all of them would be shot over. Other popular activities are swimming, boating, fishing and yabbying, 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.

Mount Arapiles, 30 km west of Horsham, is a rocky outlier of the Grampians. It rises steeply from the surrounding plains, and its rocky cliffs are a notable landscape feature. Access from the Wimmera Highway is good, and a sealed road leads to a look-out on the summit. A picnic area and a camping ground have been developed at Centenary Park, on its eastern boundary. Natimuk golf-course is located within the public land.

Mount Arapiles is not on a major tourist route, and use is mainly by local people from Natimuk and Horsham. Most rock-climbers travel from Melbourne, however.

Other resources

Water storages around the Grampians - Rocklands and Toolondo Reservoirs, Dock, Green, Pine, and Taylor Lakes, Lake Lonsdale, and Lake Fyans - provide fishing, boating, and picnicking opportunities. Map 8 shows which activities are permitted on the various lakes. A large caravan park has been established at Lake Fyans, south-west of Stawell, and this storage receives heavy usage for boating, fishing, and swimming.

Rocklands Reservoir, with a surface area of 6,560 ha when full, and a very long shoreline, is a popular fishing and boating area. It is also used for duck-hunting. There is a caravan park at the dam wall.

One Tree Hill is a look-out located on the public land west of Ararat. It commands spectacular views of the Grampians. Mount Bepcha, on the eastern shores of Rocklands, is a readily accessible fire look-out that commands views of the reservoir, Victoria Range, and western Black Range.

The 20-km stretch of coast in the study area consists of a sandy beach backed by a low dune. There is no access to the beach, however, apart from rough tracks through freehold land, and consequently recreational use is negligible. Lake Yambuk, an estuarine lake at the mouths of the Eumeralla and Shaw Rivers, receives heavy fishing and boating use in summer.

Nigretta and Wannon Falls, on the Wannon River downstream from Cavendish, provide spectacular views during the winter months. Each has an adjacent reserve used for picnicking, walking, and general recreation.

The wide reserves associated with many of the roads in the district carry fine stands of the native vegetation. Especially in the north, the remnants of the box and gum woodlands on the roadsides are an important element of the landscape.

Activities

Recreation driving

Most recreational driving in the study area is done in two-wheel-drive vehicles. 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.

Almost all pleasure driving on public land takes place in the Grampians, where it is the most popular recreational activity. Drivers tend to stay on the sealed roads (Halls Gap--Wartook, Boroka Look-out, Lake Wartook, Halls Gap--Dunkeld, and Silverband road), although on second or third visits they may venture onto gravel roads leading to Mount Zero, the Victoria valley, or Victoria Range.

Pleasure drivers usually travel to well-publicized features such as look-outs, Wonderland Forest Park, waterfalls, and Zumsteins.

The major look-outs in the Grampians are Boroka Look-out, above Halls Gap, and Reid Look-out, on the Mount Victory road; but many places on the road network afford views. Mount William is also a popular look-out, although a steep climb to the summit must be made on foot. A mob of very tame kangaroos at Zumsteins attracts many visitors, and there is a commercial deer farm on private property at Rose Gap.

Camping, Mount Arapiles

Picnicking in the Grampians

Pleasure driving is usually associated with picnicking. The Grampians contain about 40 developed picnic areas, which adequately cater for this activity.

Recreationists in four-wheel-drive vehicles also use the Grampians. The special requirements of these people are challenging tracks that give access to remote areas. The quality of four-wheel-drive touring available here is low, as many tracks are accessible to two-wheel-drive vehicles, and some four-wheel-drive tracks in remote areas have been closed due to the erosion hazard.

For four-wheel-drive enthusiasts in western Victoria, however, the Grampians offer one of the few alternatives to travelling long distances to the alpine country north-east of Melbourne. For this reason they are used by enthusiasts from Ballarat, Horsham, and Hamilton. All areas away from the popular tourist zones of Halls Gap, Wonderland Park, and Zumsteins are used, with the Mount Difficult and Victoria Ranges being the most popular.

Few hazards and conflicts are associated with pleasure driving throughout most of the Grampians. As with many recreational activities, the major factor detracting from people's enjoyment is overcrowding. In the Grampians this may be a problem only on the most popular roads during the Christmas and Easter periods. The road system can cope with recreational use without undue deterioration.

Small numbers of trail-bike riders use roads and tracks on public land. As yet no serious conflicts with soil stability and other forms of recreation have arisen. An erosion hazard is associated with the use of four-wheel-drive vehicles on steep roughly formed tracks, especially in wet weather. In the Grampians, erosion-prone sections of some tracks have been closed.

It is unlikely that the present network of roads and tracks will be extended.

Walking

Two types of activity fall under this heading: short walks on prepared sign-posted tracks; and longer ones, often taking 2 days, through remote country away from tracks (bushwalking).

Walking on tracks is a popular activity in the Grampians and at Mount Eccles. In the former, the most popular areas are the Wonderland Forest Park and around Halls Gap, where many kilometres of walking tracks leading to look-out points, waterfalls, or other features of interest have been built. Similar tracks have been built in other parts of the Grampians - many are not shown on Map 8. The walking tracks are sign-posted, and the length or duration of the walk is given. No bushcraft or map-reading expertise is required.

The attractions of the Wonderland Forest Park are the diverse rock formations -

caverns, chasms, peaks, and large areas of rock with vegetation in small pockets of soil.

At Mount Eccles, walking tracks have been built around Lake Surprise and a longer track provides access to some more-remote volcanic features (tunnels and canals).

Walking on tracks can cause minor erosion. Very heavy use in the Wonderland Forest Park is causing some deterioration. Fortunately, most of the tracks here are on bare rock.

In Victoria, the Grampians are second only to the Alps in importance to bushwalkers, as the ruggedness of the ranges provides challenging conditions for the more experienced bushwalker. The features that draw walkers are the abundant rock formations - especially peaks, gorges, and caves - the characteristic vegetation, the isolation of the remote areas, and the presence of Aboriginal cave paintings. In addition, access to the mountains is good, and the weather is fine for much of the year.

The most-used areas are Mount Stapylton, Rose Gap, Mount Difficult, the Major Mitchell Plateau, the whole of the Victoria Range, and the Serra Range from Mount Rosea to Mount Lang.

Large areas of the Victoria Range and Major Mitchell Plateau are not traversed by jeep tracks, and bushwalkers value the remoteness and isolation that can be experienced there. The Serra Range contains very steep divides, and is waterless - consequently it receives less use than other areas. Very little walking is done in the Victoria valley or western Black Range.

Bushwalking in the Grampians has little impact on the land, as the activity is dispersed over very large areas.

Although bushwalkers use roads and tracks to gain access to remote areas, extension of the system of roads, jeep tracks, and walking tracks would conflict with bushwalking use, as it would reduce the opportunities for solitude. Four-wheel-drive touring also conflicts with bushwalking, for the same reason. Experienced bushwalkers enjoy the challenge of walking in remote areas, and for this reason would oppose the building of new walking tracks into these areas.

Camping

Camping is a popular activity in the Grampians, Mount Arapiles, and Mount Eccles. Most is in established camping grounds, with facilities such as fireplaces, tables, and often toilets and water supply. Bushwalkers and four-wheel-drivers would be 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.

Hunting

Ducks are the major game species present. The lakes and swamps of the south-western Wimmera plains contain large populations during wet years, and many hunters shoot here. Most hunters are from the Western District and the Wimm-

era and South Australia, although in the last 5 years or so the number of Melbourne shooters travelling to the area for duck-opening weekend has risen. Unlike other popular shooting areas in the State, this one contains many (more than 100) small swamps rather than several large swamps and lakes (as, for example, at Kerang).

Rocklands Reservoir, the storages near Horsham, and the large swamps in the south - Bryan , Mount William, Lake Muirhead - are also shot over, especially during duck opening.

Almost all the Grampians is an official sanctuary, and all hunting is prohibited.

Quail are shot in stubble paddocks on the farms, especially around Horsham, and rabbits and foxes are shot around the edge of the public land throughout the study area.

The Grampians contains Victoria's major herd of red deer living in the wild. The size of the herd is reported to have declined over the last 6--7 years, but very little is known about the status, range, and health of deer in the Grampians.

It is possible that sambar are also present - some were released at Mount Zero in 1866, and sightings and other evidence of their presence are reported from time to time.

Although the deer is regarded as a prime game animal, this herd cannot be hunted because the Grampians is a sanctuary. There is little pressure to open the area for hunting, as the heads of this deer population do not make high-quality trophies. The herd is, however, of scientific interest.

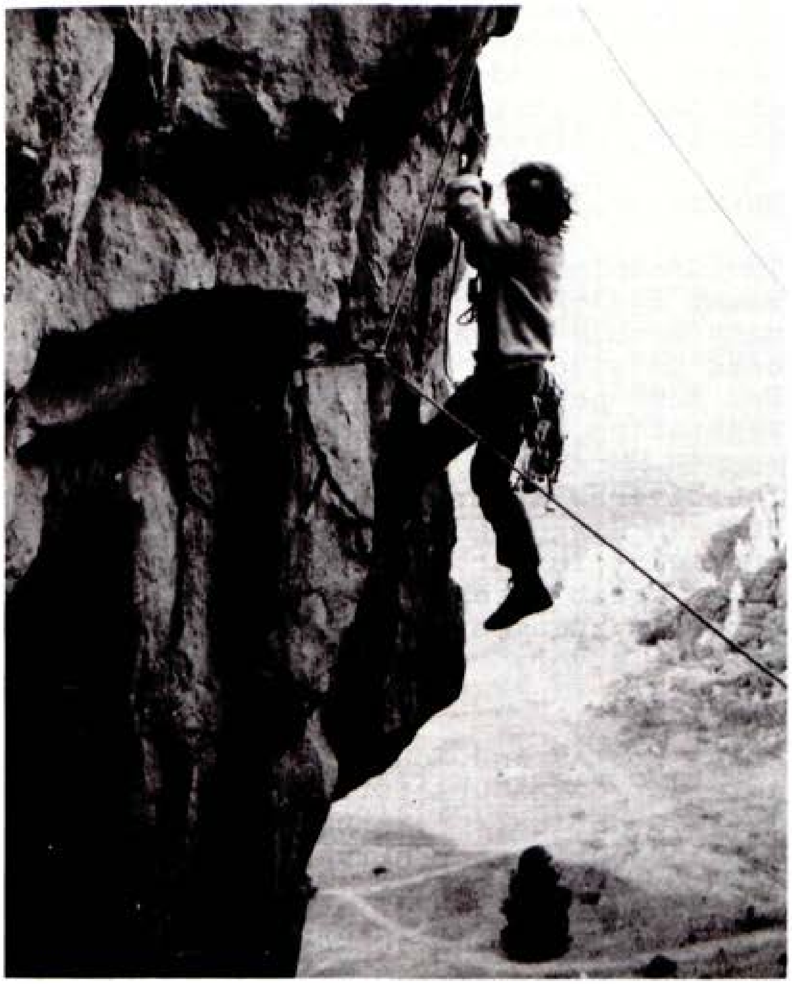
Rock-climbing

Mount Arapiles and the Grampians together comprise the most important rock-climbing resource in Victoria and are often used by climbers from South Australia and New South Wales.

Two guidebooks on Mount Arapiles have been published, describing more than 500 routes on the cliff. This area is favoured because of the high quality of climbing available, good access, low rainfall, and good camp sites in the pine plantation (Centenary Park) at the foot of the cliff.

The Grampians offer a great variety of cliffs, of differing length and difficulty, and also contain large stretches of unclimbed rock. About 40 cliffs are described in the four rock-climbing guides published for the area. The 12 most popular of these are shown on Map 8. Mount Rosea is regarded as the best cliff in the Grampians, although it is not as popular as Mount Arapiles.

Rock-climbers in the Grampians usually camp in established camping grounds near



Rock-climber at Mount Arapiles

the particular cliffs they intend visiting.

Rock-climbing has little impact on the land. Overcrowding of the camping ground could become a problem at Mount Arapiles.

Water-based activities

Swimming in the water storages is a popular activity during the hot summers experienced here. Lake Fyans is particularly popular, as it has attractive sandy beaches and clear water, and lies close to Ararat and Stawell. Lake Lonsdale also has sandy beaches, but this storage is emptied early in the summer to prevent excessive losses from evaporation.

All waters in the study area are fished, but mainly by local people - the fishing is not considered good enough to attract people long distances just to fish. Rocklands Reservoir is popular, and carries good numbers of redfin and brown trout.

Redfin and brown and rainbow trout are the most common game fish - many waters are regularly stocked with trout. Murray cod may be caught in several lakes north of Edenhope, and blackfish may be caught in the Wannon and MacKenzie Rivers and Mount William Creek.

Boating is a popular activity on the man-made water storages, and on some of the larger lakes in the south-western Wimmera plains, but is prohibited on Moora Reservoir. Power-boats are prohibited on Pine and Taylor Lakes, and Lake Bellfield, while on Lake Wartook

Fisherman with a prized catch - a Murray cod

they are restricted to 8 kW and 8 km per hr. Rocklands Reservoir, Lake Fyans, Green Lake, and Lake Wallace (Edenhope) are particularly popular for power-boating, water-skiing, and sailing.

Nature study

The Grampians, and to a lesser extent Mount Eccles and Mount Napier, attract many people who have specialized interests in studying some aspect of nature. For most people these aspects are the vegetation, or the birds.

The diverse habitats of the Grampians contain large numbers of plant and bird species. In particular, the vegetation is of great interest because of the numerous species that only occur here, or have a very restricted range outside the area.

Mount Eccles and Mount Napier are of interest to naturalists because they contain habitats - manna gum woodland with predominantly herbaceous understorey on very fertile stony soils - that are rare on public land in Victoria. In addition, the geological features associated with recent volcanic activity are of great interest to people who have some knowledge of the phenomena.

While many people would visit the public land specifically for nature study purposes, a far greater number incorporate nature study into other activities, such as bushwalking, camping and picnicking, and recreation driving.

Economics and Growth

Economic impact of tourists

The thousands of tourists who visit the Grampians and surrounding areas each year inject a considerable amount of money into the local towns. At present Stawell and Halls Gap get the lion's share of this money. Stawell Town Council appointed a Tourist Promotion Officer in 1968. The work of this officer over the following years led to an increase in the number of tourists visiting the region and expansion of tourist business in Stawell and Halls Gap. Promotion officers are now working in Horsham and Hamilton, as well as Stawell.

Surveys of accommodation have shown that 404,583 overnight visitors stayed in the Halls Gap--Stawell--Lake Fyans area in 1974/75, 406,267 in 1975/76, and approximately 413,000 in 1976/77. These figures do not include campers outside caravan parks, and day visitors.

The value of the tourist industry for the area described above is estimated to be about $3 million annually. The impact on the local economy is greater than this, due to the multiplier effect, and the total volume of business generated by tourism is estimated to be about $3.75 million.

Figures for the other towns in the study area are not available.

Demand

The demand for outdoor recreation has increased markedly over the last decade. Many factors, some interdependent, are involved, although their exact influence is not clear. The major factors are discussed below.

Population

The size, density, and distribution of the population influence the demand for land for recreation.

As discussed in chapter 2, the population of the region is low - about 55,000, including the people living in the towns of Horsham, Stawell, Ararat, and Hamilton. The population of the rural areas declined by 3.2% between 1971 and 1976, while that of the towns rose by 5.2%.

Net population in the study area rose by 2.2% between 1971 and 1976. Thus population growth here is not a factor expected to lead to greatly increased demand for outdoor recreation.

Most of the visitors to the region, however, come from Melbourne. The population of the Melbourne Statistical Division grew from 2.5 million in 1971 to 2.67 million in 1976, an increase of 6.7%. If this trend continues, population growth in that city can be expected to lead to increased demand for recreation in the study area.

Leisure

For most people, leisure time follows a definite pattern - after school or work, at weekends, on school holidays, annual holidays, long-service leave, and retirement. Leisure seems to be increasing, although the effect of second jobs on net leisure time is not clear. Introduction of paid annual leave, long-service leave, and early retirement has led to an increased demand for outdoor recreation. While this increase cannot be quantified, it may be significant for recreation in the study area, which most people take two or more days to visit. It would, therefore, be expected that the number of such visits may increase as people's leisure time becomes available in increasingly large blocks.

Income and transport

Overseas studies have shown that participation in outdoor recreation is directly related to disposable income. This is not surprising, as many recreational activities involve substantial costs for equipment, travel, and accommodation. Incomes have been rising for many years and this trend is expected to continue.

All outdoor recreation involves travel, and the private car is the most common form of transport. With increasing affluence the proportion of the population owning cars is increasing - in Victoria in 1961 there was one car for every 4.6 people and in 1971 there was one car for every 3.4 people, despite the fact that about 34% of the population is younger than the legal driving age.

Car ownership is a significant factor in recreation in the study area, as most visitors to the region (84% in one survey) travel by private car.

Other factors

The attractiveness of an area for recreation, in comparison with alternatives, is important in determining what proportion of the total demand the area will receive. This involves personal preferences, the amount of publicity or promotion it receives, distance, the condition of the roads, availability and quality of accommodation, and so on.

The Grampians have been actively promoted since 1968. Visitor numbers grew strongly during the early seventies, but growth has now fallen. This is attributed to increasing promotion of alternative areas, and the local tourist industry sees itself in the position of having to fight to maintain and extend its share of the total tourist business.

Future demand

Accurate prediction is impossible owing to the number of variables involved. In addition, changes in community attitudes to certain forms of recreation are quite unpredictable. The main conclusion that can be drawn is that most of the factors are working in favour of increasing the demand for outdoor recreation. In the study area, many people already use the Grampians and, as noted, growth in demand is slowing down due to competition from alternative areas. As this situation is likely to continue, growth in the total number of people visiting the Grampians is expected to be low.

Growth in recreational use of the remainder of the public land is also expected to be low, due to the absence of outstanding attractions and active tourist promotion.

16. WATER UTILIZATION

The Grampians have the highest average annual rainfall in the study district (700--1,000 mm). The three most important streams in the area have their sources here: the Glenelg River and the Wannon flow south, meet near Casterton, and enter the sea at Nelson; the Wimmera River flows north to inland lakes.

Flow in these streams is highly variable because rainfall, which mostly occurs in winter and spring, differs greatly from year to year. The major streams have swampy sections in which losses from evaporation are high. Infiltration of water to underground aquifers also reduces stream flow.

A few short coastal streams in the far south of the study district also have highly unreliable flows, although they seldom dry up. The south-western Wimmera plains contain many lakes and swamps of widely varying salinity, but few streams.

Salinity is one of the major problems associated with water utilization here. Water flowing in streams may be quite brackish (3,000--5,000 mg T.D.S. per l), especially during dry periods.

Groundwater

The study area has large reserves of groundwater of varying salinities. Good groundwater is available on the south-western Wimmera plains, on the Grampians and their outwash slopes, at depth from the Otway Basin in the south, and from Recent volcanic rocks. Several aquifers that are recharged by water infiltrating here are important because they supply water for stock and domestic use in north-western Victoria.

Surface water

Compared with eastern Victoria, the study district has meagre surface water resources, but these resources are intensively harvested and distributed by an extensive system of dams, channels, and storages. The present degree of utilization is so high that there are few ways in which the system can be extended.

Wimmera--Mallee Stock and Domestic Water Supply System

In the 1840s, the pastoralists who had moved into the northern Wimmera and the

The wall at Rocklands Reservoir

country around Lake Hindmarsh found that the lack of water for both domestic and stock use was a serious problem. There was only one river system, the erratically flowing Wimmera and its effluent streams. (An effluent stream is one flowing from another, or forming the outlet of a lake.) Also, run-off was insufficient to fill farm dams and water had to be carted each summer to farms away from the river.

The Wilson brothers, owners of the Longerenong run, dammed the Wimmera River at Ashens in about 1856, diverting its waters into the effluent Yarriambiack Creek. Their example was followed by other settlers, anxious to make the most of the available water. By the late 1860s the Wilsons were distributing water through pipes and channels a distance of some 30 km.

Other works were initiated, both by individuals and by the newly formed shire councils. Meanwhile, the droughts of 1877 and 1881 underlined the settlers' plight - sometimes water had to be carted up to 50 km.

Shires and trusts

In 1878 the Shire of St. Arnaud (which was afterwards split into the Shires of Donald and Kara Kara) and the Shire of Dunmunkle constructed a timber weir on the Wimmera at Glenorchy. (There is still a weir at Glenorchy - it is one of the key structures in the present system.) The Shire of Wimmera later built a weir at Longerenong.

A number of shires sponsored the formation of the Wimmera United Waterworks Trust in 1882, and this body built Wartook Reservoir, on the headwaters of the MacKenzie, between 1882 and 1887. Lake Wartook was the first irrigation storage in Victoria (and possibly Australia). John Dickson Derry was the engineer.

Between 1886 and 1894 a network of diversion weirs, local storages, and distribution channels was developed. Some streams were snagged and straightened so that they flowed faster and could be used as channels. At this time irrigation development around Horsham was intensifying, and orchards, vineyards, market-gardens, and dairy-farms were being established.

Lake Lonsdale was constructed in 1903 (1902 was a drought year). Formerly a swamp on Mount William Creek, its storage capacity was enlarged many times by constructing an earthen wall along its western flank.

By this time, seven rural waterworks trusts were operating in the Wimmera. Divided control of headworks, weirs, and channels provoked endless disagreement, and there were many difficulties relating to finance and rate collection.

Water Commission

The *Water Act* 1905 declared all natural streams and water in Victoria to be the property of the Crown, and established the State Rivers and Water Supply Commission. In 1908 this authority took over the functions and responsibilities of the trusts, which were then disbanded.

Many projects have been built since that time, to form the Wimmera--Mallee Domestic and Stock Water Supply System, one of the most extensive gravitational systems in the world.

Fyans Lake was built after the 1914 drought; Taylor Lake and Pine Lake were completed respectively in 1923 and 1928,

Lake Bellfield, from Boroka Look-out

Table 19

CAPACITY OF EACH MAIN RESERVOIR IN THE WIMMERA—MALLEE DOMESTIC AND STOCK WATER SUPPLY SYSTEM

	Megalitres	Source of water
Lake Wartook* (completed 1887)	29,360	Built on MacKenzie River
Lake Lonsdale (1903)	65,740	Built on Mount William Creek; also diversion from Fyans Creek
Lake Fyans (1916)	21,090	Diversion from Fyans Creek
Taylor Lake (1923)	37,000	Diversion from Wimmera River, MacKenzie River, and Rocklands Reservoir
Pine Lake (1928)	64,230	Diversion from Wimmera River, MacKenzie River, and Rocklands Reservoir
Green Lake (1933)	8,140	Diversion from MacKenzie River and Rocklands Reservoir
Dock Lake (1933)	5,920	Diversion from MacKenzie River and Rocklands Reservoir
Moora Moora Reservoir (1933)	6,290	Built on Moora Creek, also diversion from Glenelg River
Toolondo Reservoir (1952)	106,100	Diversion from Rocklands Reservoir
Rocklands Reservoir* (1953)	335,500	Built on Glenelg River
Lake Batyo Catyo+ (1961)	4,770	Storage near Donald
Lake Bellfield* (1966)	78,540	Built on Fyans Creek
Total capacity *c.*	763,000 Ml	

*The three major collecting reservoirs - the other storages have only small catchments, and their main function is to hold water

+Outside the study area (south of Donald) and Green Lake and Dock Lake in 1933. These storages were formerly natural swamps or lakes.

Stone from a quarry at the foot of Mount Zero in the Grampians was carried by tramway to Pine and Taylor Lakes, where it was used for beaching.

Meanwhile, completion of the Moora Channel in 1930 allowed the waters of the Glenelg to be directed over the Divide into the Wimmera River system. Three years later the tiny Moora Reservoir was storing water from one of the tributaries of the upper Glenelg River.

The largest storage in the study area, Rocklands Reservoir on the Glenelg River near Balmoral, was completed in 1953. Water from Rocklands can be stored in the Toolondo Reservoir, which was made by enlarging a natural lake, also in 1953.

Work in the upper Wannon and Fyans Creek valleys culminated in the completion of Lake Bellfield on Fyans Creek in 1967 and the installation of a pipeline to divert the headwaters of the Wannon northwards into the Fyans Creek catchment in 1971. Winter flows only are diverted.

Construction of channels has proceeded throughout the last seven decades, as they are a much more efficient means of distributing water than natural watercourses.

Importance to Victoria

The Wimmera--Mallee System serves 28,500 sq km of farmlands in western and northwestern Victoria. Farms here produce mainly sheep and cereals, including most of Victoria'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 midlands storages to where it will be used, includes some 9,600 km of State Rivers and Water Supply Commission channels and some 6,500 km of farmers' channels. About 20,500 farm dams and the storage basins of 48 townships are filled 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

The area served by the Wimmera--Mallee System and the headworks storages is shown on Map 5. The capacity of each main storage is listed in Table 19. 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 any of the storages in the study district to anywhere in the Wimmera--Mallee 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 Huddlestone Weir, a further 15 km downstream.

The channels are run once a year in winter to minimize evaporation and seepage losses. 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, but is around 118,000 Ml 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. An assessment of the capacity of the Grampians catchments is being carried out at present however, to determine whether further allocations of water can be made.

In 1968 a Parliamentary Public Works Committee recommended that the water resources of the upper Wannon River, apart from the winter diversion to Lake Bellfield from the upper 24 sq km of the catchment, should be reserved for town and industrial use and stock and domestic supply within the Wannon valley.

It is estimated that, if a 25,000-Ml dam at Burrah Gap and a 6,000-Ml storage at Lake Bullrush (see Map 5) were built and connected by a pipeline, 8,500 Ml per annum would be available from the upper Wannon. Current evidence indicates that at present it is more economic for farms in the Wannon valley to develop their private catchment resources than to embark on this scheme.

Apart from the Burrah Gap scheme, there are no plans for further development.

Improved efficiency

Although there are few opportunities to conserve more water 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 the channels are very high, particularly north of Hopetoun, because of seepage into sandy soils and evaporation. A small piped system west of Rainbow has been very successful - an area of 10,000 ha of farmland is supplied by gravity from the town storages; the use of pipelines here has saved a large quantity of water. (Pipelines have replaced channels leading from the Murray River to the Millewa (west of Mildura), where distribution losses from channels were very high.)

Pipeline installation 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 northern channels.

Water Use Within the Study Area

Urban supplies

Details of the town water supplies are set out in Table 20. Most use small storages or offtakes in the Grampians, and pipe the water to storages near the towns. Supplies drawn from groundwater often augment surface resources, and many residents use rainwater collected in tanks. Towns in the south-western Wimmera plains - except Edenhope, which draws onLake Wallace - rely on groundwater. Macarthur and Yambuk in the south of the study area do not have reticulated water supplies.

Catchments, diversions, storages, and pipelines are shown on Map 5. The Horsham, Natimuk, and Balmoral water supplies are drawn from the Wimmera--Mallee system, as are supplementary supplies for Stawell and Ararat (from Lake Fyans). Elsewhere urban water trusts have their own headworks and pipelines.

The first urban water supply was designed and constructed by John D'Alton, Stawell Borough Engineer during the 1870s (who designed and built both the Shire and Borough Halls there as well). A tunnel 1 km long was driven from the side of the valley of Fyans Creek, through the Mount William Range, to the eastern side of the Grampians. Originally a flume carried water from a storage on the upper Fyans Creek to the tunnel entrance, but this was later replaced by a pipeline. With the pipeline from the eastern end of the tunnel across the plains to the storage on Big Hill, near Stawell, this fine example of early engineering totalled 37 km in length.

In 1898, headworks at Gap Creek and four other streams at the southern end of the Victoria Range were connected with a 140-Ml reservoir at Hamilton via a 39-km pipeline. The headworks and pipeline now feed into two reservoirs at Hamilton, with a total capacity of 1,500 Ml.

Around the turn of the century, Horsham laid a pipeline about 20 km in length from a small storage on Burnt Creek, which was fed from Lake Wartook. This was superseded in 1933 when the Mount Zero reservoir was built and connected to the town by a pipeline. The Mount Zero reservoir is filled from Lake War-

Table 20

TOWN WATER SUPPLIES

Town	Population	Source	Remarks
Apsley	220	Groundwater (Duddo Limestone)	
Ararat	8,290	Lake Fyans	Supplementary supply; main source outside area (Mount Cole)
Balmoral	300	Rocklands Reservoir	Supply by pipeline 9 km to service basin 1.4-Ml capacity
Casterton	2,150	Den Hills Creek	Storage for Coleraine, Casterton--Konong Wootong Reservoir - capacity 370 Ml - by pipeline, to service basin 3.85 Ml; supplemented by groundwater (Whalers Bluff Formation - west of Casterton)
Cavendish	180		Diversion from Hamilton pipeline to storage, capacity 2.3 Ml
Coleraine	1,300	Den Hills Creek	From Konong Wootong Reservoir - capacity 370 Ml - by pipeline to service basins 2.7 Ml
Dunkeld	430	Waterfall Gully (Mount Abrupt)	Service basin 37 Ml
Edenhope	920	Lake Wallace	Pumping to elevated tanks
Glenorchy	120	Wimmera River	Pumping to elevated tank
Glenthompson	240	Local catchment	Storage 118 Ml supplemented by supply from Willaura Scheme
Goroke	350	Groundwater (Parilla Sand)	
Great Western	200	Panrock Creek	Storage 63 Ml, pipeline 5 km to township
Halls Gap	300	Dairy Creek	Storage 50 Ml
Hamilton	9,500	Gap Creek & others in Victoria Range	By 39-km pipeline to storages at Hamilton, capacity 1,500 Ml
Harrow	120	Groundwater (Parilla Sand)	

Table 20 (contd.)

Town	Population	Source	Remarks
Horsham	11,650	Wimmera--Mallee D & S System	Storage 174 Ml
Moyston	100	Stony & Mason Creeks	Reservoir 2.3 Ml, by pipeline 16 km from Willaura headworks; supplemented by groundwater (outwash slopes)
Natimuk	460	Wimmera--Mallee D & S System	
Stawell	6,150	Fyans Creek	37-km pipeline to service basins 111-Ml capacity in Stawell; supplementary supply from Lake Fyans
Tarrington	200		Diversion from Hamilton pipeline
Willaura	400	Stony & Mason Creeks	Through 27-km pipeline to storage 23-Ml capacity; supplemented by groundwater; these headworks also service Wickliffe and Lake Bolac

took via the MacKenzie River (see Map 5).

Konong Wootong Reservoir was built on Den Hills Creek in 1926 to supply Coleraine and Casterton. The waters feeding this storage are quite salty - they average 700 mg T.D.S. per l (Melbourne's water averages 100 mg per l), and salinities up to 1,200 mg per l have occurred. In dry years the reservoir cannot meet the demand for water in the two towns, and a supplementary supply using groundwater has been installed for Casterton.

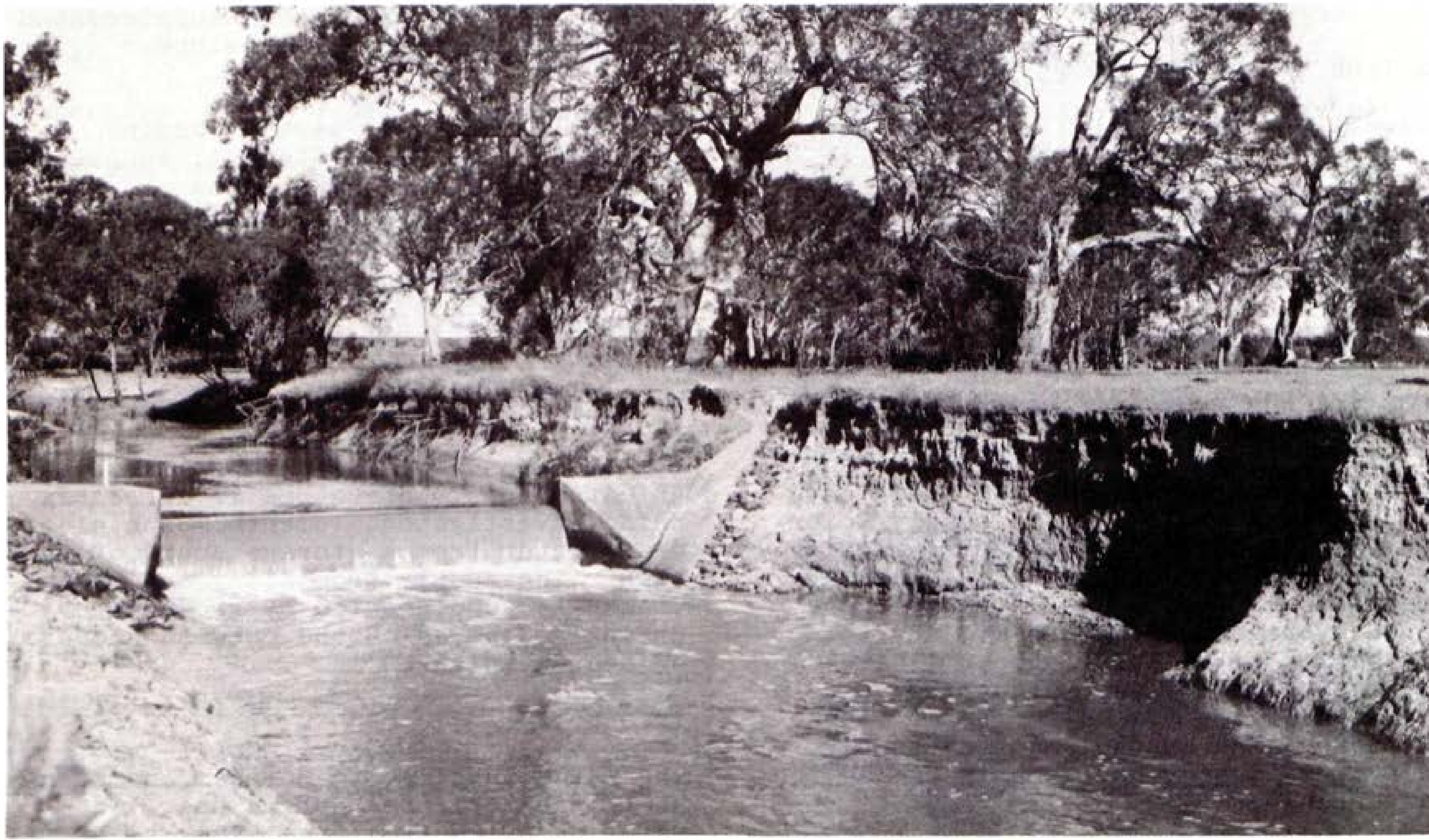
A weir at the junction of Stony and Mason Creeks (in the headwaters of Mount William Creek) diverts water into a pipeline servicing Willaura, Moyston, Glenthompson, Wickliffe, and Lake Bolac. An extension to Streatham is currently being investigated. Glenthompson also draws water from a storage south of the town. The supply from Stony and Mason Creeks is supplemented by groundwater drawn from bores in the outwash slopes of the Grampians.

Treatment

The water supplied to Horsham and Edenhope is chlorinated before use. The water supplied from Lake Fyans to Ararat and Stawell is also chlorinated. All other supplies are untreated.

Future demand

The populations of the cities and towns in and around the study area are stable or growing very slowly (see Table 1). Consumption of water there, however, has risen slowly over the past decade, and this trend is expected to continue. The rise is due to greater use for watering sports-grounds and gardens, and to rises in the numbers of automatic washing machines and evaporative coolers in use.



Outfall channel from Lake Lonsdale

Farm supplies

Farms to the north of the Grampians are served by the channels of the Wimmera--Mallee Stock and Domestic System, and those to the south of Hamilton and around Edenhope use groundwater.

Farm dams are the major source of supply for the rest of the study area. Most dams are about 1-Ml capacity, but a few, particularly in the areas north of Hamilton, are up to 30-Ml capacity. 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.

Table 21 shows the numbers of diversion permits issued for the various streams, their purposes, and the areas irrigated.

In addition to the use of surface water, groundwater tapped by bores is used for both stock and domestic supplies, and for irrigation. South of Hamilton more than 300 bores are used for stock and domestic purposes, and a further eight irrigate about 80 ha. The Edenhope area has about 200 stock and domestic bores and a further 10 bores are used to irrigate about 160 ha.

Flushes of water are sent down the Glenelg River from Rocklands in the summer to maintain acceptable water quality for stock. Prior to Rocklands being built, the Glenelg would often cease to flow in summer.

Due to the intensity of use of the area's water resources at present, and the salting hazard in many of the streams, any expansion of irrigated agriculture using surface supplies is unlikely.

Table 21

DIVERSION PERMITS

	Number		Area irrigated (ha)
	Stock and domestic	Irrigation	
Wimmera River	28	24	109
Glenelg & Wannon Rivers	30		
Eumeralla River	10	10	92
Lakes & swamps	11	8	194

In Victoria, the areas with the greatest capability for water harvesting are forested mountain catchments.

Water falling as rain (or snow) in a forested catchment may move along several paths. Some is intercepted by the foliage of trees and shrubs and is lost by evaporation into the atmosphere. Of the water that reaches the ground, a little evaporates and the remainder soaks into the soil or runs off. In undisturbed forest, only a small proportion of the water moves as "overland flow" or "run-off", except following prolonged high-intensity storms.

Water that soaks into the soil may be taken up by plant roots, and eventually passed into the atmosphere by evaporation from within the leaves. This component (transpiration) plus water loss from the soil by evaporation (a relatively small amount) constitutes "evapotranspiration". The water intercepted by the foliage and evaporated, plus evapotranspiration, represents the water "used" by the vegetation in the catchment.

The "catchment yield" is the total quantity of measurable water output from a catchment. Most stream flow from a forested catchment originates from water percolating through the soil (the groundwater) into streams. Soil permeability is thus an important attribute of catchments. Forest soils are usually highly permeable, due to the incorporation of litter and the effects of tree roots. In addition, these soils are often deep. They can therefore store large quantities of water, and release it into streams gradually over an extended period. The water yield of such a catchment is not necessarily high, however, as the forest vegetation takes up and transpires large volumes. Increased catchment yield is often associated with decreased water use by the catchment vegetation (resulting from thinning or removal of the vegetation), and vice versa.

The nature of catchments that have been cleared and sown to pasture differs greatly from that of forested catchments. In general, grassland uses less water than forest, and water yield is considerably greater. Peak (storm) flows in the streams tend to be higher.

In addition to these considerations of water yield and timing, settled cleared catchments present many problems with respect to water quality. These are considered in the following sections.

The Grampians

The processes operating in the forested mountainous catchments of the Grampians should conform to the general outline given above. In the higher parts of some catchments, where there are large areas of exposed rock, considerable overland flow would occur.

Many streams discharge water from mountainous catchments onto the highly permeable outwash slopes and the plains surrounding the Grampians. Much of the stream flow is absorbed by the thick sandy sediments of these areas to become part of the regional groundwater.

Water Quality

The main determinants of water quality are turbidity and sediment load, colour, and chemical and biological contamination.

Turbidity and sediment load

Turbidity in water is caused by the presence of suspended silt and colloidal matter such as clay and organic matter, while the sediment load is the total quantity of suspended particles it contains, including those greater than colloidal size. Turbidity may impart an unpleasant appearance, and sometimes taste, to water.

Sediment and colloidal particles may carry other pollutants, such as nutrients, pesticides, bacteria, and viruses. This increases the cost of water treatment, as the particles can shield pathogens from chlorination, and filtration becomes necessary. High sediment loads also spoil fish habitat and reduce other wildlife values. Sediment carried by streams may block water-courses and structures, and reduce the capacity of weirs and storages when deposited as silt.

Colour

Water colour may arise from a number of causes. Although the processes operating are not well understood, the kino, or gum, in eucalypts is known to be a strong colouring agent. While colour may make water visually unattractive, it alone is not harmful to health. Strong colouring of water is often associated with other forms of pollution, however.

Chemical quality

The main sources of deterioration in chemical quality are salinity (concentrations of dissolved salts, mainly common salt), contamination by fertilizers and pesticides, and industrial wastes.

Salinity of stream flow may increase when - in catchments with saline groundwater at depth, or in certain climatic zones - removal of the native vegetation produces major changes in the movement of soil moisture or in the level of the groundwater. (Irrigation schemes may also cause salinity, but are not considered further here.) These changes result in salt being carried into streams.

High levels of the plant nutrients nitrogen and phosphorus sometimes occur in water storages, and create problems by causing eutrophication - the very fast growth of aquatic organisms, mainly algae. In extreme cases the oxygen content of the water falls so far that fish are killed, the water develops bad taste and smell, and mats of dead algae block screens and distribution works.

Eutrophication is usually associated with settled catchments - the nutrients coming from farms and sewage works. On the other hand, some enrichment of water with plant nutrients has been reported following wildfires in forested catchments.

Pesticides, particularly insecticides, can be serious pollutants. The persistence of some compounds, particularly the organochlorine compounds (DDT, dieldrin, aldrin, and chlordane) results in their being incorporated and concentrated in the food chain, and they may adversely affect fish and birds. These compounds are seldom used on public land in catchments.

Biological contamination

This arises from the presence of pathogenic organisms of several types - bacteria, viruses, eggs and larvae of parasitic worms, and protozoa. Severe contamination can result in the rapid spread of disease.

The source of biological contamination is the presence of man and animals in catchments. Major sources in settled catchments are sewage and farming waste; in forested catchments they are recreational activities and wildlife.

Biological contamination can be assessed by determining the concentration of indicator bacteria of the faecal coliform group. The method assumes that a high coliform count indicates the possible presence of human pathogens. A zero count does not conclusively indicate absence of pathogens, however. Bacterial counts in monitored catchments often vary widely, and are difficult to interpret. It is not practical to routinely examine water for all pathogens. The viruses in particular are difficult to detect.

It should be noted here that streams flowing from catchments closed to humans sometimes exhibit high bacterial counts. This contamination originates from the wildlife in the catchments, and while *Escherichia coli* (the species commonly used in bacterial counts) is not pathogenic, studies on Australian birds and marsupials have demonstrated the presence of pathogenic organisms in their faeces. Thus completely closed catchments may not be free from some forms of bacterial contamination.

It should also be noted that the importance of a decline in water quality depends on the system itself. Water storage is quite an effective means of purifying water, and a supply system with considerable storage is less subject to quality changes than one that simply diverts water into supply mains. Storage of water permits breakdown of pollutants and settling of suspended solids. Deterioration in water quality can be rectified by treatment, but at considerable cost.

The importance of changes in water quality also depends to some extent on the end uses to which the water is to be put. Usually these are domestic, stock, industrial and irrigation supply, recreational use, and nature conservation.

Land Use and Water Production

The relation between the various forms of land use that may take place on a catchment and the quantity, quality, and timing of water that flows from the catchment are imperfectly understood. Although research into catchment management in Australia has increased greatly in recent years, many aspects have not been investigated, and the results of overseas studies must be taken as guides. No detailed research has been carried out in the public land catchments in the study area.

Forest harvesting

Maintenance of vegetative cover, especially low ground cover, is most important in retaining soil stability and preventing the movement of sediment into streams.

Logging disturbs the vegetation and the soil, and can lead to greatly increased sediment loads. The heavy machinery used in logging may also reduce the permeability of the soil resulting in overland flow, erosion, and transport of sediments into streams. These effects can be greatly reduced by careful design and control of logging operations.

It is especially important to avoid logging on very steep slopes, near streams, and in very wet weather. Rapid regeneration to re-establish the vegetative cover is essential. Rehabilitation works carried out after harvesting, such as ripping log landings and barring snig tracks, also reduce the impact of harvesting on water quality.

The burning associated with regeneration treatments following logging may affect the chemical quality of stream flow (discussed below). Dense regeneration following harvesting may use more water and thus reduce catchment yield. This is unlikely to be an important effect in the Grampians.

Timber-harvesting operations in the Grampians are usually confined to relatively small areas scattered through large catchments. These activities, and other forest operations, must conform with detailed prescriptions that are designed to protect water-supply values. The prescriptions cover the period during which logging and carting operations are permitted; the location, design, and construction of roads and snig tracks, log landings, and dumps; the retention of protective strips along streams and storages; and other operations in (and uses of) the forest. The effectiveness of prescriptions depends largely on their proper implementation, by means of education and employment.

As noted previously, in some areas extensive forest clearing may result in increased stream salinities. It is known that a salinity hazard is associated with clearing the eucalypt woodlands around Rocklands Reservoir. The extent to which the current forest operations, which consist of removing scattered individual trees, are affecting groundwater levels is not known.

Work in Western Australia has shown that death of trees caused by the root-rotting fungus *Phytophthora cinnamomi* on areas overlying saline groundwater may lead to increased stream salinities. In the Grampians, however, *P. cinnamomi* activity at present is confined to areas where the salinity of the underlying groundwater is low.

Roading

Roads are a major source of sediment in water, especially in the first year after their construction. Those crossing streams or steep sideslopes (needing extensive earthworks) and those with inadequate drainage generate the highest sediment loads.

The comments made with respect to the soil disturbance associated with logging apply also to road construction and maintenance. Roading should be planned to avoid problem areas if possible. Great care must be taken in the design and construction of stream crossings, and unnecessary crossings avoided. In areas with unstable or dispersible soils special measures may be needed to quickly stabilize cut and fill batter slopes.

Water draining from roads should be directed, at low velocities, into undisturbed forest, where it can lose its sediment load. Water from table drains should not be discharged directly into streams.

Recreation

The effects on water quality of recreation in catchments have long been debated. Evidence from overseas indicates that recreation on water storages - swimming, fishing, and boating - usually results in some contamination of the water. As described above, however, the design of the system, the detention time in storage, and the end use of the water are all factors that must be considered in assessing whether recreational use of a particular storage should be permitted. If the water receives treatment by disinfection before consumption, and the intensity and range of water-quality monitoring are increased, controlled recreational use of the storage would not pose a hazard.

Most studies show that controlled recreational use of catchments (as opposed to storages) does not lead to great increases in bacterial counts, turbidity, or chemical pollution, provided the use of roads by recreational vehicles is controlled, especially in wet weather.

In the Grampians, no restrictions are placed on access to water catchments (except where the catchments are within areas that are currently zoned "Primitive Areas"), but camping is discouraged in the small catchments serving local towns.

Mount Zero Reservoir

Clearing for agriculture

The difference between cleared settled catchments and forested ones have been briefly described earlier. Conversion of a forested catchment to grassland and farm settlement can be expected to lead to generally poorer-quality stream flow, and to higher peak flows following storms. Water yield from the catchment may increase.

Within the study district, experience has shown that serious increases in the salinity of streams will result from clearing the areas of gum woodlands around Woohlpooer, Rocklands Reservoir, and to the south of the Black Range. The salinity of the water held in Rocklands Reservoir would also be expected to rise.

The problems of salinity arising from clearing, and the processes operating, are described in the Hazards chapter.

Gravel extraction

Exposure and compaction of soils in gravel pits can lead to locally high sediment loads. These can be greatly reduced by proper attention to drainage, and by ensuring rapid revegetation of disturbed areas.

Grazing

Forest grazing could affect catchment values if the vegetation was browsed to the extent that the soil was bared - heavy rain could then be expected to result in overland flow and high sediment loads. Heavy grazing could also lead to localized soil compaction, especially around watering points. This also generates excessive surface runoff. Control of stock numbers by the managing authorities is essential to avoid these hazards.

Stocking rates in the forests are generally low, and it is unlikely that stock make any appreciable contribution to levels of bacteria and other pathogens in streams and storages, although very little work has been done on this aspect.

Fertilizers and pesticides

Use of chemicals in catchments may affect water quality. Overseas experience indicates that the most important mechanism for entry of chemicals into water supplies is the direct application or drift of spray chemicals onto the surface of streams or storages. Use of buffer strips along streams and storages, choice of chemicals that break down quickly, and selection of suitable weather to prevent drift can greatly reduce the risk of water pollution.

"Phoschek" (di-ammonium phosphate) is mixed with water to make a slurry that is used in "water-bombing" fire outbreaks. The compound is soluble in water, but the amounts used each year in the study area are very small and any phosphate enrichment of streams and storages would be negligible. Herbicides have been used to control wattle regrowth in the Billywing plantation.

Pine plantations

Investigations into the hydrology of *Pinus radiata* plantations in Australia have shown that stream flow is much less from catchments carrying dense plantations of pines than from similar catchments carrying native eucalypt forest.

The differences in stream flow are attributed to the high rate of interception (and subsequent loss by evaporation) of rainfall by the dense canopy of the pines. In thinned pine stands interception is less and stream flow is greater, in some cases higher than from a similar catchment under eucalypts.

Similar results have been reported in overseas work on the effects on stream flow of converting native vegetation to pine plantations. A reduction in stream flow was also recorded when grassland (in Ohio, U.S.A.) was converted to mixed hardwood--softwood plantation. Australian work has shown that pine plantations use more water than does grassland.

Fire

When high-intensity storms follow severe wildfire, catchment yield increases, and surface run-off and sediment loads can be very high. The values of all three variables fall as the vegetation re-establishes. Rapid regeneration and light rainfalls after fire may result in negligible erosion.

Fire may adversely affect the structure and permeability of soils, although the effects vary with soil type. The effects of low-intensity prescribed (fuel-reduction) burns are not clear. Any adverse effects, however, are probably preferable to those that would follow a high-intensity wildfire burning in the same fuel.

Burning following clear-felling may result in increased amounts of nitrogen and phosphorus being released into streams. Increased water yield may reduce the severity of this effect by dilution.

Legislation

Current legislation provides for water catchment areas to be proclaimed by the Governor in Council. The most suitable use in the public interest of all lands in catchment areas, and the conditions under which various forms of use may be permitted, may then be set by determinations.

In the study area the catchment of the Rocklands Reservoir and most of the catchment of the Wimmera River have been proclaimed, and a land use determination has been made (in 1959) for part of the

Rocklands catchment (see Map 5). The determination - covering parts of the parishes of Tyar, Daahl, and Yat Nat - is:

"(a) That in the public interest that part of the area which is Forest Reserve be retained as such and used for forestry and water conservation purposes

(b) That the area already alienated may be used for pasture and grazing, provided suitable erosion control and soil conservation methods are adopted by the owners of such land."

Prescriptions covering forest operations are complementary to any land use determination.

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17. AGRICULTURE

In 1975/76 the gross value of agricultural production in the study area exceeded $80 m. The economic well-being of the towns, as well as of the farms, is directly related to the incomes that primary producers receive. The townships are largely based on service industries, which supply farm inputs and which transport, market, and process agricultural products.

The study area contains 3,215 separate holdings, occupying just under 1,200,000 ha, as shown in Table 22. Beef and sheep production dominate farming here but 100,000 ha are cropped yearly and dairying, pig- and poultry-raising, horticulture and viticulture are also practised. (See Map 9.)

Table 22

LAND USE 1975/76

Number of holdings	3,215
Area occupied (ha)	
Crop	103,983
Native pasture	158,503
Sown pasture	868,823
Balance	154,687
Total	1,285,996

Source: Australian Bureau of Statistics

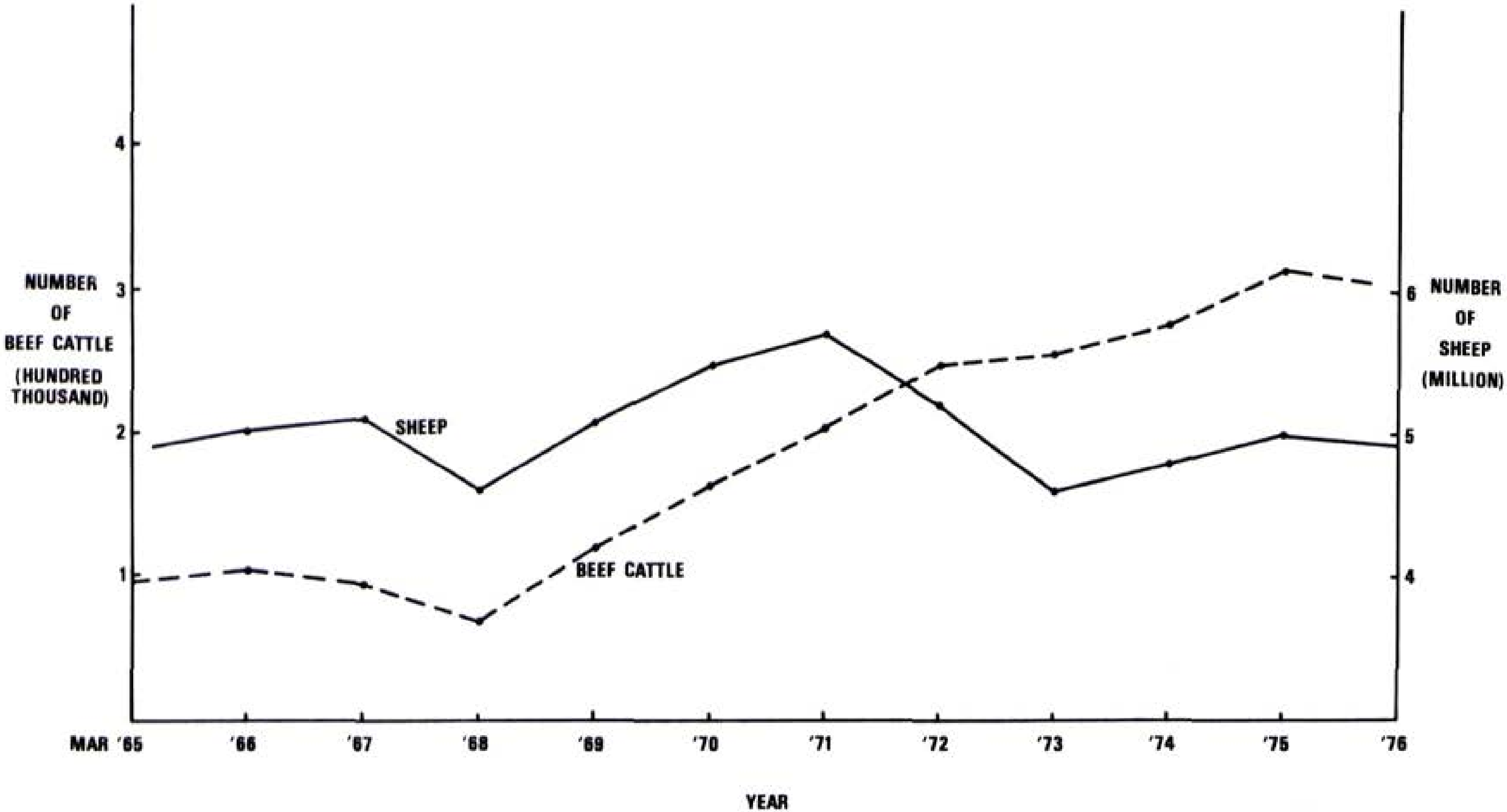
The grazing industries here have expanded rapidly since the introduction of subterranean clovers in the early 1920s and the more-widespread use of superphosphate in the late 1920s. The "sub and super" revolution, which really got under way in the 1930s, was checked by shortages of manpower and materials in the war years but expanded rapidly again after the war.

The substantial improvement in pastures allowed a steady increase in stocking rates on properties throughout the area. Sheep numbers increased by 250% and cattle numbers by 50% from 1920 to 1965 (see Figure 5).

Since 1965 stock numbers have fluctuated with changes in economic and climatic conditions. Sheep numbers dropped after the '67 drought and fell again when wool prices plummeted in the early '70s. Numbers then recovered to approximately 5,000,000 in 1976, but fell to 4,500,000 in 1977.

FIGURE 5

TRENDS IN NUMBERS OF SHEEP AND BEEF CATTLE
SOUTH – WESTERN STUDY AREA DISTRICT 2



High cattle prices in the early '70s triggered off rapid increases in numbers - in 3 years the study area's cattle population rose from 100,000 to 300,000. With unfavourable prices since 1974, however, numbers have declined, and in March 1977 the total was 260,000. Total stocking rates continued to increase until 1975, but this trend has been reversed - at least temporarily.

Pastures

Subterranean clover has continued to be the basic legume component of pastures over most of the area. In more recent years the use of perennial grasses such as perennial ryegrass, cocksfoot, and phalaris has widened. Lucerne has also been introduced into some of the lighter soils, which occur particularly in the north-west of the study area.

The growing season of pasture is closely related to annual rainfall and varies from about 8 months in the northern parts of the area to 11--12 months in the southern higher-rainfall districts.

Fertilizer is still required regularly on pastures. Most soils require regular topdressings of superphosphate, which is normally applied at rates varying from 80 to 200 kg per ha. During the years from 1965/66 to 1975/76, an average of 570,000 ha of pasture were topdressed annually, using an average of 68,000 tonnes of superphosphate a year. This was approximately 10% of the superphosphate used on pastures in the State.

There has been a decline in the amount of superphosphate applied to pastures in the last two seasons, due mainly to lower returns from grazing and to substantially higher costs of fertilizer.

Regular applications of potash and the trace elements copper, zinc, and molybdenum are also required on the relatively small areas of lighter soils in the region.

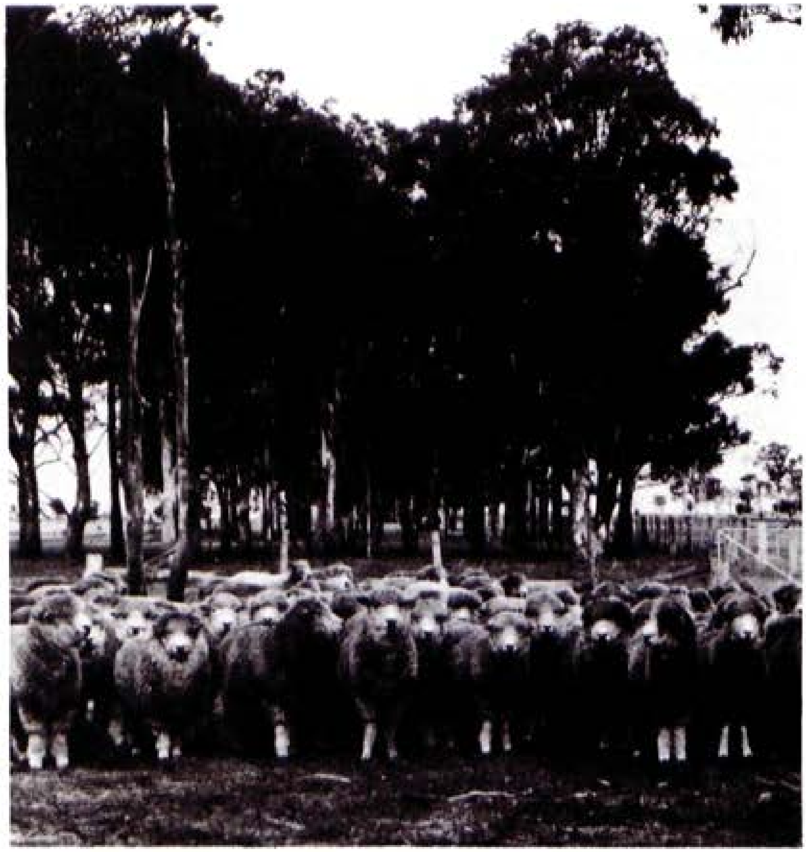
Only a small amount of pasture (1,500 ha) is irrigated. About half this is at Quantong, west of Horsham, and is watered from the Wimmera--Mallee water supply system. Originally this area supported dairying, intensive grazing, and fruit production, but it now has a variety of uses including hobby farming and agistment. Some of the land is still used for dairying. The rest of the irrigated land consists of small areas watered from streams, lakes, or farm dams.

Sheep

Sheep- and wool-growing are the major primary industries of the study area, in terms of both land use and value of production. At present 68% of the sheep in the area are Merinos, 11% Corriedales, 9% crossbreds, and 5% Merino comebacks.

Wool production is the dominant enterprise, but production of prime lambs is also of significance. Wool produced has averaged 24,680,000 kg per year (19% of the State's production) over the last 5 years, while in 1976/77, 838,000 fat-grown sheep and 315,000 prime lambs were sold out of the area. Prime-lamb production is of particular importance on the south-western Wimmera plains and in the Macarthur region.

The Middle East market for live sheep and sheep-meat has assumed great import-



Wool-growing is an important farm enterprise in the study area

ance for local sheep-producers. In 1976 Victoria exported 90,000 live sheep to countries in the Middle East, and in 1977 the number rose to 300,000. Most of those sheep were Merino wethers of more than 50 kg liveweight. Many of them were produced within the study area. In addition, large quantities of sheep-meat are now being exported to the Middle East. Prices received on this market have been excellent and if this situation continues many local producers will gear their flocks to producing for this trade.

In the north of the study area sheep are integrated with cereal-growing enterprises. Towards the south, the amount of cropping decreases and the number of beef cattle on farms increases. Cattle contribute just under half the total grazing pressure in the southern half.

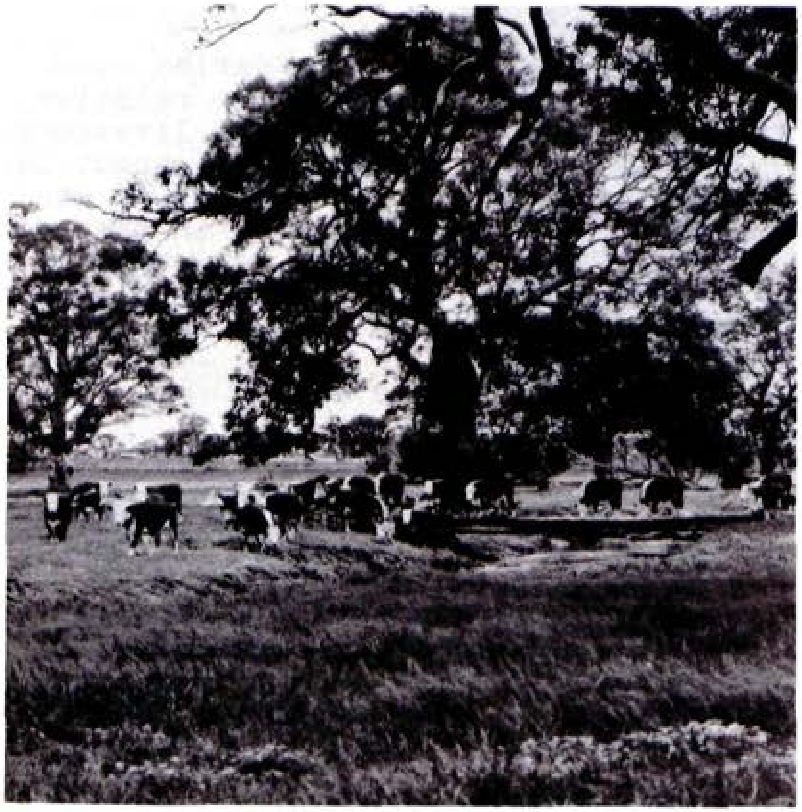
Autumn is still the preferred time for lambing, but there has been a small but significant swing to late winter and spring since the early sixties. Two major factors affecting performance are the condition of the ewes at joining and weather during lambing. Lambing percentage for Merino ewes in the study area averages 80%.

Seasonal feed shortages are a major problem. During winter in-lamb and lactating ewes can suffer severe nutritional stress, while in summer weaner sheep usually need a supplement of good-quality fodder to maintain satisfactory growth. Internal parasites are the major cause of disease.

Beef

Beef cattle numbers have followed similar trends to those in other parts of Victoria. Total numbers in the study area increased from 102,000 in 1965/66 to 316,000 in 1974/75. These figures represented a steady 7% or so of the State's cattle population over that period. The rapid increase in numbers occurred because of the high returns from beef relative to those from sheep in most of these years.

Since the collapse of the beef market in 1974/75, numbers have fallen back to 260,000 - this is illustrated in Table 23, which gives data from a group of properties near Hamilton.



Typical farmland scene in the study area

Table 23

RETURNS FROM BEEF CATTLE

	Average price for cattle sold ($)	Gross margin* per cow ($)
1970/71	93	22.80
1971/72	90	34.80
1972/73	97	36.00
1973/74	134	62.40
1974/75	56	16.20
1975/76	53	0.00
1976/77	57	12.00

*Gross margin is the gross income less the variable costs

Source: Department of Agriculture

Beef cattle are mostly run in association with sheep. The study district is predominantly a breeding area, with calves dropped in autumn and early winter and sold at weaning the following summer. The best steer-calves are normally sold as vealers and the remaining calves, not required as replacements, sold in the store weaner sales in the new year. Some properties, particularly in the south, retain steers and fatten them for sale at heavier weights.

Herefords are the most popular breed, with Shorthorns and Aberdeen (Angus) also common. Crosses of these British breeds are also widely used for meat production.

Shortage of paddock feed for lactating cows in the wet cold winter months is a major problem in the south. This is overcome by feeding hay.

Internal parasites are the major disease problem, but these can be controlled with a strategic drenching programme.

Most cattle are sold at auction centres within the study area, particularly at Hamilton, Horsham, and Ararat. There are no major meatworks there, and most cattle are killed at Portland or in Melbourne works.

Fodder

Fodder conservation is an important part of stock management on most farms here. The major proportion of hay is made from pasture, although in poorer pasture years up to 50% of the area cut for hay in the north is cereals, usually oats. A swing to the use of larger fodder equipment has reduced the amount of labour required with earlier methods. In many cases this new machinery is owned jointly by groups of farmers.

The area cut for hay varies from year to year, but in recent years an average of 555,000 ha has been cut for an average production of 2,352,000 tonnes. Most of this hay has been used for the winter feeding of cattle and the summer feeding of young sheep.

There are only very small areas (2,900 ha) of fodder crops - mainly rape, choumollier, millet, and turnips. These areas are usually used to finish prime lambs over summer.

Cropping

The area devoted to crops varies considerably with changes in the relative profitability of cropping and livestock enterprises. In recent years, about 15% of the State's oats area and 5% of its wheat area have been located in the study district (see Table 24). Most of the crops are grown in the north, on the south-western Wimmera Plains.

Table 24

CROP PRODUCTION 1975/76

	Area (ha)	Production (tonnes)
Wheat	46,713	72,011
Oats	39,698	49,396
Barley	8,650	13,148
Linseed	356	306
Rape	682	332
Sunflower	896	518
Field peas	208	220

Source: Australian Bureau of Statistics

Harvesting wheat on the Wimmera plains

Excessive rainfall - causing waterlogging and an increased incidence of pests and diseases - is the major constraint to an expansion of the area sown to cereals. Nevertheless, advances in technology such as minimum tillage, new drainage techniques, and new cereal varieties are resulting in an expansion of cropping.

In addition, economic pressures are directing the attention of livestock producers and research workers to cropping. Another impetus is the fact that the study area has sufficient moisture available to grow a crop a year, whereas in the northern Wimmera and Mallee an additional year of fallow is required in most seasons.

The most widespread crop - oats - is relatively resistant to wet conditions and provides an important source of stored fodder for livestock.

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A cropping rotation frequently used is 3 years of clover pasture followed by two crops of wheat and one of oats. Cereal crops grown in this area do not require any special fertilizer other than superphosphate. Special care has to be taken however, to avoid damage by underground insect pests, bird damage, and attacks by armyworms and climbing cutworms. Weeds are a considerable problem, but the technology to overcome them is readily available.

Many other crops are grown in the study area. These include rapeseed, safflower, sunflower, mustard, lupins, and field peas. Major interest is being shown at present in sunflowers, on soils that retain moisture, and in lupins on sandy soils. Lupins used in a rotation with barley offer the possibility of considerable improvement to these lighter soils. It should be noted that a high level of expertise is needed for the successful production of these and other oilseed crops.

Some of the best cropping country is situated just east and south-east of Hamilton. Most of this country was settled by farmers of German descent in the 1840s and 1850s and has been cropped intensively over many years. The major crops grown now are linseed, mustard, rape, sunflower, and cereals. Mustard has been grown on contract since the early 1930s. During World War II, flax, carrots, and red beet were also produced on these soils. Weed control is critical to the success of crops here. This means careful attention to the seed-bed preparation and the use of pre-emergent weedicides. Root rots and insect pests are also significant problems.

Dairying

Dairying is a declining industry in the study area - which supports less then 1% of Victoria's dairy cows - and is concentrated in the south. Poor prices and increasing costs of recent years have resulted in an exodus from the industry in an area that, for the most part, is climatically unsuited to dairy production.

Pigs and poultry

These two industries are also of minor significance. Pig numbers increased from 7,200 in 1965/66 to 22,500 (4% of the State population) in 1972/73. This increase mainly occurred in the north-west. Since then increased feed costs and lower returns have caused a drop in numbers. In 1975/76 the study area had a pig population of 12,000.

The poultry industry is relatively new here. Fertile-egg production is carried out in six sheds, each of 5,000 layers, situated at Tooan, Quantong, and Willaura. The eggs are used to hatch chicks for the broiler industry in the outer metropolitan area. High land values near Melbourne have forced the sheds into these outlying areas, where the remoteness also confers the advantage of isolation from disease outbreaks.

Horticulture

Several types of horticulture are carried on in the study area. These include fruit- and vegetable-growing, olive-growing, and wine production.

The Quantong--Horsham irrigation district once supported a large pome and stone-fruit industry and also a processing-tomato industry. A.J.C. operated a large processing plant and orchard there. Fruit and vegetable production has declined rapidly since about 1960 because of high freight costs and competition from the Goulburn Valley and Swan Hill regions. Now fruit and vegetables are grown for local demand. In most cases horticulture forms part of a mixed farm. The area is subject to severe frosts, and the low land becomes waterlogged in wet years.

Production at Pomonal has also declined for much the same reasons. Now small blocks of mixed orchards just meet local demand. Trees here suffer heavily in dry years and biennial bearing is therefore a problem. Frosts are severe. Small quantities of cut flowers are grown for the Melbourne and local markets.

The Great Western area is famous for its high-quality table wines. Seppelts specialize in grape varieties suitable for the production of quality champagne and varietal table wines. The area is subject to drought and frost damage.

Small areas are irrigated by trickle and flood irrigation. The wine industry here is still expanding, with recent developments at Halls Gap and Mount Chalambar. This expansion is likely to continue, at least for several years.

Two large olive plantations, containing about 40,000 trees, are growing on the outwash slopes of the Grampians near Laharum and Mount Zero. Growth on the poor sandy soils is slow and fruit production is very low. The trees produce about 0.4 tonne per ha, which is one-tenth as much as trees under irrigation on fertile Mallee soils. In earlier years most of the olives were crushed, but now they are mainly used as table olives.

Research station

The Pastoral Research Institute is situated on 1,215 ha of public land near Hamilton. Staff members are engaged in a wide range of grazing industry research, covering the breeding, husbandry, feeding, and management of sheep and cattle, and the development, maintenance, and utilization of pastures.

Potential of Private Land

Although scope to increase production from the private land exists, at present there is little economic incentive to undertake improvement.

The brighter outlook for crops relative to livestock has created considerable interest in their production. While the area cropped may increase significantly, the presence of large areas of unsuitable soil types will ensure that grazing remains the main agricultural pursuit in the study district.

A number of hobby farms lie on the outskirts of the major towns, particularly Hamilton and Horsham, and on the fringes of the Grampians in the Laharum and Moyston areas. As yet, however, hobby farming has had little impact on agricultural production.

Cleared land

In 1976, 15% of the pasture area had not been sown to improved species; some scope still remains, therefore, for increasing agricultural production by introducing these species. Improved topdressed pastures can yield up to 10,000 kg of dry matter per ha per year in the central and southern areas and up to 6,000 kg per ha in the north. Most of this is produced in the spring. This represents a large increase in production over the local unimproved pastures.

Present stocking rates are approximately 11 dry-sheep-equivalents per hectare in the central and southern areas and 7 dry-sheep-equivalents per hectare in the lower-rainfall northern parts. Research at the Pastoral Research Institute at Hamilton and on private property in the north has revealed scope for improving these stocking rates by at least 20%. This potential may not be realized, however, as farmers are being seriously affected by rising costs and lower returns from livestock.

In response to large increases in its price, they have greatly reduced the amount of superphosphate added to pastures in recent years. This decrease has occurred particularly in the last two seasons (see Figure 6); the amount of super used and the area of pasture topdressed in 1975/76 were only half those for the 1973/74 season. Although the effects of this reduction may not be seen for some years on paddocks that have been heavily topdressed, pasture and livestock production will fall markedly if the trend to use less fertilizer continues.

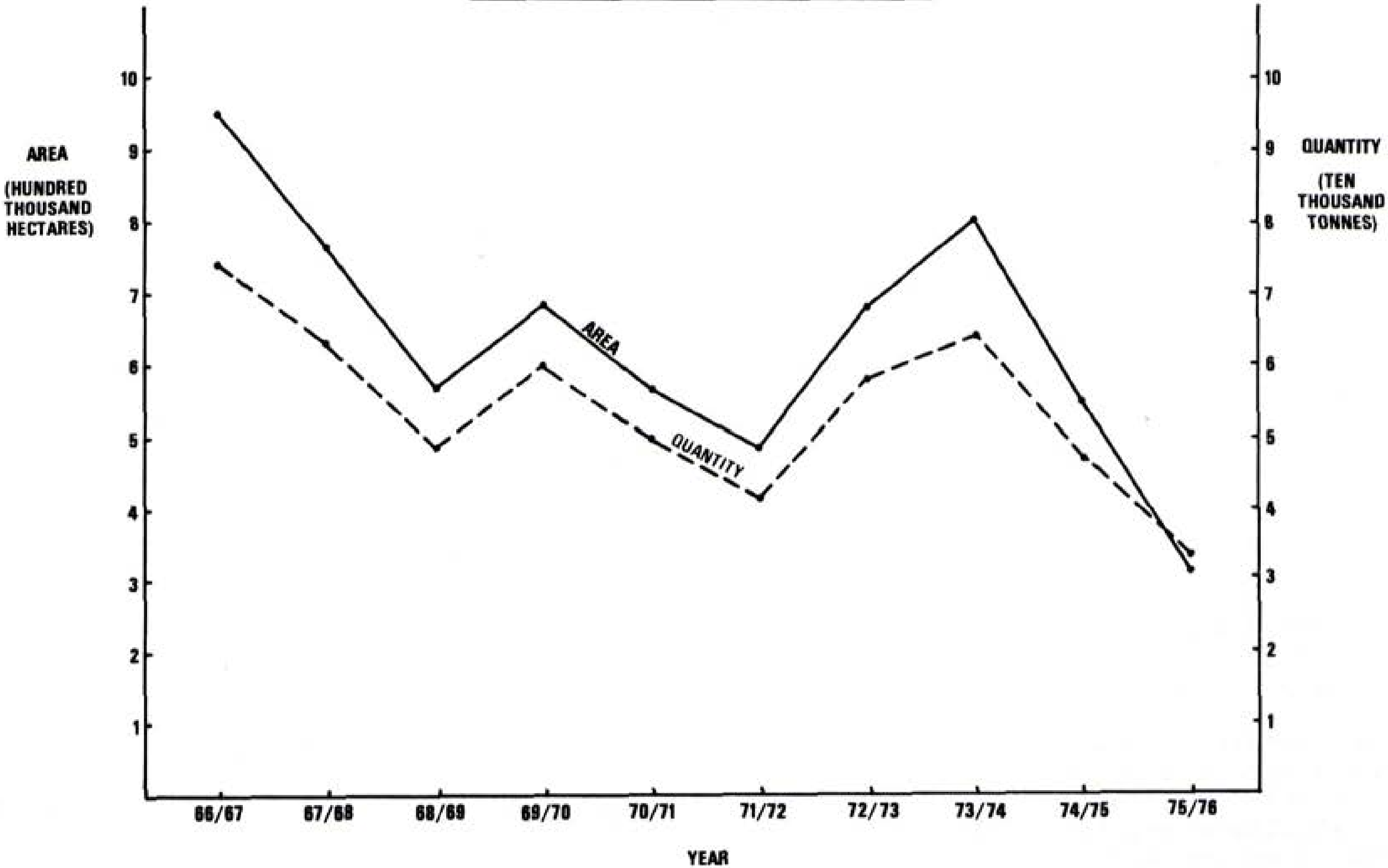
In any case, farmers are wary of further increases in stocking rates. Recent experience has shown that the use of high stocking levels greatly reduces the farmer's flexibility - unfinished stock have had to be sold at giveaway prices in times of feed stress.

Therefore, while there appears to be potential for increasing production on cleared and improved land, it is unlikely to be realized given the present economic climate. In fact in 1975/76

FIGURE 6

SUPERPHOSPHATE USED ON PASTURE

SOUTH – WESTERN STUDY AREA DISTRICT 2



and 1976/77 the average stocking rate in the study district has declined quite markedly.

On some privately owned areas of deep sandy soils in the north, agricultural production could be improved by the establishment of lucerne pastures. Here again, costs of establishment, using trace elements plus lime and superphosphate, make it uneconomic to develop these sands at present.

Potential of Public Land

The mountainous parts of the Grampians and the midland hills are unsuitable for agriculture. The stony rises at Mount Eccles and Mount Napier are also unsuitable for development because of their rockiness and shallow soils.

The public land on the south-western Wimmera plains contains heavily leached sandy soils that are acid and have a low capacity to store water. At present these soils support low woodland and heath, which vary in density and height depending on rainfall and depth of sand.

As the result of research into fertilizer requirements, carried out by the Victorian and South Australian Departments of Agriculture and by the C.S.I.R.O., recommendations for establishment of pastures on these soils can now be made with confidence. Lucerne is the most suitable species, and the application of phosphorus, potassium, calcium, and the trace elements copper, zinc, molybdenum, and cobalt is necessary.

In experiments in the Kowree Shire from 1970 and 1974, lucerne pastures established with these elements and subsequent topdressings produced an average of 6,000 kg of dry matter per ha per year. Experience on farms has shown, however, that precise establishment methods must be followed, and that the lucerne must be carefully grazed to achieve such good yields while maintaining the pasture.

Some farmers have also established pasture of perennial veldt grass on these deeper sands; others have also obtained satisfactory establishnent of phalaris, cocksfoot, and subterranean clover species on some of the shallower sands.

The sands on the outwash slopes on the fringe of the Grampians are not suitable for long-term lucerne pastures. They are generally more acid and lower in potassium, and are not well drained through the profile. Lucerne is therefore more difficult to establish and does not persist. The soils can, however, be sown to phalaris and sub clover pastures. For establishment they also require applications of all of the elements used in the northern sands.

Woodlands of red gum, yellow gum, and yellow box growing in heavy clay soils constitute another land type common on public land at Woohlpooer, Cherrypool, Rocklands, and south-east of Edenhope. This land type is flat to undulating, and large areas of similar country have been cleared and developed.

There has been considerable debate during the last 20 years on the feasibility and advisability of developing the gum woodlands for agriculture. Certainly the technology is available. The areas could be cleared and sown to subterranean clover and perennial grasses. Several important constraints affect such development, however.

The first is the high cost. Bulldozing, windrowing, burning, and then ploughing, cultivating, and harrowing would cost approximately $300 per ha, plus the costs of fertilizer, seed, fencing, and water supply. In total the cost would be enormous when weighed against the returns from pastures that might carry 8 to 10 dry sheep per ha. (Many of the gum woodlands are used for rough grazing at present.)

In addition, experience has shown that removal of the tree cover could lead to salting and erosion in the cleared areas and a serious decline in the quality of the water flowing from these areas, many of which are in the catchment of Rocklands Reservoir.

Soil salting and high salinities in streams are common on the cleared parts of the Dundas Tablelands. Indeed, attempts are now being made to establish more trees on these areas to ameliorate the salting problems. Salting is discussed in more detail in the hazards chapter.

In summary, while it is technically possible to develop much of the public land for agriculture, at present the returns available from agricultural production do not justify further development.

In addition to the salting hazard associated with development of the gum woodlands, much of the public land has potential for use for nature conservation, recreation, apiculture, and timber production.

There is still scope for expanding agricultural production from the existing farmlands.

Grazing on Public Land

The rapid expansion of pastoral occupation during the 1840s resulted in the movement of domestic stock into almost all parts of the study area by the 1850s. Grazing by 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 was accelerated throughout the study area in the following decades by the passage of various *Land 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 Grampians was covered by grazing licences up until the 1940s. Following the 1946 Royal Commission into forest grazing, licences for the mountainous areas and the Victoria Valley were withdrawn. Grazing at Mount Arapiles ceased in 1966.

Areas grazed

The gum--box 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 the capability for grazing falls.

Map 9 shows the major areas currently held under grazing licence or agistment rights. They consist mainly of gum woodlands. Although some brown stringybark forest 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. Most of the grazing in the study district is carried out under annual licences. Rentals are based on the carrying capacity of the land. About 140 grazing licences are current, covering about 70,000 ha. The licensed areas vary from about 10 ha to 800 ha - many are about 50 ha.

Under agistment, the number of sheep permitted to graze on a given area is regulated according to the condition of the ground vegetation. Charges are made on a per-head, per-week basis. About 10,000 ha near Woohlpooer are used for short-term agistment.

Throughout the study district, stocking rates vary from one sheep to 1 ha on the very best sites to one sheep to 5 ha or more on poor sites. Under average conditions, the public land currently grazed could carry about 20,000 sheep.

In the Grampians some areas suitable for grazing remain ungrazed, although all but a few suitable ones in the rest of the study district are held under licence. The area grazed in the red gum forests around Woohlpooer and the western Black Range has fallen in recent years, as farmers find that the returns from forest grazing do not justify the payment of the licence or agistment fees.

Pattern of grazing

Farmers use grazing on public land as an adjunct to operations on their farms - no licensee depends completely on public land for his livelihood.

Sheep may be run throughout the year in the forested land, which is usually stocked with wethers rather than ewes. Rough forest grazing produces very clean, high-quality wool and is a healthy environment for sheep, although drenching for fluke is necessary, as it is on the farms.

The forest grazing is of considerable value to many farmers in supplementing production from freehold land, especially in cases where the farmer has insufficient freehold to be completely viable. It is particularly valuable in dry years when feed on the farms is in short supply. The best management usually involves grazing forests close to the licensee's freehold land.

While most licensess forest-graze for wool production, a number use relatively small areas (less than 40 ha) for stock shelter following shearing and during bad weather, and as holding areas during wet weather. Scrubby stringybark forest is quite suitable for this type of use.

Water supply on the grazed land may be a problem, especially in dry years. Water is usually conserved in bush dams - often these have been constructed for fire-protection purposes.

Impact of grazing

Relatively little is known of the impact of grazing on the forest ecosystem. Grazing does affect the vegetation. Stock graze the vegetation selectively, choosing species that contain little fibre and that 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.

A Hamilton field naturalist has carried out a small investigation into the differences between adjacent grazed and ungrazed areas of yellow box--red gum--swamp gum woodland near Woohlpooer. The investigation recorded the understorey and ground species (excluding grasses) in square-metre quadrats. Ten quadrats were examined in the grazed woodland, and ten in the ungrazed. The results showed that the grazed quadrats contained significantly fewer plants and fewer species than the ungrazed ones.

While these results were obtained from a limited survey of a small area, they confirm what one would intuitively expect - that grazing does affect the species composition and density of the ground vegetation.

It would be difficult to scientifically compare grazed and ungrazed land on a broad range of sites because it is likely that all areas have been grazed at some time, and the effectiveness of present management in ensuring that stock do not stray outside "grazed" areas is doubtful. The impact of the native herbivores on the vegetation is also difficult to assess.

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.

Grazing may be excluded from timber-producing areas when regeneration is being sought following harvesting. Red gum woodlands have produced evidence that satisfactory regeneration may be obtained while they are being very lightly grazed. Generally the fire-protection advantages of controlled grazing are considered to outweigh the loss of seedlings due to browsing by animals.

The impact of grazing on the vegetation, soil, native wildlife, and recreation value of an area can be reduced by ensuring that it is lightly stocked, and that the available forage is undergrazed.

18. APICULTURE

Apiculture is a small primary industry producing honey, beeswax, and some other minor products. Honey is used for table consumption, confectionery manufacture, stock feeds, and in the preparation of meat, vinegar, and some pharmaceutical and cosmetic products. Beeswax has many uses, including candle, cosmetic, and polish manufacture. The minor products - pollen, royal jelly, and propolis - are used as health foods. Apiculture also contributes to the welfare of other primary industries, as bees pollinate vegetable, fruit, and seed crops - this is the major value of the apicultural industry to the community. It is possible that bees assist in the pollination of native species, especially the eucalypts.

The industry

Table 25 sets out statistics for the honey production industry in Victoria over the last 4 years.

The figures for 1973/74 show that there is a large number of apiarists who oper-

Table 25

HONEY PRODUCTION IN VICTORIA

	1973/74*	1974/75	1975/76	1976/77
No. of apiarists	1,160	468	492	520
No. of hives	98,359	87,982	91,203	92,734
Honey production (tonnes)	3,161	2,783	3,470	1,713
Beeswax production (tonnes)	47	34	60	30

*The 1973/74 figures include all apiarists; those for the following years include only apiarists with more than 40 registered hives.

Source: Australian Bureau of Statistics

ate a few hives and make an insignificant contribution to honey and beeswax production.

The level of production fluctuates considerably from year to year depending on the intensity of flowering of the best honey-producing eucalypts. This depends to some extent on climatic factors.

Victoria's honey production is about 20% of the Australian total, of which about half is exported. Britain is the principal buyer, followed by Europe, the Middle East, Africa, and more recently Japan. Beeswax is also exported. Apiary products return about $2 million of export income annually.

Beekeeping

Although Australia contains some native bees, the species used in apiculture is the European honey bee, *Apis mellifera*.

In the natural state, bees collect and store sufficient nectar and pollen (the bee's sole source of protein) over the summer months to provide themselves with food for winter and for rearing young bees in spring.

Thus, when a beekeeper manages bees for honey production, he never harvests all the honey the colony makes, but leaves a large quantity (up to 80 kg a year) for the prosperity of the colony. His crop is the honey that is surplus to the basic requirements of the hive.

The principal supply of nectar in Victoria comes from the eucalypts. A few other native trees and shrubs, and clovers and pasture weeds, also yield some useful nectar and pollen.

The value of a particular eucalypt species to the apiarist depends on its flowering period and its yield of nectar and pollen. Flowering periods vary, not only between species, but also within species from district to district, depending on local climatic conditions. Most eucalypts flower every second or third year.

Migratory beekeeping

Because of its dependence upon flowering eucalypts, beekeeping must be migratory. For maximum production of honey, hives are moved from district to district to coincide with peak nectar flows of various eucalypts over the summer months. Hives must be placed not only close to the nectar source, but also close to a reliable water source. An adequate source of pollen must be available, especially in autumn when bees are storing food for winter.

Apiculture in the Study Area

The study area is one of the most important in the State for the apicultural industry. This is due to its diversity of suitable eucalypt species, the lengthy flowering period, the intensity and dependability of flowering, the wide range of non-eucalypt flowering plants, and the generally favourable climatic conditions.

Species used

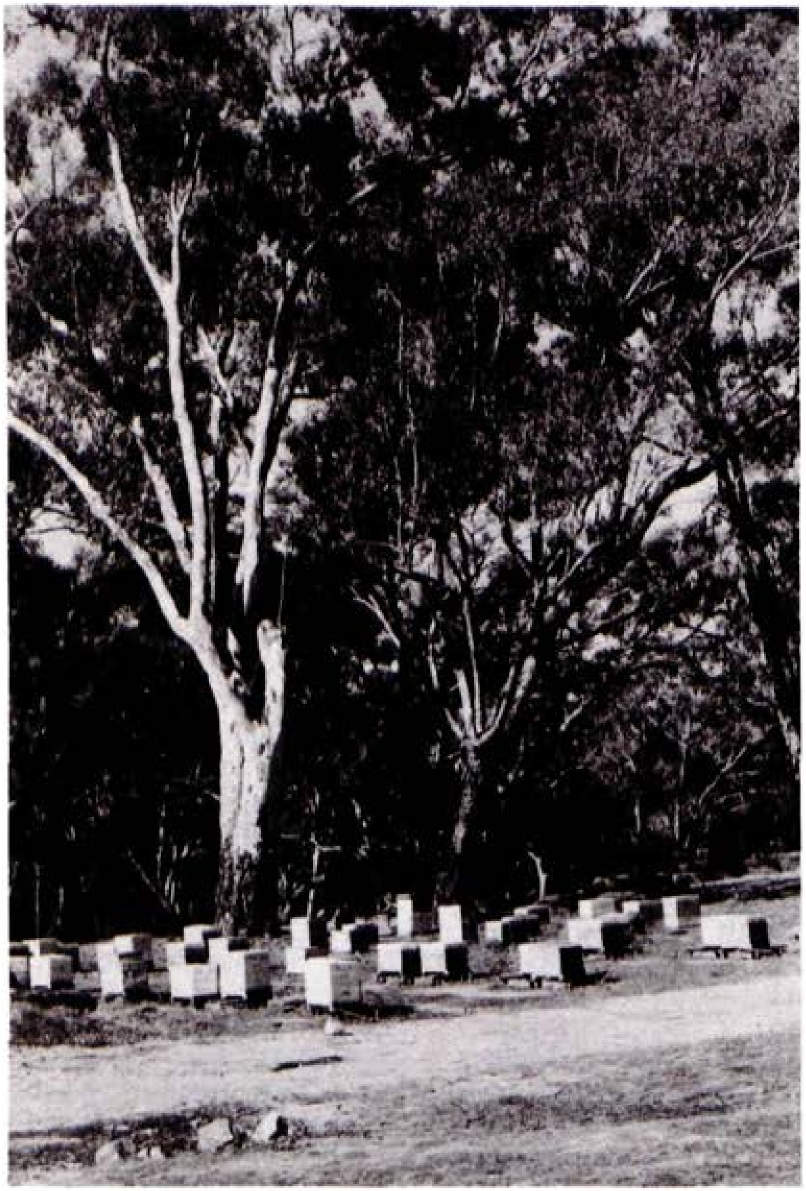
In the study district, the most important eucalypts for honey production are yellow box, yellow gum, and red gum. Other important species are grey box, messmate, brown stringybark, and long-leaf box (although this last species is important because it yields large quantities of pollen rather than nectar). Table 26 lists the main nectar- and pollen-producing plants here.

The box--gum areas are the most useful and sought-after areas, and produce the highest-quality honey.

Table 26

HONEY FLORA

Species	Flowering period	Honey yield	Pollen yield
Yellow box	Oct--Feb	Very good	Poor
Yellow gum	Aug--Dec and Mar--Jul	Very good	Poor
Red gum	Dec--Jan	Very good	Very Good
Grey box	Feb--Apr	Good	Good
Manna gum	Mar--May	Light	Very good
Swamp gum	Winter	Fair	Good
Mountain grey gum	Autumn	Fair	Good
Long-leaf box	Mar--Nov	Light	Very good
Scent-bark	Feb--Apr	Light	Very good
Messmate	Dec--Jan	Good	Very good
Brown stringybark	Feb--Apr	Good	Very good
Banksia sp.	Feb--Jul	Fair	Good
Coast beard heath	Jun--Sep	Fair	Good
Hop bushes	Sep--Nov	Fair	Fair
Drooping mistletoe	Feb--Apr	Good	Good
Cape weed	Aug--Oct	Fair	Very good
Flat weed	Feb--Apr	Poor	Good
Onion grass	Jul--Aug	Poor	Good
Plantain (*Plantago* spp.)	Oct--Mar	Poor	Good



Hives in red gum--yellow box in the Grampians

Honey produced from yellow box is probably the most highly rated in Australia. Bees collect little or no pollen from this species, however, and hives deteriorate unless other species in the area can provide pollen.

Red gum produces a highly rated honey of light colour and mild flavour.

Brown stringybark and messmate produce dark rank-flavoured honeys, which, although poorly-rated for table use, are useful in cooking as they retain a honey flavour through the baking process. Bees thrive on these species, and on the understorey species associated with them - tea-trees, heaths, acacias, grevilleas, hakeas, banksias, and thryptomene.

Flowering of desert banksia, a species found on sandy ridges in the north-west of the study area, is important to beekeepers because it provides nectar and pollen for overwintering of bees. Hive activity slows down in the cooler weather, and careful management of hives is necessary to ensure that they remain healthy and ready to take advantage of the first nectar flows of spring. This species has great value in preparing hives for working honey flows in red gum, yellow gum, or yellow box.

Pattern of use

While the beekeepers who live locally use the area every year, professional beekeepers from central and north-eastern Victoria, and some from South Australia, would use the area 2 years out of 3. Honey production on a small scale is a sideline for many local farmers.

Technological advance in beekeeping has been slower than in many other primary industries, possibly because of the highly specialized nature of the occupation and the relatively small market. The major advances in recent times have been the introduction of sophisticated machines for removing the wax capping from the honeycomb, and large-scale extractors set up in central plants fed by high-speed road transport. A high labour component still exists in the daily management of apiaries in the field.

Beekeepers are issued with licences in order to work their bees on public land. The licence gives the beekeeper the right to use a small area to set up his hives and other equipment, and he has the exclusive right to work his bees within a radius of about 1.5 km.

The best areas are covered by permanent sites; that is, the beekeepers pay the licence fees whether or not they use them that year. The study district contains about 160 permanent sites, centred on areas carrying red gum, yellow gum, or yellow box.

Temporary sites are taken up when nectar flows. There are about 250 temporary sites here - many are in the stringybark and heath areas in the Grampians. Rarely would more than half of them be occupied at any one time. Each site can carry 150--200 colonies of bees. Very little use is made of the areas south of Hamilton.

Many beekeepers use private property adjoining public land to place their hives to make use of nectar flows on the public land. It is estimated that 200--300 sites occupy such locations. This is detrimental to the beekeeper who has paid licence fees to have his bees work from a permanent or temporary site on public land.

Beekeepers also use stands of red gum, yellow box, and yellow gum, and some pasture weed species on private land, and are concerned about the gradual removal of trees from farms by sleeper-cutters. Good stands of mature trees on roadsides may provide useful honey flows.

In the scattered forested areas west of the Grampians, limited access and sandy soils make it difficult for vehicles to reach some bee sites. An allied problem is lack of suitable water. This is normally obtained from dams built for fire-protection purposes in the public lands, and the spacing of dams is not necessarily suited to the best use of the area for apiculture. Water is required near the site, particularly in hot weather.

Authentic figures of production of honey and beeswax on a regional basis are difficult to obtain, but the current estimated annual gross market value of this produce is approximately $750,000. This figure exceeds the returns from any other form of public land use current in the study area.

Beekeeping and other uses

Honey production has little impact on the forest environment. In physical terms, beekeepers need access tracks and small clearings in which to locate their hives and other equipment. Although it is sometimes claimed that apiaries compete with native nectar-feeding birds and insects, this has not been clearly demonstrated.

Logging is usually considered detrimental to the interests of beekeepers because it removes nectar-producing flora. In the study area, beekeepers claim that utilization of red gum and yellow gum for posts and sleepers has seriously affected the capability of the land to produce honey. Silvicultural work such as thinning or liberation can enhance honey-production values by producing mature trees with wide spreading crowns.

The eucalypts favoured for honey production are susceptible to infestation by mistletoe, which can result in the death of the trees. One solution is to remove the trees before their vigour is completely lost so that coppice regeneration from the stump may provide a new crop.

Fuel-reduction burning may conflict with honey production, although burning is restricted to parts of the messmate--brown stringybark forests. The timing of the burn causes most concern. If an area is burnt just before a flowering, the buds are likely to be killed and drop off, thus putting the tree out of production until the next flowering cycle. The understorey vegetation is also affected. Burning after flowering should not have any adverse effect, as the trees would have recovered before the next flowering.

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19. TIMBER PRODUCTION

While large areas of forests and woodlands have been cleared for agriculture, public land in the study district contains timber stands that support a small local sawmilling industry. Most of the public land, however, does not have high potential for timber production - the best stands are found in the Grampians, and the other merchantable stands are widely scattered.

The Grampians forests have traditionally supplied timber for housing, heavy construction, and farm use in north-western Victoria and south-eastern South Australia, where there are very limited hardwood timber resources. Small areas of softwood plantations in the Grampians are now producing significant quantities of timber for the local sawmilling industry.

History of Timber Use

Timber from the study district, particularly the Grampians, has been used since the first European settlers arrived in the 1830s and '40s.

Gold was discovered in the midlands in the mid 1850s and mining continued until early this century. Structural timber for the Stawell mines was obtained from a steam-powered sawmill at Ledcourt, which drew its logs from the lower reaches of Fyans Creek and the nearby foothill forests. The best trees were felled and snigged (dragged) to the mill by horse or bullock team.

This was typical of early logging practices and led to a gradual degradation of the forest (in terms of timber production), as successive harvesting operations removed the desirable trees and left the defective and overmature. This mill continued operating after closure of the mines in 1920, and in 1934 it was shifted to Halls Gap.

Another mill, which was situated at Zumsteins, drew logs from the Wartook basin during the period 1869--85. The midlands forests were heavily exploited for fuel-wood, mainly to power mining machinery at Ararat, Moyston, Great Western, Stawell, and Deep Lead.

The brief gold-rush at Mafeking in 1900 stimulated the growth of the timber industry in that locality. Further utilization took place in these forests in 1915 and from 1935 to 1940. In the early 1920s, several small mills operated in the valleys of Stony Creek and Fyans Creek. The red gum forests in the Victoria Valley and at Woohlpooer were worked by two separate sawmills, both of which were constructed in the forest, the former in 1928 and the latter in 1930. Meanwhile, in the forests around Tyrendarra and Heywood, sawmilling was an important industry and an adjunct to the clearing of land for agriculture. Mills were generally small and steam-powered. When the surrounding stands were cut out, the miller shifted his plant and crew to another part of the forest.

The 1939 bush-fires burnt through most of the Grampians, and several people were killed. About 30 men and women, led by Mr. R. Mair of Halls Gap, sheltered in culverts at Sanderson's mill, near Borough Huts. The mill was burnt out, but the group survived. The southern part of the study district also had severe fires in 1939. Virtually all the forest areas were burnt, including The Stones, near Macarthur.

Following the fires sawmills were shifted out of the Grampians to the towns on the surrounding plains. The introduction of the bulldozer and efficient heavy road transport helped make this industrial change possible.

After the end of World War II there was a great demand for sawn timber, especially for housing construction, and the Grampians forests were heavily logged (see Table 27) for two decades. This depleted the resource, and during the 1970s sawlog harvesting has been greatly reduced.

Table 27

OUTPUT OF HARDWOOD LOGS FROM THE GRAMPIANS STATE FOREST

Period	Volume (m^3)
1930--40	29,000
1940--50	75,000
1950--60	153,000
1960--70	135,000
1970--78	48,000

The red gum and brown stringybark woodlands of the south-western Wimmera plains were also the scene of intensive sawmilling after the War. For a decade, six millers cut in the Edenhope district, but only one remains in operation today. The main products were sleepers, sawn posts, droppers, and house stumps.

Sawn timber was not the only product of the forests. Broad-axemen hewed beams and sleepers, and bushmen cut large quantities of poles, piles, posts, and timber for farm construction. In addition, the forests yielded industrial fuel-wood, firewood for domestic use, and charcoal, particularly during World War II. The Forests Commission operated charcoal kilns at Borough Huts, near Halls Gap, and at Woohlpooer throughout that period. Another forest product was wattle bark, harvested since the early days of settlement in the Victoria Valley and elsewhere, and processed locally or in Melbourne for the leather-tanning industry. This activity had virtually ceased in the study area by 1960.

Hardwood Production

Forest Types and Products

Stringybark forests

This type is found in the Grampians and near Tyrendarra, where rainfall averages 600--900 mm per annum. Its major species are brown stringybark, messmate, manna gum, and mountain grey gum, and the group is often referred to as "mixed species". The height of the best stands exceeds 30 m. This type is the most important source of sawlogs in the study area. The timber is used mainly for house framing and heavy construction, while small quantities have been kiln-dried and converted to floorboards. Messmate and brown stringybark are the most important timber species, in terms of both quality and quantity.

After 100 years of utilization, much of this forest type in the Grampians now contains a high proportion of cull trees. These are large, old, branchy trees that are not merchantable, and that prevent or suppress growth of younger trees. (They provide valuable habitat for native birds and mammals.)

The current method of harvesting aims at killing most of these trees and replacing them with regeneration. It involves clear-felling all the merchantable timber in small patches (10--20 ha). Unmerchantable trees are ringbarked or poisoned, which induces seed fall after the logging debris on the ground has been burnt in a hot fire. The fire, and the soil disturbance caused by the logging machinery, creates a suitable seedbed for germination of eucalypt seeds and rapid early growth of seedlings.

Some areas that carry well-stocked stands of sapling or pole-sized regrowth

Regeneration work in the Victoria Range are treated differently. Mature trees are harvested, and the large old cull trees that suppress the growth of younger ones are poisoned.

Drier sites in the Grampians, and the sands of the south-western Wimmera plains, carry extensive low (5--20 m) stands of brown stringybark. While most of the trees in these stands are not merchantable, some small sawlogs and farm timbers are cut.

Gum woodlands

Stands of red gum and yellow gum occur on flat sites with heavy clay soils in and around the Grampians, and on the south-western Wimmera plains. The most extensive stands are at Woohlpooer and the Victoria Valley in the Grampians, at Kadnook and Connewirricoo south of Edenhope, and at Ledcourt and Illawarra east of the Grampians. These species yield a hard durable timber, used for heavy construction and for posts, sleepers, small poles, rails, and house stumps. Harvesting is by selection of single trees.

Utilization of red gum near Edenhope

A few places in the north contain remnants of the grey box, buloke, and black box stands that once covered the fertile Wimmera plains. These species yield heavy durable timbers suitable for heavy construction and posts. Very small quantities are harvested.

Yellow box, which occurs in woodlands in the Grampians and the midlands, is reserved from timber harvesting because of its value for honey production.

The species described above (and red box and red ironbark) fall into the group known as "durable species".

The stands of manna gum on the stony rises at Mount Eccles and Mount Napier have not been logged because of their poor quality and the difficulty of extracting timber over the rocky terrain. Manna gum is not a preferred species for timber production.

Box--ironbark forests

Such forests extend along the northern fall of the Divide from Chiltern to the

Table 28

MINOR FOREST PRODUCE

	1972/73	1973/74	1974/75	1975/76	1976/77
Firewood (tonne)	3,230	3,590	3,280	3,120	3,340
Hardwood fencing material (number)	33,670	15,000	22,200	20,000	14,670
Softwood fencing material (number)	18,500	12,230	-	10,950	12,150
Hardwood poles (linear metre)	6,050	7,850	850	1,010	1,040
Softwood poles (linear metre)	-	-	40	-	1,090
Sleepers (number)	8,870	6,480	60	-	450
Stringers and beams (linear metre)	133,000	138,700	850	1,500	2,870

Grampians. They are usually found on heavy soils derived from sedimentary rocks, and contain red ironbark, yellow box, yellow gum, grey box, long-leaf box, red box, and red stringybark.

This forest type extends into the area on the low hills of the midlands, near Stawell and Ararat. All the species listed above, except red ironbark, occur here. Apart from long-leaf box and red stringybark, they are very durable and are used for posts, rails, construction timbers, and sleepers. The study area contains small areas of these slow-growing species, and the amount of timber harvested annually is very small.

The major tree species are listed in Appendix 2C.

Minor products

Table 28 shows the yield of minor forest produce from the forests of the study area during the last 5 years. Fencing material includes round and split hardwood posts, and strainers, stays, and rails. Hardwood and softwood poles have been cut for Telecom, State Electricity Commission, and farm use.

Production of minor produce, with the exception of firewood and softwood poles, has declined over the last 4 years.

Resources

Stringybark forests

In the Grampians, stringybark forests currently used for timber production cover about 35,000 ha, with sawlog resources currently estimated at 108,000 m^3. There is a further 800 ha of this forest type at Tyrendarra. The forests have been harvested continuously for more than 100 years, including very heavy cutting in the two decades after

World War II. Consequently, their ability to supply large quantities of timber in perpetuity has declined.

At present the total annual allocation (permitted cut) of mixed species from the Grampians is 18,450 m^3. Since 1970, however, the volume of timber produced has averaged 5,000 m^3 per annum. Clearly, the resource would be rapidly depleted if cut at the rate of 18,450 m^3 per annum. No further information on the hardwood resource, such as the volumes and growth rates of the various stands, is currently available.

The growth rate of the timber stands can be improved by silvicultural treatments

Table 29

HARDWOOD TIMBER PRODUCTION

Forest type	Main timber species	Predominant soils	Productivity (MAI in m^3/ha/annum)
Stringybark forest (>20 m)	Messmate and brown stringybark	Red clay loams; gravelly duplex soils	Estimated MAI about 1--4, potential 3--5; suitable for sawlogs and minor forest produce
Stringybark forest (5--20 m)	Messmate, brown stringybark, and red stringybark	Duplex soils; shallow stony soils	MAI very low; mostly unsuitable for sawlog production
Gum woodlands	Red and yellow gum, grey box, and manna gum	Yellow sodic duplex soils; heavy grey clay soils	Estimated MAI between 0.5 and 1.5; potential about 1.75; mostly slow-growing durable timber suitable for sleepers and fencing timbers

1. MAI (mean annual increment) = total merchantable volume production divided by the number of years in the rotation.

2. Potential MAI is that expected to be achieved from natural forests under intensive management.

Thinned mixed-species regeneration in the Grampians such as thinning and liberation. In thinning, the best stems are retained on a wide spacing and the rest are removed. This concentrates growth onto stems that will yield valuable sawlogs. Liberation is poisoning or ringbarking cull trees that suppress the growth of established regrowth stands. Stands at Mafeking, Wartook, Borough Huts, Mount Victory road, and Stony Creek were treated in the 1920s and 1930s, and more work has been done in these areas by unemployment-relief workers in recent years.

It appears that the mixed species stands in the Grampians could sustain a fairly low level of production of sawlogs until regrowth stands reach merchantable size in the 1990s.

Table 29 shows the estimated present and potential productivity of the main forest types, and Map 9 shows the most productive areas.

The small stands of forest in the south (in the Homerton--Bessiebelle district) belong to larger stands, which extend into the South-western study area, District 1, and which form part of a large hardwood timber resource supplying mills in the Heywood district. The Final Recommendations for that study area, published in April 1973, covered these forests, and recommended that they be reserved for hardwood timber production. Those recommendations have been accepted by the government, and are being implemented.

Durable-species forests

In the Grampians, these forests cover 34,000 ha. The annual log allocation of durable species from the Grampians is 1,140 m^3 - in most years all of this is cut. The area of such forests outside the Grampians is about 3,600 ha, supporting an annual log allocation of 225 m^3. These forests also yield much of the minor forest produce listed in Table 28.

The Crown repurchased 2,000 ha of red-gum at Woohlpooer in 1913. The stands originated in 1886, after settlers had cleared the land. They were thinned in the 1920s, '30s, and '50s, creating the present heavily stocked forest. This area has the potential to yield considerable volumes of timber for sawmill and other uses. The thinnings have a ready market as fencing timbers.

In the parishes of Kadnook and Connewirrecoo, about 1,050 ha of land carrying red gum regrowth that originated in 1928 was purchased in the last 1940s. Thinning the tangled mass of red gum saplings and seedlings has produced healthy stands of small pole-sized trees.

Private property

Logs cut from private property supplement Crown supplies to most of the sawmills operating in the study area. The volumes involved are not known, and would vary widely from year to year.

Logs come from clearing bush, removal of retained trees in paddocks (often red gum), and felling of wood-lots and windbreaks - the latter often yield softwood logs. The level of supply from private properties can be expected to decline, as in most cases the timber harvested is not replaced. In the west of the study area several mobile sawmills work private property, cutting sleepers for the South Australian railways.

Farmers come under pressure to sell the trees on their farms for the quick financial return in these times of shrinking rural incomes. Felling these trees, however, has several disadvantages. The well-known western Victorian landscape of paddocks dotted with large old red gums is being destroyed. The debris that remains after logging is very difficult to dispose of, and becomes a harbour for vermin, especially rabbits, and an obstruction to machinery. Stock shelter is lost, salinity problems due to high water tables may be aggravated, and animal habitat, especially for birds, is lost.

Softwood Production

Victoria's requirements of softwood timber have increased during the last 30 years, and are expected to continue to grow, although there is some debate as to the extent of this trend. The State has an insignificant native softwood resource, and its supplies are drawn from local or interstate plantations of exotic softwoods, or from overseas.

The main tree species used for softwood timber production in south-eastern Australia is radiata pine *(Pinus radiata)*, a Californian species that grows quickly, tolerates a range of environmental conditions, and yields a useful, readily seasoned timber.

Softwood *vs.* hardwood

Pine logs have many advantages over hardwood logs as a raw material for sawmilling. They are in general much less variable than hardwood logs with respect to taper, cross-section, and straightness. Hardwood logs are often defective - they are rotten in the centre, or contain rot pockets or gum veins, or have been attacked by ants or insects. Pine logs rarely have defects, because of lack of insect and fungal pests, and more intensive management of plantations.

Plantations of radiata pine are much more productive than native hardwood forests on equivalent sites. Poor- to medium-quality pine stands have a mean annual increment (MAI) of merchantable wood of 20 m^3 per ha. The estimated potential MAI of the best hardwood stands in the Grampians is about 5 m^3 per ha, and their present MAI is estimated to be 2.5 m^3 per ha.

Radiata pine - Mount Difficult Plantation

Site requirements

Commercial plantations of radiata pine require the following general environment:

* a minimum annual rainfall of 750 mm
* an acid soil of at least moderate fertility
* good drainage
* more than 0.5 m of fertile topsoil over any soil zone that impedes root growth or percolation of water - in certain soil types in the study area the minimum depth is much greater

Other considerations include access, slope (which should not be too steep for mechanical planters and harvesters), protection from fire, and whether the area available is large enough to form a viable plantation unit.

Much of the study area is unsuitable for the commercial growth of radiata pine, although the species has been widely grown for windbreaks and ornamentation throughout and is a common feature of the rural landscape. The Wimmera plains are generally too dry. A large proportion of the Grampians has sufficient rainfall, but the soils are too shallow and rocky. South of Hamilton most of the public land consists of young lava flows and is too broken and stony.

The only relatively extensive tracts of public land suitable for softwood afforestation are:

* parts of the outwash slopes and plains flanking the Grampians
* parts of the Victoria Valley

In addition, some small areas of the public land south of Apsley and Edenhope may be marginally suitable for radiata pine.

Softwood development

In the last 50 years, limited development of State-owned softwood plantations has occurred in three separate localities within the study district (see Map 9). Each plantation is managed by the Forests Commission.

The oldest plantation lies on the outwash plains to the east of the Mount Difficult Range. The first plantations were in 1926, and 447 ha had been established by 1933. Fire destroyed some 360 ha in January 1934, about one-third of which had been replanted by 1936. Today, of the gross area of the plantation of 400 ha, some 106 ha carry excellent stands of radiata pine.

Because of a hardpan that occurs in the soil at different depths throughout the plantation, tree growth has been extremely variable. Where it comes within 0.9 m of the surface, growth has generally been unsatisfactory. It is thought that deep ripping of the shallower hardpans and fertilizing will correct this problem, and research plots have been established to verify this.

Stawell High School has 12 ha of radiata pine alongside the Mount Difficult plantation. There is also a stand of mature Canary Island pine, retained as part of a State-wide programme to preserve specimens of various exotic tree species. The second substantial area of softwoods is alongside Lake Fyans, on land vested in the State Rivers and Water Supply Commission, where some 45 ha of radiata pine were planted between 1923 and 1937.

Harvesting of these two plantations will produce an annual volume of 2,250 m^3 of sawlogs. At present Stawell Timber Industries takes all the logs that are harvested.

No additions were made to the publicly owned softwood plantations in the study area until the 1960s. The Forests Commission undertook surveys and identified sites that could be suitable for commercial softwood forestry, including a significant area in the Victoria Valley. For environmental reasons, including landscape and fauna preservation, and the difficulties of fire protection, plantation development was confined to the Billywing area, near Glenisla at the foot of the western scarp of the Victoria Range. The native vegetation at Billywing is woodland and heath.

The 1964 planting commenced here near Cultivation Creek. The planned final gross area of 700 ha has now been attained. It comprises 556 ha of pines and some 144 ha of roads and firebreaks.

The potential sustained production of the plantation is of the order of 12,000 m^3 per annum.

Growth in the Billywing plantation has been satisfactory, and thinning to produce round material for preservative treatment will begin soon. An allocation of 1,270 m^3 per annum has been granted to Stawell Timber Industries. By 1983 thinning operations will be producing sawlogs.

The Forests Commission does not intend to establish more softwood plantations on public land in this study district, because of the lack of large areas of suitable land and the conflict with other uses and values, especially in the Grampians.

Other plantations

Hamilton Water Trust has planted 42 ha of pines on public land under their control north of the town.

Seven private plantations of radiata pine totalling about 130 ha have been established with the assistance of farm forestry loans from the State government. These wood-lots are located in the midlands, Dundas Tablelands, and on the volcanic plains. Logs from these plantations should find a ready market in the local sawmilling industry.

A War Memorial plantation of 7 ha was established on private property south-west of Apsley in 1953. Measurements indicate that the plantation's growth rate is satisfactory from a commercial point of view. As the annual average rainfall at Apsley is 570 mm, far below the accepted minimum of 750 mm for good growth of radiata pine, the trees in the Memorial plantation are probably tapping good-quality groundwater at shallow depth.

The extent to which these conditions exist in other parts of the south-western Wimmera plains is not known.

Pine products

Radiata pine is used for a wide variety of purposes. Timber from the plantations in the study area will be used in the following ways:

* peeler logs for production of wood veneer and match splints
* sawlogs - the sawn timber is usually kiln-dried and dressed, and used for house framing and joinery
* small round material, which is impregnated with preservative and used for posts, poles, and rails

In addition, sawmill waste from the Stawell mill is carted to the Ballarat chipboard factory.

The plantations on public land provide an attraction for tourists. In particular, the camping area in the Mount Difficult plantation is very popular.

Industry

Sawmills

Table 30 sets out information concerning the industries processing hardwood and softwood logs from the study district. Altogether, six sawmills draw about 6,000 m^3 of hardwood logs from the area each year, while Stawell Timber Industries (S.T.I.) has an allocation of 3,520 m^3 of softwood.

Two mills, S.T.I. and Gavin Rowe & Co. Pty Ltd, are equipped with automated or semi-automated sawing equipment. The remainder use the traditional Australian breaking-down saws to cut hardwood logs into flitches - these are then sawn into dimension pieces on a breast bench operated by 2--4 men. The logs supplied from the forests of the study district are not of high quality, and skilful sawing is necessary to prevent excessive waste.

It is difficult to present in a simple form the importance of the timber resources here to the sawmilling industry, as four of the mills draw supplies from

Table 30

TIMBER-PROCESSING INDUSTRIES

Regional centre	Name of company	Type of plant & major products	Annual log allocation from S-W 2 area	Percentage of S-W 2 allocation cut last year	Logging areas in S-W 2	Other sources of logs: Public land	Other sources of logs: Private property	Total allocation from public land	Number of men directly employed
Stawell	Stawell Timber Industries Pty Ltd	Automated mills cutting softwood & hardwood; scantling joinery, boards, modular houses	Mixed species - 13,800 m^3; durable species - 450 m^3; softwood - 3,520 m^3	Hardwood 8%; softwood 100%	Hardwood - Wartook, S. Victoria Range, Fyans Ck, Mafeking, Balmoral; softwood - Lake Fyans, Mt. Difficult, Billywing	Hardwood - Mt. Cole; softwood - Scarsdale, Ballarat	Small quantities of radiata pine and red gum	Hardwood - 18,320 m^3; softwood - 10,395 m^3	200 approx.
	Smith Bros.	Conventional hardwood mill; construction timber, scantling, posts	Mixed species - 600 m^3; durable species - 90 m^3	56%	Lake Wartook, Illawarra, Ledcourt, Victoria Valley	Pyrenees, Maryborough	Varying quantities	1,290 m^3	5, and part-time logging crew of 2 men

Table 30 (contd.)

Regional centre	Name of company	Type of plant & major products	Annual log allocation from S-W 2 area	Percentage of S-W 2 allocation cut last year	Logging areas in S-W 2	Other sources of logs		Total allocation from public land	Number of men directly employed
						Public land	Private property		
Horsham	G.B.N. Sawmill	Conventional mill; construction timber, scantling, posts, pallets	Mixed species - 1,800 m^3; durable species - 150 m^3	100%	Zumsteins	Nil	Varying quantities	1,950 m^3	12, plus logging contractors
Hamilton	Gavin Rowe & Co. Pty Ltd	Semi-automated mill; scantling	Mixed species - 750 m^3; durable species - 150 m^3	56%	Bullawin, Cattle Station Creek	Heywood (S-W 1)	Small quantities	8,500 m^3	16, plus bush crew of about 5 men
Dunkeld	W.A. Fitzpatrick	Conventional mill; construction timber, scantling	Mixed species - 1,500 m^3; durable species - 300 m^3	57%	Southern Grampians, Victoria Valley	Nil	Nil	1,800 m^3	5 men for part of the year, plus logging contractors
Edenhope	M.G. Crawford	Conventional mill; construction timber, scantling, posts	Mixed species - 75 m^3; durable species - 225 m^3	100%	Kadnook, Connewirrecoo, Karnak, Yallakar	Some small quantities from S-W 1	Varying quantities	300 m^3	2 men

Heywood — A number of mills in the Heywood district take logs from the Dunmore and Bessiebelle forests. These forests were considered when recommendations were made for the South-western area, District 1, and the government has accepted the recommendation that they be reserved for hardwood timber production.

Notes:

1. "Mixed species" includes brown stringybark, messmate, mountain grey gum, and manna gum. "Durable species" includes red gum, yellow gum, and very small quantities of grey box and black box.
2. I.J. Sanderson operates a steam-powered hardwood scantling mill at Ararat. It employs about 8 men and a part-time bush crew. Its annual allocation is 1,350 m^3 from public land in the Ballarat study area.
3. A number of small portable mills operate solely on private property around Edenhope.
4. No pulpwood has been taken from the softwood plantations in the area.
5. Total log output from public land in Victoria in the 1976/77 year was: hardwood - 1,154,412 m^3; softwood - 276,794 m^3.

outside the area and at one (S.T.I. at Stawell) sawmilling is associated with a large factory producing modular houses.

Excluding S.T.I., the processing of timber drawn from the study area provides full-time employment for the equivalent of about 25 men.

S.T.I.'s main enterprise is manufacturing modular houses - the various parts of each house are prefabricated in the factory, transported to the site, and put up by an erection team. The houses have been sold as far afield as northern Australia and the Middle East. The number of men directly employed in sawmilling is not known. About 50% of the hardwood timber and 60% of the softwood sawn by S.T.I. is used to build modular houses. The remainder is sold locally, except that some dried and dressed softwood has been sold interstate.

Most of S.T.I.'s logs are drawn from areas outside the study district - softwood from Scarsdale, and hardwood from Mount Cole (Ballarat study area). Logs are also drawn from private property. Although S.T.I. holds about three-quarters of the total allocation of hardwoods from the Grampians, it cuts less than 10% of its entitlement, due to the poor quality of the logs currently available.

At S.T.I. there has been a trend in recent years to use more softwood logs and less hardwood. This is likely to continue as greater quantities of softwood logs become available.

Table 30 shows that S.T.I., Gavin Rowe & Co. Pty Ltd, and Smith Bros. would not be greatly affected by a decrease in the volume of hardwood timber available from the Grampians. M.G. Crawford would not be affected at all.

20. MINING AND QUARRYING

The eastern part of the study area has a history of intensive mining activity. The country around Stawell, Ararat, and the Grampians was the scene of extensive prospecting and gold-mining last century, first by individuals and small groups and later by larger companies. Although no minerals are mined in the study area at present, it has seen an active interest in exploration for base (that is, non-precious) metals over the last decade.

Of the minerals yielded by the region, gold has been the most valuable. The price of gold has fluctuated lately, but if it continues to rise certain deposits previously considered unworkable may become economically viable.

Of much more immediate importance is the extraction of stone for road and building construction. Annual production currently exceeds 900,000 tonnes.

In this chapter "stone" means rock of any kind, massive quartz, slate, gravel, sand, earth, and soil, but does not include "minerals". The latter term, in general, covers metallic and non-metallic ores, crystals, precious stones, and organic deposits such as coal.

Map 10 depicts the various mining and quarrying operations within the study area.

Gold

Lying within the study area are portions of two major mining regions of the last century - almost all of the Ararat gold-field, and the southern and eastern sections of the Stawell gold-field.

Stawell

Alluvial gold was first found in 1853 at the nearby Pleasant Creek, but not until the winter of 1855,when reef mining started, did the industry become firmly established at Stawell. Numerous alluvial leads (e.g., Commercial Street Lead, Deep Lead, etc.) continued to be discovered. Many of the smaller ones were buried by up to 30 m of Tertiary or younger sediment. During 1860--70 the discoveries and minor rushes tended to be north of Stawell. Although the life of the alluvial deposits was generally short, reef mining continued for many years and the last mine closed in 1920.

The early reef mining was carried out by individuals or small parties who treated their ore at public batteries. Later, companies were formed by the amalgamation of claims, but they were small and often had too many shafts inefficiently working the field. Lack of capital prevented adequate exploration beyond known ore bodies. The total recorded production from the reefs was 39.9 tonnes; the figure would be much greater if the quantity of gold won from the extensive alluvial deposits was known.

Ararat

In 1854, gold was discovered at Pinky Point on the eastern slopes of Mount Ararat. Mining activity steadily increased, so by 1855 the field, then designated the "Mount William Diggings", extended south to Cathcart and north towards the Divide. A small field at Armstrongs was opened in mid 1855 and further discoveries were made east of the original find.

In 1857 Chinese miners opened up the rich "Canton Lead" and initiated the largest Victorian rush ever. Within weeks some 20,000 people had flocked to the field, and commenced mining. The resulting settlement grew into the township of Ararat.

Minor rushes continued over the years as numerous leads were opened. Around 1880 the main centres were Campbells Reef at Moyston and the Black Lead at Ararat, but by 1900 the industry had begun to peter out.

Moyston

In 1857 the first operations began at "Campbells Diggings", Moyston. One quartz mine on Campbells Reef operated for many years and yielded 2,500 kg of gold.

Great Western

Mining commenced here with the opening of the Great Western lead in 1858. At the height of the rush in August 1858, 9,000 diggers worked on this field.

Eastern Grampians

In June 1900 the Mafeking field was discovered. This was one of the last real gold rushes in Victoria. The day after the first claim was filed, 300 men were at work. The population rose briefly to an estimated 9,000 people, but soon declined as the field's limited productivity became obvious.

During its short heyday, Mafeking - and its outlying settlements of Ladysmith and Masonville (the Boer War was being fought at the time) - supported 20 "hotels" and wine saloons, an improvised theatre with entertainers from Melbourne, and billiard halls, as well as the usual commerce of a large rural town. By 1903 the population had declined to about a hundred.

Over a period of 15 years, miners won some 800 kg of gold from the shallow alluvial gravels resting on granodiorite that formed the field at Mafeking. Similar deposits at Stony Creek near Halls Gap were worked by hand or dredged early this century.

Minor occurrences

Small amounts were obtained from gravel deposits south of Balmoral.

In 1862 fine gold was found in holes sunk in gravel deposits above Mather Creek, near Kongbool. In 1898 these deposits were sluiced with water pumped from the creek.

The numerous quartz reefs that cut the Cambrian--Ordovician sediments south-east of the western Black Range yielded some gold. In the Glenisla area several reefs and shallow alluvial deposits were worked. Along Mouchong Creek a few shafts gave gold values up to 10 g per tonne (0.3 oz per ton).

Small quantities of gold were mined south of Kadnook.

Other Metallic Minerals

Since the mid 1960s more than 15 exploration licences have been granted in the study district. Interest has been concentrated on the Cambrian--Ordovician sediments. Investigations of the linear outcrops of Cambrian volcanics running south from Mount Dryden, and also the outcrop in the western Black Range, have revealed weakly mineralized strata in which small quantities of base metals such as copper and zinc are present.

Three areas, each of about 200 km^2, are currently under exploration licence, and another three are under application. They are concentrated in the region east of the Grampians stretching from Glenorchy to Maroona, taking in the old Stawell--Ararat gold-fields. All these licence areas contain blocks of public land, including those (in part) north and south-east of Lake Lonsdale and west of Ararat. In the north-west, exploration for heavy mineral sands has been conducted.

During this century the gold-fields have been prospected intermittently by individuals and small companies. Numerous gold leases have been issued, particularly east of the Grampians. One gold lease is current, and covers 77 ha south of Ararat, including some public land.

Manganese and cobalt

Road cuttings in the Cambrian--Ordovician slates and sandstones near Mount Chalambar contain low-grade manganese and cobalt mineralization associated with quartz veins. Drilling did not intersect any significant bodies of ore.

Copper

In Carroll's Copper Mine near Mount Ararat, lode material showed up to 23%

copper. Further investigations are being conducted in this area.

Geochemical analysis of rocks found along streams associated with the Victoria Valley and MacKenzie River granitic intrusions has shown locally high values.

South-east of Mount Dryden, drilling in Cambrian rocks has revealed small copper anomalies. The shallow shafts in the vicinity of Golton Gorge apparently result from operations for copper.

Iron

A small irregular outcrop of micaceous hematite containing up to 54% iron outcrops some 2 km west of Wartook Reservoir.

Molybdenum

Molybdenite occurs as films on joint planes in both the plutonic rocks in the Grampians at Mafeking and the sediments they intrude at Mount William. Low-grade molybdenite mineralization is associated also with pyrite in fracture fillings in small quartz veins through part of the Victoria Valley granodiorite.

Tin

Tin was discovered in Mather Creek near Balmoral and traced south-west upstream towards Englefield. Cassiterite has been reported from lateritized conglomerates capping Rocklands rhyolite to the west of the old Glendinning homestead.

Mineral sands

Traces of heavy mineral sands on private and public lands have been recorded in Pliocene stranded beach ridges in the north-west of the study area.

Non-metallic Minerals

Coal

Thin seams of black coal have been recorded in the Mesozoic sediments.

Feldspar and mica

Pegmatite bodies on private land at Mooree contain both mica and feldspar. Although the muscovite crystals are unusually large for Victorian mica, deformation makes them unsuitable for production of sheet mica. Pink feldspar crystals up to 3 m are also present, but generally the feldspar is finely intergrown with quartz, making separation difficult.

Gemstones

To the west of the old Glendinning homestead, topaz, ruby, garnet, and quartz crystals have been found in lateritized conglomerates capping Rocklands rhyolite. Opaline quartz outcrops on the spurs above Mouchong Creek. Diamonds are alleged to have been found on the spurs on the west of Mather Creek, south of Balmoral.

Salt

Evaporite salt has been extracted from a series of small lakes on public land near Douglas and south of Mount Arapiles. Salt harvesting here is less predictable than further north in the Mallee, as the lakes may not dry out in wet years. No extraction operations are current on these lakes.

Stone and Gravel

Extraction of stone in the study area takes place on both private and public

The quarry at Mount Eccles

land. The material is quarried by shires, government departments, and private operators. Although mostly for the construction and maintenance of roads, it is also used as building stone and for the manufacture of bricks, pottery, and agricultural lime.

Six licences under the *Extractive Industries Act* 1966 are current on private land, and two leases are on public land (for hardrock quarries) - at Heatherlie near Mount Difficult, and a small area at Coleraine. All gravel extraction operations are controlled by other *Acts*. Applications have been received to lease a further two sites (at Dunkeld and Mount Napier, both on public land).

Table 31 shows the total output from operations in the study area.

Approximately 18% of crushed and broken stone comes from public land.

By far the greatest demands made upon public land for stone extraction concern sand and gravel use. Table 31 shows that sand and gravel extraction greatly exceeds production from hardrock quarries. Whereas quarries are few in number and generally confined to a limited area, sand and gravel are predominantly won by surface stripping numerous sites to a depth of 1--2 metres.

Shallow stripping operations are more effectively and easily carried out on relatively flat, treeless land. Such

Table 31

QUANTITY OF STONE EXTRACTED : 1975/76

Material	Quantity (tonnes)
Brick clay and shale	7,500
Crushed and broken basalt	25,700
Crushed and broken rhyodacite	51,403
Crushed and broken granite, schist	38,853
Crushed and broken sandstone	43,787
Scoria	62,867
Salamander	2,500
Limestone	17
Sand and gravel (Shires, govt. depts.)	680,000
Total	912,627
Total 1974/75	918,000

operations when carried out on private land are generally orderly, with topsoil stockpiled ready for progressive re-spreading and sowing down following extraction. Unfortunately, the reverse is often true for gravel and sand extraction on public land, and many old pits are bare and unsightly.

In the Grampians, all gravel used for making tracks and unsealed roads comes from public land. In some instances, quarries and pits can be readily seen from, or are even placed next to, major tourist roads. Better choice of extraction sites and reclamation immediately following extraction would improve the amenity of the road and track system.

Use of stone

Most of the aggregate produced in quarries in the study area is supplied to shires and the C.R.B. for road construction and maintenance. Small amounts of aggregate are used in concreting, and for private roads and landscaping.

As a group the 10 shires extract and use the greatest amount of sand and gravel annually. Some - such as Arapiles, Minhamite, and Belfast - obtain all their gravel requirements from private land. Ararat Shire obtains 22% of its gravel requirements from public land , while Stawell Shire has systematically worked out most of its small gravel reserves.

A roadside gravel pit in the Grampians

In the west of the study district, several pits exist on forested blocks of public land, accounting for a significant amount of the gravel requirements of those areas.

Most shires report depleted gravel reserves. Some look to the remaining Crown land within their boundaries as future gravel resource areas. One has utilized the gravel search facilities available from the State government.

Types of stone

The type of stone extracted depends on the local geology and transport economics. Shires in the south draw heavily upon the Newer Volcanics for basalt aggregate and scoria, mainly from private land.

Some shires abutting the Grampians, together with government departments, draw upon the extensive outwash slopes or the weathered pockets of granite. Material is removed by shallow stripping operations. Many of these areas are on public land, and the shires and other users regard them as continuing to be a source of gravel into the future.

Buckshot gravel

Buckshot gravel is particularly sought after for pavement construction on unsealed roads. This gravel is a laterite found on a variety of rock types in the study district.

It is particularly extensive in the Dundas Tablelands, the south-western Wimmera plains, and part of the Grampians. As it is only a relatively thin deposit, its extraction involves stripping of considerable areas. On the Wimmera plains this "buckshot" gravel overlies Tertiary sandstone, which is used by the Shires of Wimmera, Arapiles, and Kowree as a base course for sealed roads.

Such areas exist on both private and Crown land.

Tertiary limestone

Limestone outcrops extensively from Byaduk to the coast. Quality varies from pure to marly (clayey). The magnesia content is very low, making the material suitable for a variety of uses. For example, excellent cement could be made from the mixing of limestone from Bald Hill (Ardonachie) with marl from the Condah--Dunmore area.

Further south near Tyrendarra, limestone similar to that outcropping in the study district is very pure and would be suitable for making hydrated lime.

Most of the limestone and marl deposits and potential quarry sites are on private land. The only significant area of public land containing marl and limestone is in the Parish of Dunmore.

Limestone is mixed with gravel and used for surfacing unsealed roads, and as a base course before final sealing on shire and C.R.B. roads. In the Wimmera plains small amounts of surface limestone (kunkar) have been worked in the past.

Agricultural lime is extracted south of Edenhope on private land abutting public land. Small quantities of limestone have probably been used for agricultural lime in many areas.

Quaternary dune limestone

Dune limestone (Bridgewater Formation) outcrops near the coast, mainly on private land. Analysis of similar limestone near Portland indicates sections

Old stone quarry at Heatherlie

there suitable for use in glass manufacture (as a flux) or lime production.

Dune limestone at Warrnambool, similar to that in the study district, has been used in the past for building purposes.

Quartz sand

Quartz sand of the Malanganee Formation outcrops on public land in the Dunmore--Bessiebelle area. Analysis of this formation west of the study district revealed sands suitable for glass manufacture, although sands from swampy areas may require treatment.

Most shires contain deposits of sand in some form, which are used when required for mortar and concrete. Sand and fine gravel are extracted from Koroite Creek at Coleraine, and the Wannon River north of Hamilton.

Sandstone

Grampians sandstone was widely used in the past as a building stone. Quarries are located on public land at Mount Difficult (Heatherlie) and near Dunkeld. Although not currently producing, they will be needed to produce stone for restoration purposes or special projects such as extensions to Victoria's Parliament House. A current Extractive Industries Lease is held at Heatherlie.

Mine tailings

On both private and public land, between Stawell and the Grampians, tailings dumps containing red clays are particularly sought after for brick manufacture at Stawell. These clays are blended with the predominantly white clays currently extracted at Stawell to produce red and other coloured bricks.

Glossary

Alluvium - unconsolidated sediments of recent origin laid down in river beds, lakes, and estuaries, on flood-plains, and at the foot of slopes.

Alluvial mining - operations to reclaim commercially valuable minerals from alluvium.

Deep leads - gold-bearing alluvial deposits, particularly river gravels, buried under lava flows, or, in some cases (e.g., Deep Lead, Stawell), covered by younger, non-auriferous alluvium.

Geochemical exploration - prospecting methods depending on chemical analysis of rocks, soil, stream sediment, soil gas, or of plants.

Mineralization - the process of forming deposits of minerals in rock strata.

Quartz reef (or vein) - massive deposits of impure silica found in or cutting across older rocks (in Victoria, lower Palaeozoic sediments); gold is often included in quartz reefs; when it occurs in sufficient quantity to be payable, the reef material can be mined, crushed, and treated to separate the metal from the quartz.

Salamander - crushed mining tailings used in the construction of base courses and foundations; this material is generally variable.

Scoria - slag ejected from volcanoes; it is characterized by a dark colour, an abundance of bubbles (i.e., it was frothy when molten and cooled to form a cellular-structured rock), and a partly glassy, partly crystalline texture.

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21. UTILITIES

Utilities and services essential to community welfare are often located on public land. These include transport, communications, supply of electricity and gas, and areas for waste disposal, aerodromes, and air and marine navigational aids. This chapter describes the current use of public land for these purposes, and attempts to assess future requirements.

Electricity Supply

The Victoria power grid

Although the study area contains no power stations, and none are planned, distribution of electricity is an important consideration in land use planning.

The State Electricity Commission distributes power throughout Victoria by a vast transmission complex. The main transmission grid conducts high-voltage power (at 220 or 500 kV) from the generating station to terminal stations in the regions where it will be used. The lines are strung between steel towers.

The sub-transmission grid radiates out from the regional terminal stations, conducting medium-voltage power (66 kV) to zone sub-stations. These lines are carried by wooden poles.

The distribution grid links zone sub-stations with individual users of power. Lines are strung between wooden poles or (less commonly) buried underground. They transmit power at moderately low voltages (either 12.7 or 22 kV - the former system is called single-wire earth return or S.W.E.R.).

Table 32 lists easement widths for each type of transmission line.

Table 32

EASEMENT WIDTHS FOR TRANSMISSION LINES

Main transmission lines	40 m+
Sub-transmission lines	up to 40 m
Distribution lines	up to 30 m

Note: In tall forest, easements may be even wider for each type of line.

Main transmission grids are generally constructed along the most direct route between terminal stations, to minimize costs and drops in voltage and to facilitate pylon design. The route can be varied to take advantage of high features that may offer the opportunity to lengthen cable spans, or to avoid areas where construction difficulties may arise.

In recent years, landscape architects have helped engineers to design and locate main transmission lines in order to minimize their impact on the landscape.

Future construction in south-western Victoria

The S.E.C. is to construct a new terminal station at Ettrick, near Heywood. This will be connected by double-circuit 220-kV transmission line with the existing terminal station at Terang.

It is intended also to provide a second link between Horsham and Ballarat, to give increased security during emergencies. The existing direct 220-kV line (part of which is in the study area) may be duplicated, with the new line being constructed on a similar, although separate, route. An alternative would be to construct a single-circuit 220-kV line between Ettrick and Horsham - this would have to traverse or skirt the Grampians.

More sub-transmission lines will be constructed and the distribution grid will be continually expanded, as required by increases in population and industry. Where these lines are to be duplicated, the second line would probably be located some distance from the existing one to prevent simultaneous failure due to storms or fires.

Easements and the rural environment

Main transmission lines (i.e., 220-kV) cut across both private and public land and require a cleared easement where they pass through forest or woodland. As stated earlier, however, thorough planning and imaginative location of easements can greatly lower the intrusive effect of a transmission line on the landscape.

In contrast, most sub-transmission and distribution lines have been constructed along road reserves. The remainder, including the bulk of the 12.7-kV S.W.E.R. lines, are on easements, usually through private land.

The use of road reserves with functioning thoroughfares ensures unhindered, year-round access for maintenance vehicles, but may require the destruction of some roadside vegetation during construction. Fire-protection measures such as tree-pruning and the subsequent burning of branches can be unattractive and can damage ground flora.

Other Service Uses

Telecommunications

Telecom Australia operates three radio-telephone repeater stations on public land in the study area - One Tree Hill (Ararat), the northern fall of Mount Stapylton (Grampians), and Mount Arapiles. Each station occupies a site of about 2 ha, with a single-storey building and a tower 40 metres high. Telecom has no plans for construction of more repeater stations on public land.

The study area receives television transmission from installations outside the district (Mount Buangor near Ararat, Mount Clay near Portland, and Mount Burr between Mount Gambier and Millicent). At present, two installations within the study area are being planned.

The first is a major transmitting station to be located on Mount Dundas to serve the Hamilton--Casterton--Coleraine area. The site is on public land, near the existing fire look-out. The tentative design calls for a one- or two-storey building on an 800 sq m site, and a 158-m-high steel tower. The access track serving the fire look-out would have to be upgraded.

The second proposal is for a much smaller translator to serve the Halls Gap--Bellfield Village area. Two antennae, mounted on a 6-m wooden pole, within a 3 m x 3 m enclosure would be located 200 m south of the Boroka Look-out. A power line would not have to be built into the site.

The Forests Commission operates a VHF radio repeater on the Mount William Range, 1 km south of Mount William. The S.E.C., C.F.A., and Shire of Ararat occupy small radio mast sites on the ridge south of One Tree Hill, near Ararat.

Waste disposal

The volume of waste produced by urban communities is growing faster than population growth, due largely to increasing affluence and greater use of packaging.

Radio-telephone repeater, One Tree Hill

Solid waste from towns in the study area is usually disposed of by the land-fill method, often on public land reserved for waste disposal, or in old quarries or other land of low commercial value. Use of land for rubbish disposal usually destroys its value for most other forms of use - loss of amenity and creation of ugliness are often major problems. In some situations, pollution of surface or groundwater resources is also a problem.

Careful choice of locations for rubbish tips and sound management of their use can reduce the impact of this form of land use.

Selection of new sites for tips as the existing ones become fully used can be difficult, as there is often little public land near towns, and conflicts with recreation and landscape preservation often arise.

No sewage-treatment plants occupy public land in the study area.

Military training

With a few exceptions, recent military training in the study area has been confined to 30,000 ha of public land in the Grampians. Extending west from Mount Victory to Wartook and Glenisla, this land has been proclaimed as Mount Victory Training Area and is used about once a month by groups of up to 300 soldiers. The major activities are bushwalking, tactical exercises, and signals training. In general, supporting vehicles are wheeled and do not leave roads. Lake Wartook is occasionally used for activities involving small craft.

Railways and roads

Railway easements were reserved decades ago and often contain significant remnants of the original vegetation, particularly where they pass through agricultural country.

Of the railway lines constructed in the study area only one, the light tramway between the Mount Difficult sandstone quarry and Stawell, has been totally dismantled. A portion of this easement has been sold. The Hamilton--Coleraine line remains open, although it is not now used for regular services.

Road reserves throughout also contain remnants of the original vegetation, many of which are of conservation interest. Roadside vegetation often makes a strong contribution to the local landscape. The use of road reservations for power transmission and telephone lines, and also the construction required in upgrading roads to take faster and heavier traffic more safely, can reduce these stands and their viability.

Most of the roads and tracks within the large areas of public land are maintained by the Forests Commission. Exceptions are the major tourist roads in the Grampians, which are under the control of the Country Roads Board. It is generally accepted that the present level of roading in the Grampians is adequate for management and recreation use, and that no more roads are required.

The only roading project under discussion at present is the upgrading of the Rocklands--Cherrypool track to a standard suitable for tourist traffic. This track goes through generally flat terrain carrying woodland, between Rocklands Reservoir and the Black Range.

Aerodromes and navigation aids

Only one air strip - the Forests Commission's landing field at Forest Lodge in the Grampians - occupies public land in the study area. All others are owned by municipalities or by private individuals or organizations.

The Department of Transport maintains a navigation aid on the summit of Mount William, and leases approximately 1.5 ha from the Forests Commission for this purpose. No other navigation aids are planned for construction on the public land.

Fire look-outs

Four elevated sites in the study area are used as fire look-outs - Mount Arapiles, Mount Bepcha, Mount Dundas, and Reid Look-out (Grampians). Other look-outs outside the district, which complement the coverage provided by these four, are Big Hill (Stawell), Chetwynd, Corndale, Ben Nevis, and Mount Clay and Annya (Heywood).

Detection of fires in the north-west of the study district is difficult because of the flat terrain. A tower at Comaum, north of Penola, S.A., is useful as its sightings can be co-ordinated with those from Mount Arapiles. Nevertheless, accurate location of outbreaks in the area usually depends on ground reconnaissance and contact with local residents.

Proposed observatory at Mount Arapiles

A group of Victorian astronomers has proposed that a new observatory should be built on Mount Arapiles. This location has the advantage of a high proportion of cloudless nights. It was considered as a possible location when a new site was being sought for the Commonwealth Observatory, then at Mount Stromlo, Canberra. The site ultimately chosen was Siding Springs Mountain, near Coonabarabran, N.S.W.

The proposal calls for two telescopes to be built and housed on Mount Arapiles, with other buildings for workshops, office, observers' quarters, and public viewing and display areas. The main instrument would be a telescope of 120-cm aperture, which would be used at first for infra-red astronomy, but which with a suitable mirror could also be used for optical programmes. The whole observatory should occupy a site 100 m x 100 m.

It is proposed that the observatory should become a tourist attraction - one telescope would be available for public viewing - and this could bring large numbers of cars to the summit area. The proposal is currently before the government, which is carrying out feasibility studies.

Miscellaneous uses

In some places public land is used for cemeteries, schools, sites for trigonometric stations, and service basins.

There are no gas pipelines - gas is transported by tankers.

The Mental Health Authority has a large hospital at Ararat and conducts the Mount Pleasant Special School at Stawell, but these institutions occupy Crown land in the City of Stawell. Similarly, Ararat Prison is located in an adjacent study area, but prisoners do forestry work on public land in the midlands and the Grampians. The Forests Commission assists the Social Welfare Department with the organization of this work.

PART IV

BLOCK DESCRIPTIONS

BLOCK DESCRIPTIONS

For this part of the report, the study area has been divided into five blocks. These areas, in which the public land has similar climate, soils, and topography (within broad limits), are thus convenient for describing and assessing natural resources. Map 11 shows the boundaries. Note that these boundaries have been drawn to facilitate description and assessment, and they have no significance for making recommendations on land use.

For each block the present tenure, nature of the land, present uses, and capability for various uses are given. Hazards are also assessed. The sections dealing with uses refer only to the public land except where explicit reference is made to private land. A consistent format of headings and sub-headings is used to help readers compare specific details between blocks.

Capability

The capability of land means the degree to which it can be used to produce specific goods or services. It depends on the inherent characteristics of the land, such as rainfall, soil fertility, slope, and so on, but is also affected by other factors such as the hazards (erosion, salting, etc.) arising from a form of land use, constraints such as costs of development, distance from markets, access, and susceptibility to wildfires. In most cases capabilities are given in general terms, as the information available varies from block to block, and some values are difficult to quantify.

The capability of land is relative, in that it depends on the size and nature of the area being considered. For many forms of use, land may have a high capability on the local scale but a low or moderate one when considered in the State-wide or national context. In this report capability statements are made in the context of the study area, except where comparison with some other area is specifically referred to.

The extent of the land under discussion may also influence consideration of its usefulness - for example, a very large area of a land type that has low to moderate capability may be more important for a particular use than a small area with a high capability.

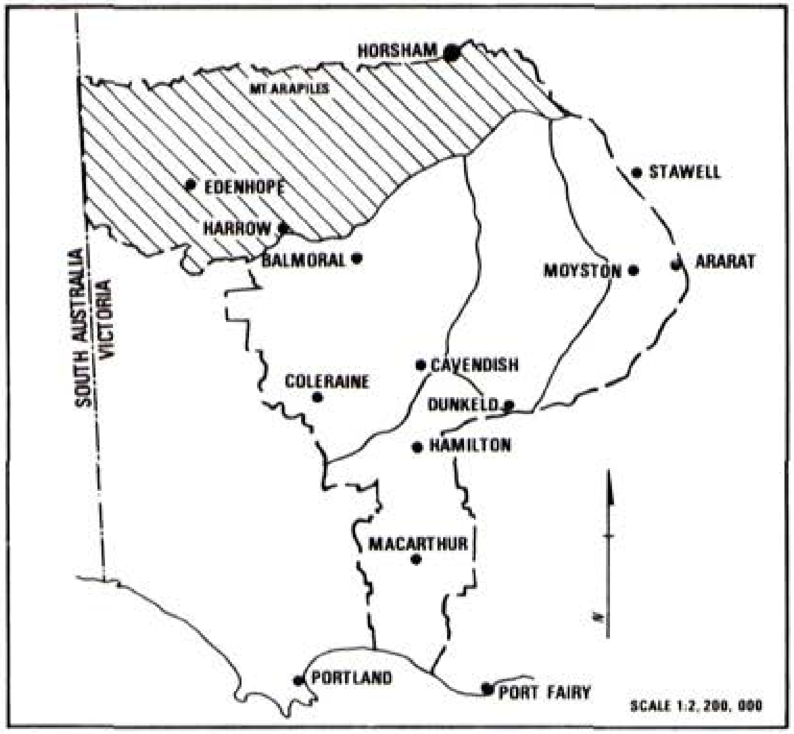
In many cases the current uses on each land type, including those on private land, give a good indication of the capabilities of the land.

1. SOUTH-WEST WIMMERA PLAINS

A. Tenure and Nature of the Land

1. Present tenure

This block lies on the edge of the Wimmera plains, one of the most productive cropping regions in the State. Almost all land that could easily be developed for agriculture has been alienated and cleared.

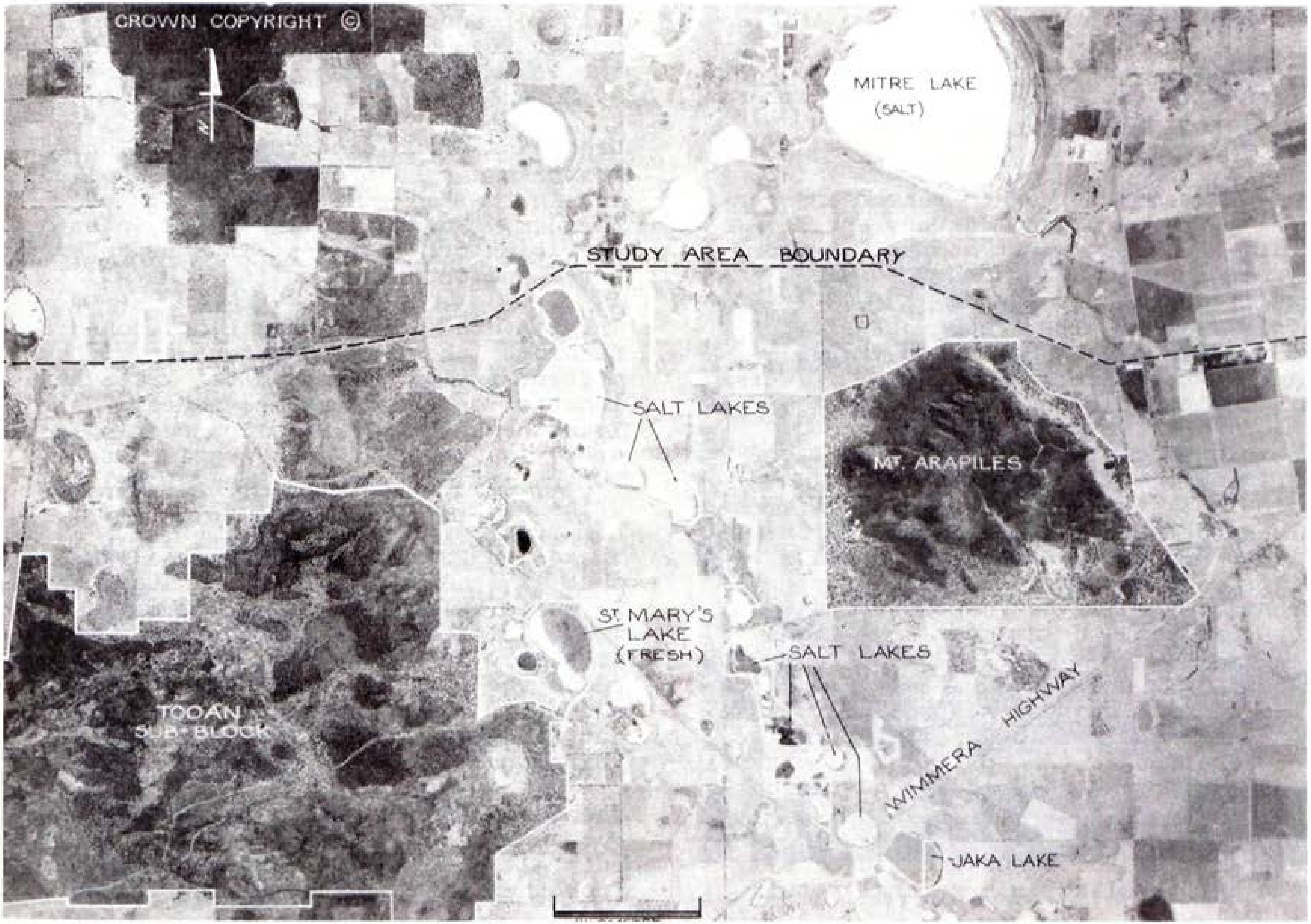


The public land consists of areas of poor sandy soils, the rocky outcrop of Mount Arapiles, and swamps, lakes, and man-made water storages, and covers a total area of 74,000 ha. Most of this is unoccupied Crown land, although many of the wetlands are water reserves. There are small flora reserves at Edenhope and near Wonwondah North.

The 16 scattered, mainly small, blocks of reserved forest comprise about 10,500 ha. Mount Arapiles (1,470 ha) is reserved under section 50 of the *Forests Act* as a forest park. The water storages - Toolondo Reservoir and Dock, Green, Pine, and Taylor Lakes - occupy 3,490 ha. Mullinger Swamp (45 ha) straddles the South Australia--Victoria border, and the section of the swamp in South Australia (14 ha) has been reserved as a conservation park. No other substantial areas of publicly owned land in South Australia adjoin the Victorian border.

2. Climate

Average annual rainfall declines from 600 mm in the south-west to 450 mm in the north-east. As the regional topography is flat, this decline occurs evenly across the block. Most rain falls during the period from May to September.



While summer rainfall is more variable than winter, it is more evenly distributed across the block - winter rainfall is markedly higher in the south-west than in the north-east.

Annual evaporation is estimated to average 1,100 mm. Evaporation is highest in January (170 mm) and lowest in July (50 mm).

Maximum temperatures in summer are generally 26--29°C, and January and February are the warmest months. Summer minima average 12--14°. In winter, maximum temperatures average 10--14°, and minima 3--4°. Temperature usually exceeds 38° on about 6 days a year.

3. Geology and physiography

The block consists of plains of late Tertiary to Quaternary sediments, overlain in the west by low sheets of wind-blown sand and dunes. Around Horsham, rivers deposited Quaternary sands, silts, and clays, while west of Mount Arapiles similar sediments were laid down in lakes and swamps. The low sheets and dunes of fine white to yellow sands occur on four sub-parallel ridges of marine Pliocene sandstone (Parilla Sand) aligned NNW--SSE. These ridges are regarded as the positions of stranded coastlines developed by the retreating Pliocene sea.

Reworking of the sandstone ridges by wind has resulted in a generally thin but continuous capping of dune material for much of their length in the study area. Most of the public land is on these sands. The plains lie at an elevation of about 160 m. The sands vary in height from a metre above the plains in the west to 15--30 m in the east near Gymbowen.

Grampians Group sandstones of Silurian--Devonian age outcrop at Mount Arapiles and in the MacKenzie River south of Horsham. Mount Arapiles rises to an elevation of 370 m, and is surrounded by scree and outwash deposits.

The western part of this block contains numerous lakes and permanent and intermittent swamps. Many of the lakes have lunettes on their eastern sides. Salt lakes occur in a depression running generally south from Mount Arapiles to Centre and White Lakes, near Douglas, which are the largest.

These are groundwater discharge lakes; that is, the regional groundwater, which is quite saline (7,000--9,000 mg/l T.D.S.) in this area, contributes water to them. During summer, evaporation exceeds the rate of groundwater discharge, and after a dry winter the lakes dry out, leaving a deposit of common salt that is sometimes harvested.

The lakes further west are groundwater-recharge lakes. They are filled by rainfall and run-off, and water moves from them into the underlying groundwater. The quality of the groundwater west of Wombelano improves dramatically, as one of the subsurface units changes rapidly from silt and marl to limestone.

To the west of Edenhope the lake system is not well defined because of gentle dissection of the area by four streams - Mosquito, Koijak, Thompson, and Yalla Creeks - which flow westward into South Australia.

East of Toolondo streams that rise in the Grampians and flow north to the Wimmera River traverse the block. Mount Talbot Creek flows from the Black Range into Toolondo Reservoir. The streams flow sluggishly over the plains, and are reduced to deep pools in summer.

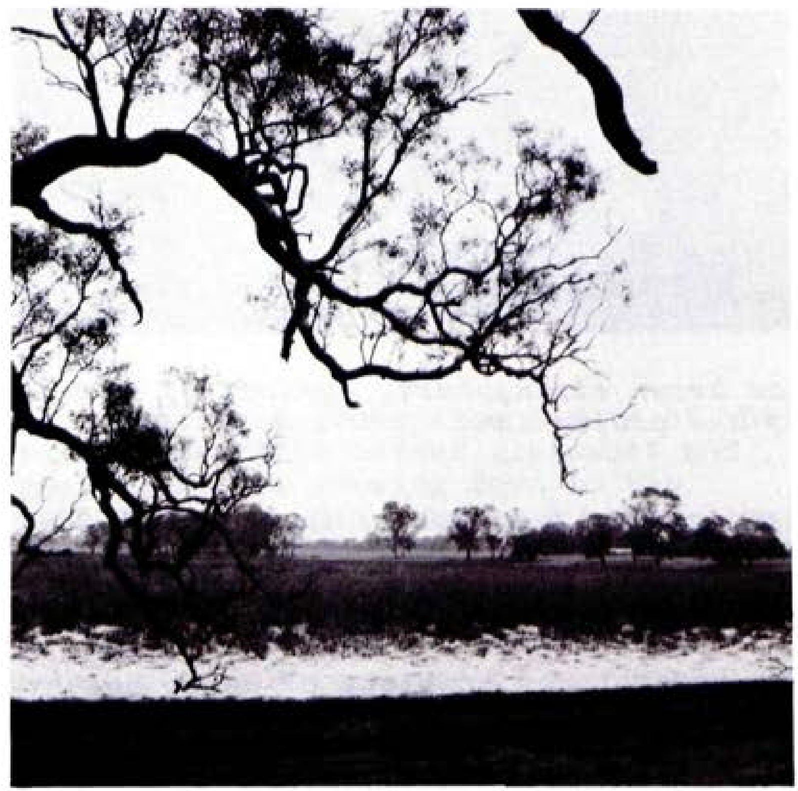
4. Soils

Leached sands occur on the sand dunes and deeper sand sheets, and calcareous sodic duplex soils on shallow sand sheets. These are the major soil types on the public land. Mount Arapiles has shallow stony gradational soils on the rocky areas, with leached sands in the surrounding outwash slopes.

On the cleared Wimmera Plains, calcareous sodic duplex soils are widespread, with gilgaied yellow sodic duplex soils. Grey clays occur in lower situations. These soil types occur in restricted areas on public land, in small patches or around the edges, where they are associated with gum woodland vegetation.

5. Vegetation

The most widespread vegetation type is open forest I to shrubby woodland 5--20 m high. A single tree species - brown stringybark - dominates this type, and is confined to the sheets and dunes of windblown sand. Black wattle grows sparsely in some areas, and manna gum and scent-bark sometimes occur on the edges of brown stringybark stands. The height of the trees varies from about 20



Kurrayah Reserve, south of Edenhope

Low brown stringybark, typical of much of the public land

m on good sites, mainly in the better-watered southern parts of the block, to 5 m on very deep sands. The spacing of the trees widens as their height falls.

The understorey consists of dense heathy shrubs 0.5--1 m high: daphne heath, silky tea-tree, bush-peas, small grass-tree, Oyster Bay pine, desert banksia, and guinea flowers are prominent species. Bracken is a major component of the understorey on well-drained sites in the south-west.

A small isolated stand of slender cypress pine occurs among the brown stringybark open forest I at Bringalbert, north of Edenhope.

Where the sands are absent, heavier duplex soils and grey clays support woodland vegetation. Woodlands of red gum grow on the heavy soils in low topographic positions. The understorey is sparse, usually scattered silver banksia, although dense thickets of scarlet bottlebrush often occur on the edges of the stands. A ground cover of grasses and sedges is common. The most extensive stands of red gum occur in the Kadnook--Connewirrecoo sub-block.

Scattered veteran red gums, remnants of the original woodland, occur widely through the farmlands. Red gum woodland also borders the streams in the east - Wimmera River, Mount William Creek, MacKenzie River, Burnt Creek, Norton Creek, and Darragan Creek - and the numerous fresh-water swamps and lakes.

Woodlands of yellow gum are widespread, occupying drier sites than red gum. The understorey usually consists of sparse grasses and herbs. Two other woodland species - grey box and buloke - grow in small areas of public land. Most of the land carrying these species has been alienated and cleared for agriculture.

Remnants occur in the Tooan sub-block, and around the northern edges of the Jilpanger sub-block.

Black box occupies a few areas in the north. Pink gum, an uncommon species in Victoria, occurs in mixture with yellow gum and swamp gum in the Meereek sub-block.

The public land at Mount Arapiles contains diverse vegetation types. The high rocky land carries low woodland of long-leaf box and yellow gum over a dense shrubby understorey. Most of the lower country is covered by grey box and yellow gum woodland. At present golden wattle is conspicuous in the understorey in the east of the public land as a result of a wildfire that burnt through the area in December 1972.

Stands of open scrub (mallee) occur on public land to the west and north of Mount Arapiles, and in the Tooan sub-block. Prominent species are dumosa, yellow, and slender-leaf mallees. Peppermint box also grows at Mount Arapiles and, with bull mallee and Kamarooka mallee, at Lower Norton. The major understorey species, which are often more abundant than the eucalypts, are broom honey-myrtle and broom baeckea.

The Marma sub-block lies between the Mount William Creek and Wimmera River, and supports a very open woodland of grey box, yellow gum, and yellow box, with red gum on the banks of the streams. The ground cover is grassy, with almost no shrubs.

Small areas of wet heath occur in the Jilpanger and Meereek sub-blocks. In Jilpanger, desert hakea and mallee honey-myrtle are the dominant species, while in Meereek the heaths are more diverse, with beaked hakea, lavender grevillea, pink eyes, and slaty she-oak prominent.

Most of the fresh-water swamps and lakes have fringing vegetation of red gum woodland, or its remnants. Many lakes, especially those surrounded by cleared land, are ringed by dead red gums. Clumps of lignum grow under the red gums and down to the water's edge in some areas. Spiny flat sedge is the most common shoreline species. The most common aquatic species are water-milfoil, eel-grass, cane grass, water-ribbons, jointed twig-rush, and pithy sword-sedge.

Salt paperbark grows around some of the salt lakes, with beaded glasswort and grey glasswort growing down to the water's edge. Sea tassel, a grass-like plant, forms dense mats in many of the saline lakes.

6. Fauna

The low forests and shrubby woodlands of brown stringybark contain about 33 commonly occurring bird species, 20 mammals, and 12 reptiles and amphibians.

The dense undergrowth in many areas appears to be important to some species, particularly certain thornbills and honeyeaters and the western pigmy possum. The red-tailed black cockatoo also occurs in this habitat, and large numbers have been observed in the Jilpanger sub-block.

The little wattlebird may be seen in large numbers feeding in the dense stands of desert banksia. The silky desert mouse lives on sand ridges that have not been heavily grazed or burnt. Mouse dunnarts are probably widespread, but their numbers are difficult to assess because they are not easily trapped. Other native mammals living in this habitat include the echidna, yellow-footed antechinus, western grey kangaroo, and red-necked wallaby.

The remnants of the gum woodlands form an important habitat, in which about 60 birds, 25 mammals, and 15 reptiles and amphibians occur at present. The common mammals are the echidna, yellow-footed antechinus, tuan, fat-tailed dunnart, brush-tailed possum, sugar glider, feathertail glider, western grey kangaroo, and red-necked wallaby. Evidence from deposits of sub-fossils found in caves suggests that a number of mammals have disappeared from this habitat since European settlement.

This block contains a large proportion of the wetland habitat in western Victoria. The large permanent swamps and lakes and the man-made water storages are important refuges for waterfowl during periods of low rainfall.

The wetland survey (see Appendix 4) described and evaluated about 120 wetlands here. The survey recorded the presence of 63 species of water-birds in the wetlands of the study area. Of the 33 of these wetlands placed in the top rating for water-bird conservation, 28 are in this block, including three of the saline ones (Lake Mullancoree, Centre Lake, and White Lake).

The mud flats associated with some of these wetlands also provide foraging areas during the non-breeding season for six species of intercontinental migrants, two of which breed in the Arctic (red-necked stint and curlew sandpiper), three in Eurasia (Latham's snipe, greenshank, and sharp-tailed sandpiper), and one in New Zealand (double-banded plover).

The saline lakes and swamps are important habitat for waders such as pied and banded stilts and red-necked avocets. Very large numbers of these birds, and swans and ducks, have been reported there. Large waders (e.g., great egret, and pacific and white-faced herons) use the numerous shallow temporary wetlands. The brolga is conspicuous along the open margins of the wetlands.

The wide range of aquatic habitats is in part also responsible for the widespread occurrence in the block of at least five species of amphibians, as well as vertebrates such as the eastern water rat and the long-necked tortoise. The lakes also support populations of redfin and yabbies, both of which are sought by amateur fishermen.

The open nature of the pasture and crop lands (on private property) makes them suitable for hunting over by such predatory birds as eagles, kites, harriers, and falcons. Some members of the parrot and cockatoo family (particularly long-billed corellas, galahs, and sulphur-crested cockatoos) forage in the pastures for roots and bulbs. Other species particularly well adapted to survival in this open habitat include some quails and larks, yellow-rumped thornbills, white-fronted chats, jacky winters, magpies, and ravens; mammals such as fat-tailed dunnarts; and reptiles such as common bluetongues, stumpy tails, and brown snakes.

Fat-tailed dunnart, a widespread native mammal

B. Present Uses and Capabilities

1. Nature conservation

Areas specifically set aside for nature conservation are the John Smith Flora & Fauna Reserve (8 ha) near Wonwondah North, and a flora reserve on the southern boundary of the township of Edenhope. Mount Arapiles is a forest park in which nature conservation is a major aim of management, and Lake Wallace at Edenhope is well known as a nesting area for the great crested grebe. While the remainder of the public lands are not managed specifically for nature conservation, there are few conflicting uses, with the possible exception of grazing and duck-hunting.

Various sub-blocks have a moderate to high capability for flora conservation. Mount Arapiles has the most diverse flora, including many rare species and isolated records. Surveys have recorded 430 species of native plants here. The occurrence of open scrub (mallee) is of particular interest.

The Tooan sub-block is also very diverse, and includes examples of buloke, grey box, and yellow gum woodland, mallee, heath, and low open forest and shrubby woodland of brown stringybark. The Jilpanger sub-block again has a varied flora (284 species of native plants), and includes some salt lakes.

The John Smith Reserve has an isolated occurrence of Kamarooka mallee, a central Victorian species.

The Meereek sub-block contains pink gum, a species generally restricted to the far south-east of South Australia, but extending a short way into Victoria. Recent surveys have located *Eriocaulon australasicum* in the Meereek sub-block. This plant is extremely rare in Victoria, the last record being on the Murray River in 1853.

The brown stringybark open forest I and shrubby woodland form part of a continuum extending from the tall open forests in the high-rainfall areas in the lower Glenelg region to the low mallee-like form of the species in the Little and Big Deserts. Large areas of these vegetation types remain on public land throughout this range.

The gum and box woodlands remaining on public land have a high capability for nature conservation. The largest areas of these are in the Kadnook--Connewirrecoo, Meereek, Tallageira, and Kalingur sub-blocks. The Marma sub-block contains a good example of very open woodland on heavy clay soils.

Originally the most widespread habitats, the remaining woodlands are important for the conservation of a wide range of birds and mammals. While it is impossible now to determine all the species that once lived in these habitats, evidence from sub-fossils found in caves suggests that a number of mammals have disappeared from western Victoria since European settlement.

Such habitats are important for the maintenance of a number of species whose populations may be falling. These species fall into one or more of three categories:

* birds such as lorikeets and honeyeaters that move seasonally to the woodlands to feed on pollen and nectar (and possibly associated insects) when the dominant tree species (river red gum, yellow gum, and grey box) are flowering
* birds such as corellas, cockatoos, and owls, mammals such as possums and tuans, and reptiles such as tree goannas, which require hollows in trunks or limbs of large trees for breeding and/or sheltering
* ground-foraging birds such as curlews and babblers, which appear to depend upon relatively unchanged native undergrowth being present in the woodlands.

The range of the red-tailed black cockatoo has decreased since European settlement, and the large areas of brown stringybark, especially in the Jilpanger sub-block, appear to be one of the last strongholds of this species in Victoria.

Birds such as the southern scrub-robin, variegated fairy-wren, Gilbert whistler, white-fronted honeyeater, and spiny-cheeked honeyeater reach the southern limit of their range in western Victoria in the small patches of mallee in Mount Arapiles and Tooan sub-blocks.

In 1975 a nesting mound of the mallee fowl was reported to be in use in the mallee areas in the Tooan sub-block. This is the southern-most occurrence of this species in Victoria.

The wetlands of the block have a very high capability for conservation of water-birds, and 28 wetlands were placed in the highest rating by the survey carried out for the Council. Brine shrimps in the saline lakes attract large numbers of waders, especially banded stilts and red-necked avocets.

The brolga uses the margins of open pastures and wetlands, and still breeds in the area, but its long-term survival may be threatened.

The Fisheries and Wildlife Division has recently established a Murray cod hatchery on Lake Charlegrark. Two nearby wetlands, Booroopki Swamp and No-where-else Swamp may be used as alternate Murray cod holding sites as the project develops.

Aboriginal relics have been recorded near Lake Kanagulk and west of Toolondo. The Aborigines would no doubt have used many of the wetlands in this block, and more relics may be found when surveys are carried out.

Two species of foraminifera (simple animals generally with calcareous shells) have been reported in the saline lakes of this block. These protozoans are usually marine and are rarely found in inland lakes.

The rocky cliffs of Mount Arapiles are a conspicuous feature of the landscape when viewed from the surrounding plains, especially those to the east. The remainder of the public land is low-lying and has less landscape significance, except for the larger lakes.

Many roadsides in this block carry very attractive stands of gum, box, and buloke, and these make a major contribution to the regional landscape.

2. Recreation

At present recreational use in this block is concentrated on Mount Arapiles and some of the lakes.

Mount Arapiles is used for camping, picnicking, walking, rock-climbing, sight-seeing from the look-out, and golf on the Natimuk golf course. It has a high capability for recreation, and use by rock-climbers, picnickers, and campers has been increasing. The cliffs at Mount Arapiles are among the best in Victoria for climbing, and attract many climbers from Melbourne and interstate.

Recreational use of the other public land, excepting the lakes, is at a very low level. Activities include nature study and pleasure driving.

Cliffs at Mount Arapiles

Access through much of this land is difficult, and the sparse regional population means that pressure on most of the land is low. At Edenhope an oval and part of the golf course are on public land.

The storages, lakes, and swamps are used for fishing, boating, hunting, swimming, water-skiing, yabbying, picnicking, and camping. The Recreation map shows which lakes and swamps receive intensive use for these activities. Of the storages, Green Lake and Toolondo Reservoir are particularly popular for boating and water-skiing. Natural lakes and swamps that are popular for a number of activities include Lakes Charlegrark, Carpolac, Wallace, Ratzcastle, Dollanoke, and Jarracteer, St. Mary's and Clear Lakes, and Booroopki and Charam Swamps. Almost all the wetlands are shot over during duck-opening.

The lakes and swamps have a high capability for recreational use. The present level of use is relatively low because of the small regional population, and the isolation from population centres.

3. Agriculture

Less than half the public land is covered by annual grazing licences. The largest licensed areas are in the Tallageira, Kadnook-Connewirrecoo, Kalingur, Awonga, Morea, and Toolondo sub-blocks. The fringes of many of the lakes are also grazed.

The major farming enterprises on the private land are cropping and grazing sheep for wool and mutton, with some beef cattle. In the south-western corner of the block there is less cropping, and more emphasis on production of prime lambs.

The soils on most of the public land are deep sands, which are infertile, acid, and have low water-holding capacities. Their capability for agricultural development is low. Research has shown that, given precise establishment techniques and application of fertilizers and trace elements, pastures can be grown on these soils. Lucerne is the most suitable species, although some farmers have successfully established pastures of other species. The costs of development are high, and the low returns received for the agricultural products that would be grown on these areas do not justify development at present. Exceptions may be small areas of public land that protrude into farmlands, and are a "nuisance" to farm managers.

The gum--box woodlands and the small areas of heath have a moderate capability for agriculture. These land types occur in scattered small areas, however, and do not constitute a major potential agricultural resource.

Again, the costs of developing pastures would be high - in excess of $300 per ha - and would not be justified by the returns that could be expected.

4. Honey production

The block has a moderate capability for honey production. At present, about 80 permanent and temporary sites are located on the public land. The gum--box woodlands have the highest capability, and the brown stringybark open forests and the heaths have a lower capability. These latter areas, and especially the understorey species such as desert banksia, tea-trees, heaths, and grevilleas, are important in maintaining and preparing hives for working honey flows in red gum, yellow gum, and yellow box.

Use of many of the areas of public land is limited by poor access for trucks along the sandy tracks, and lack of water for bees in warm weather.

5. Timber Production

Small quantities of hardwood timber are harvested from this block. M.G. Crawford's mill at Edenhope cuts 75 m^3 of mixed species (brown stringybark) and 225 m^3 of durable species (red gum, yellow gum, and box) annually from public land, and some logs from private land. In addition farmers and residents cut small quantities of firewood, and farm timbers such as posts, poles, and rails. Sleepers are no longer cut from the public land.

The larger areas of red gum woodland in the Kadnook--Connewirrecoo, Tallageira, and Kalingur sub-blocks have a moderate capability for the production of durable timbers. The areas of red gum regrowth in Kadnook--Connewirrecoo, which have been thinned several times, have a higher capability. The growth rate of these stands is very slow compared with that of the mixed species forests of the Grampians and Mount Cole.

The capability of the brown stringybark stands for timber production is low.

No commercial pine plantations occupy the public land. Several small stands of radiata pine near Apsley are exhibiting growth rates that would be satisfactory for commercial plantations. As the average annual rainfall at Apsley (570 mm) is well below the accepted minimum of 750 mm for good growth of radiata pine, the trees are probably tapping good-quality groundwater at shallow depth.

The extent to which these conditions exist in other parts of the block is not known. Any suitable areas are most likely to be in the west of the block, as further east the groundwater available at shallow depth is saline. Generally, the capability for softwood timber production is low, due to the infertility of the soils and the low rainfall.

6. Water production

Many of the fresh-water lakes are reserved for water supply purposes. Edenhope draws its water from Lake Wallace.

This supply is chlorinated. Others yielding supplies for domestic use are Charlegrark, Yampitcha, Ratzcastle, and Collins Lakes. Water is also taken from Brig Brig Swamp and St. Mary's Lake. Some is used for irrigation. Dock, Green, Pine, and Taylor Lakes, and Toolondo Reservoir, are storages in the Wimmera--Mallee Domestic and Stock Water Supply Sustem.

There are about 200 stock and domestic supply bores, and 10 bores supplying water for irrigation on private land.

The small non-perennial streams flowing through the west of the block into South Australia have no water supply significance. Little investigation into the potential of the lakes and swamps for this purpose has been done. While many of them dry up, the 25 or so permanent lakes have a low to moderate capability to supply water for stock and domestic and irrigation use.

Good-quality groundwater is available at depth beneath the areas generally west of Douglas, and from deep leads running north through Wonwondah East towards Horsham.

7. Mineral and stone production

No minerals are taken from this block at present.

Small quantities of gold have been mined at Kadnook. Mining companies have explored for heavy mineral sands in the Pliocene stranded beach ridges. Only traces of these minerals have been found.

Salt is harvested from four of the saline lakes that occur between Douglas and Mount Arapiles. Common salt forms a crust on the beds of the lakes when they dry up in summer. It is scraped off by machinery and heaped on the side of the lake. Harvesting in this area is less reliable than in the Mallee, as the lakes may not dry up every year. Over the 5 years to August 1977, a total of 130 tonnes has been removed from three of the lakes - none has been taken from the fourth.

Buckshot gravel used for road-making has been removed from a number of shallow pits on the public land. This gravel overlies sandstone (Parilla Sand), which is used as a base course for sealed roads. Mount Arapiles contains large quantities of gravel and stone, but it is unlikely to be quarried due to the area's status as a recreation and conservation reserve.

A large quarry with crushing plant works an outlier of Grampians Group sandstone in the MacKenzie River south of Horsham.

Very large reserves of quartz sands are present on the public land. Little is known of their quality, as distance from markets has precluded their use to date. Metropolitan construction requires large quantities of sand, and sand deposits are not as abundant as is commonly thought. Although the deposits in this area are remote, some may eventually be required and exploited. At present, sand is extracted (in a haphazard manner) from the public land at Edenhope. Lime for agricultural purposes is extracted from private land adjacent to public land south of Edenhope.

8. Utilities

Mount Arapiles carries a radio-telephone repeater station and a fire look-out. In addition, there is a proposal to build an astronomical observatory there. The proposed buildings would occupy a site approximately 100 m x 100 m on the top of the mountain and would not be visible from the surrounding plains.

C. Hazards and Conflicts

The hazard of soil erosion in this block is low to moderate. The sand dunes are susceptible to wind erosion when cleared. Lunettes are particularly susceptible, and have the highest hazard.

The risk of wildfire is high. The brown stringybark stands and their shrubby understorey are highly flammable. Although their frequency has fallen in recent years, fires still occur, and lightning strikes are a constant threat in summer. A system of bush tracks to provide ready access and the co-operation of landholders in reporting fires have led to a higher level of control.

Rabbits and foxes inhabit the fringes of the public land and feed on adjacent farms. Populations are low, and regular control work is carried out.

There are no major weed problems. One-leaf cape tulip occurs on roadsides near Apsley and Edenhope, and bridal veil creeper (which is not a proclaimed noxious weed) has appeared in the Tallageira, Goroke, and Telangatuk areas.

At Mount Arapiles increasing use for recreation may conflict with wildlife conservation. In particular, rock-climbing may disturb nesting by peregrine falcons. 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, and especially landscape values.

2. GRAMPIANS

A. Tenure and Nature of the Land

1. Present tenure

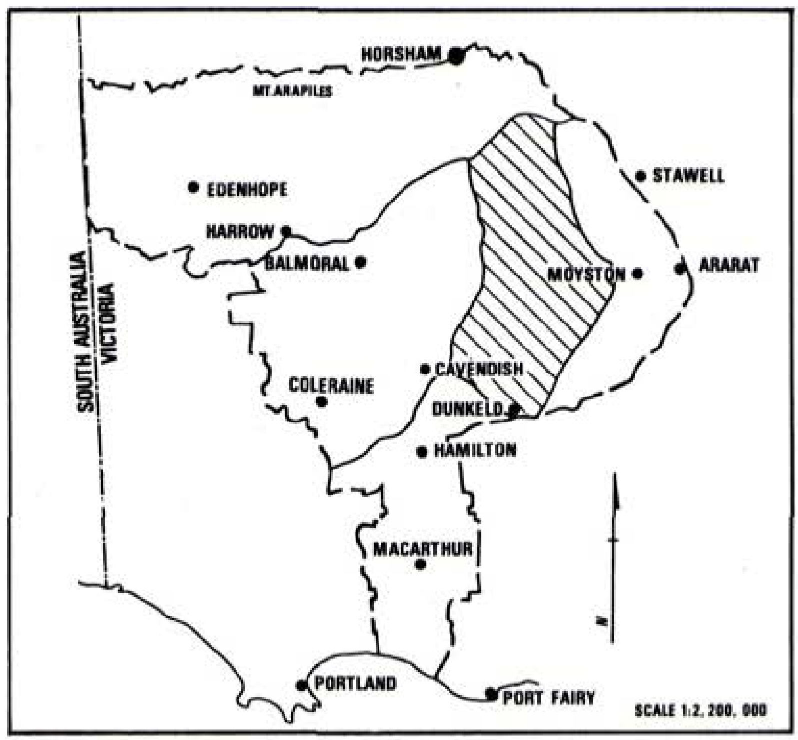
Grampians block contains the Grampians ranges, their outwash slopes, the Victoria valley within the ranges, and the surrounding plains. These plains, the southern part of the Victoria valley, and some parts of the outwash slopes have been alienated - the remainder (160,000 ha) is public land.

Reserved forest occupies 120,000 ha. It includes two areas reserved under section 50 of the *Forests Act* - the Wonderland Range Forest Park of 900 ha (west of Halls Gap) and the 360-ha MacKenzie River Special Purposes Reserve (downstream from Lake Wartook). Bryans Swamp (650 ha) at the south of the Victoria valley is a State Game Reserve. The block contains three major water storages - Lake Wartook (1,000 ha), Moora Moora Reservoir (485 ha), and Lake Bellfield (477 ha).

The remainder of the public land is unoccupied Crown land. An area (583 ha) of alienated land within the public land south of Mount Stapylton has recently been purchased by the government for conservation purposes.

2. Climate

On the plains, average rainfall varies from 550 mm in the north to 650 mm in



the south. The high steep ranges intercept and force upwards the moisture-laden south-westerly winds coming off the Southern Ocean. As the clouds rise and cool they lose their water as precipitation, and as a result average annual rainfall on the higher parts of the Grampians exceeds 900 mm. Light snowfalls are common in winter, but the snow melts quickly.

Most rain falls during the period April to September. The ranges receive much more rain than the plains during this period - the difference in summer rainfall is less marked. Due to the haphazard nature of summer storms, summer rainfall is more variable than that of other seasons.

Average annual evaporation is estimated to be 1,100 mm on the plains in the north of the block, and 900--1,000 mm in the Grampians. Evaporation is greatest in January, when values are 150--180 mm, and least in winter, when values are 24--35 mm per month.

Maximum temperatures in summer average 26--29°C on the plains and 25--26° in the Grampians. Summer minima average 12--14° on the plains, and 10° in the Grampians. In winter average maxima are 10--14° on the plains and less than 10° in the Grampians, while minima average 3--4° on the plains and less than 4° in the Grampians. Maximum temperature exceeds 38° on an average of 6--8 days a year in the north, and on 4--5 days in the south. January is the hottest month and July the coolest.

3. Geology and physiography

The Grampians ranges consist of quartzose sandstone, with some mudstones and siltstones, of Upper Silurian--Lower Devonian age. The sediments have been gently folded. They have been intruded by granitic rocks, which outcrop in the Victoria valley, and at Mafeking, Stony Creek (west of Halls Gap) and Zumsteins. Porphyritic rocks outcrop as dykes near Lake Wartook.

Erosion and faulting have formed the Grampians sediments into five main ranges (see Figure 7). The granitic rocks have been eroded more than the sandstones and form basins - except in the Victoria valley, where they form low rounded hills.

The Mount William and Serra Ranges have been moulded by erosion into cuestas - they consist of a line of steep cliffs facing east, with a gentle slope facing west. The Victoria and Mount Difficult Ranges are bounded by steep cliffs on all sides. Topography throughout the ranges is very rugged and broken, except for the central part of the Mount Difficult Range, which is a shallow basin holding Lake Wartook.

Mount William (1,167 m) is the highest peak in the Grampians. The Major Mitchell Plateau, just to the south,

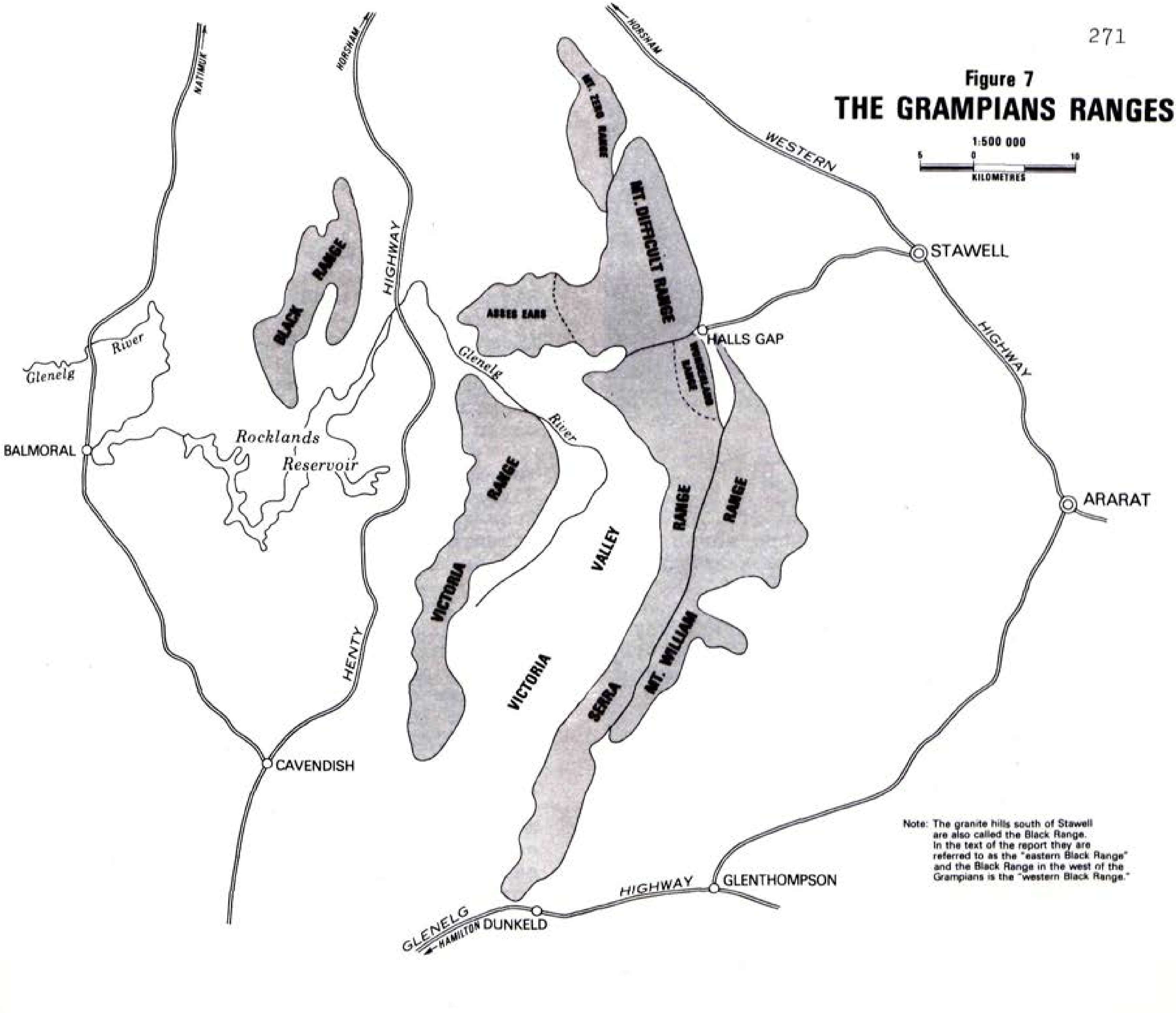


Figure 7
THE GRAMPIANS RANGES

Note: The granite hills south of Stawell are also called the Black Range. In the text of the report they are referred to as the "eastern Black Range" and the Black Range in the west of the Grampians is the "western Black Range."

Victoria Range

lies at a general elevation of 1,000--1,140 m. Mount Rosea, in the north of the Serra Range, and Mount Thackeray, in the Victoria Range, reach 960 m.

The elevation of the ranges falls away to the north and south from this central high area. Mount Difficult is 750 m, Mount Stapylton 530 m, and Mount Zero 375 m. To the south, peaks in the Victoria Range south of the Chimney Pots lie at about 800 m, and in the south of the Serra Range Mount Abrupt lies at 825 m and Mount Sturgeon at 450 m. The granite hills in the Victoria valley have elevations of 450--600 m.

The Grampians ranges and the rocky hills in the Victoria valley are surrounded by steep to gently sloping scree and outwash deposits. In the north and to the east, the plains around the ranges consist of alluvial deposits. In the south of the Victoria valley, basalt of the Newer Volcanics and alluvial deposits occur.

Mount William Creek, Fyans Creek, Golton Creek, Burnt Creek, and the MacKenzie River flow northwards from the Grampians to the Wimmera River. The Glenelg River flows out of the Victoria valley in a north-westerly direction, but then swings around to the south-west and eventually flows into the Southern Ocean.

The south-flowing streams are the Wannon River and Dwyers and Little Tea Tree Creeks, which join the Wannon. These streams have indistinct swampy courses in the south of the block.

4. Soils

On the ranges, the main soil types are shallow stony gradational soils, with some areas of leached sands on saddles and the lower slopes. On the outwash slopes leached sands predominate, with some areas of yellow gradational and yellow sodic duplex soils. In the Victoria valley leached sands and calcareous sodic duplex soils predominate. Calcareous sodic duplex soils and yellow-brown calcareous sodic duplex soils are the most widespread soil types on the cleared plains.

5. Vegetation

This block contains diverse vegetation types, and about 1,000 species of vascular plants - reflecting the variability of elevation, aspect, rainfall, and soil type - are found here.

Open forest II (height greater than 20 m) grows where soils of moderate fertility and depth occur and where average annual rainfall exceeds 700 mm. It is found on the eastern fall of the Victoria Range, and around Mafeking, Fyans Creek, Mount Victory, and Wartook Reservoir.

The major tree species, messmate and brown stringybark, dominate the minor species of swamp gum, manna gum, mountain grey gum, and black wattle. There is usually a dense shrubby understorey dominated by prickly moses, narrow-leaf wattle, prickly tea-tree, and spyridium over bracken, sedges, and grasses. Almost all of these forests have been logged for many years, and contain many old branchy trees and areas of regrowth. They have often been burnt by wildfires.

In the most sheltered sites messmate and mountain grey gum form a very tall forest (height sometimes exceeds 30 m). This type occurs in only a few places - the heads of gullies draining the eastern fall of the Victoria Range, along Dairy Creek (near Halls Gap), and on the south-western fall of the Major Mitchell Plateau, where annual average rainfall is about 900 mm. The understorey contains blackwood, tree ferns, and other moisture-loving plants such as hazel pomaderris, clematis, and ferns.

The Grampians contain very large areas of open forest I--shrubby woodland. Brown stringybark is the most common tree species, with some messmate, shining peppermint, swamp gum, manna gum, scent-bark, and long-leaf box. The heathy understorey contains a large number of species. This formation occurs on shallow stony gradational soils and leached sands at the foot of the ranges and on the outwash slopes.

Rocky sites most commonly carry Grampians gum, long-leaf box, and brown stringybark, with Oyster Bay pine and

Eucalypt scrub on a rocky hillside

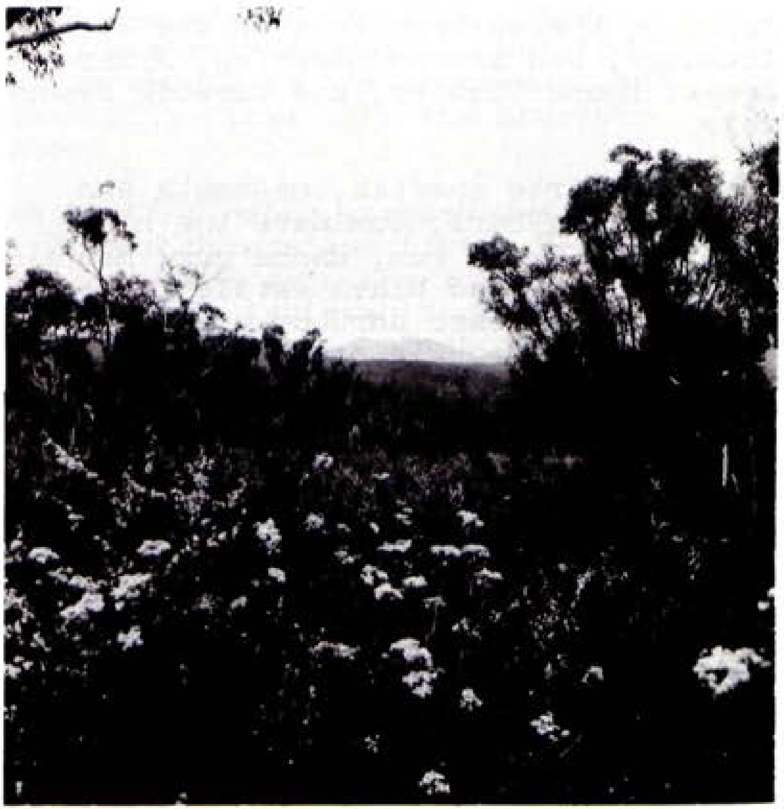
fringe-myrtles conspicuous in the understorey. The deep sands carry brown stringybark as the most common species, sometimes with messmate. The understorey here is a dense community of heathy plants.

On very rocky sites the open scrub becomes more open and lower, and is then classified as low open shrubland. This consists of low shrubs growing in crevices between rocks. The species found in this formation are the same as in open scrub. The vegetation on Mount William and the Major Mitchell Plateau has been placed in this grouping, although it has been referred to in the past as "sub-alpine". It is low and wind-pruned, but lacks a distinctive alpine element, despite snow gum growing over snow grass in a few places in the south of the plateau. A large proportion of the surface area is rock. Gram--ians gum and coast banksia are common dominants.

The most extensive heaths in the study area occur in the Victoria valley along the swampy course of the Glenelg River. They also grow along the lower Wannon, Fyans Creek, and in wet areas on the outwash slopes. The heaths consist of low shrubs with hard small leaves. Low clumps of trees occur in and around them. The heaths are usually rich in species and, although the composition varies from place to place, the genera listed in Table 12 are usually prominent. In this block scrub and dwarf she-oak, prickly tea-tree, silver banksia, and austral grass-tree are often the most common species.

Patches of dense cross-leaf honey-myrtle - closed scrub (2--8 m) - grow among the heaths along watercourses.

Small areas of dry heath occur on the outwash slopes where the soil is too dry for tree growth. The most common spec-



Heathy woodland on outwash slopes

ies here are the shiny tea-tree and Grampians fringe-myrtle.

The vegetation in Bryan Swamp consists of sparse water ribbons and thick mats of water-milfoil. There is some red gum on the northern and western edges.

Pine plantations cover 120 ha on the outwash slopes 7 km north of Halls Gap. The main species is radiata pine, and a small area carries Canary Island pine.

6. Fauna

Grampians block contains a great diversity of habitats, and a correspondingly large number of animal species.

The few small scattered areas of tall open forest (>30 m high) are at the western-most limit of this habitat type in Victoria. Although only about 30 species were recorded in this habitat in recent surveys, it is important for at least five of these (rufous fantail, satin flycatcher, crescent honeyeater, smoky mouse, and Coventry's skink).

The large areas of low open forest (5--20 m high) support at least 55 commonly occurring bird species, 25 mammals, and 20 reptiles/amphibians, although most of these species are found in other formations within the survey area.

Common mammals in this habitat include the red-necked wallaby, grey kangaroo, echidna, heath-rat, and yellow-footed and brown antechinus, with Swainson's antechinus on wetter sites with dense ground cover. The smoky mouse is uncommon in this habitat. Ring-tailed possums live in dense tall shrubs, and feathertail and sugar gliders live in hollows in over-mature and damaged trees. Koalas, released in the Grampians 20 years ago, occupy forest and woodland habitats.

Red deer inhabit the forests of the block, and it is possible that sambar are also present. Very little is known of the herd, but it is thought to be declining.

The heath and low open shrubland communities contain 45 species of birds, 25 mammals, and 12 reptiles and amphibians. The heaths occur mainly in the Victoria valley (wet heaths), with small areas of dry heath on very freely drained outwash deposits. The low open shrubland occurs on Mount William and the Major Mitchell Plateau, and on high rocky slopes.

The fauna of the Victoria valley heaths is of interest to biologists because of its similarities to the vertebrate fauna in Victorian coastal heaths.

The smoky mouse was found to be a common inhabitant of the high-altitude low open shrublands, along with the brown antechinus, Swainson's antechinus, and the swamp rat. Most of the birds in the wet heaths also live in the high-altitude open shrublands.

The extensive rocky habitats found in the Grampians are also important. Notable species in these areas are the brush-tailed rock wallaby and the peregrine falcon. Other species include Australian kestrels, welcome swallows, goats, eastern pigmy possums, some bats, marbled geckos, garden skinks, and black rock skinks.

Aquatic habitats are represented by natural swamps, streams, and man-made storages. Bryan Swamp and Freshwater Lake, both situated in the south of the Victoria valley, were placed in the highest rating for water-bird use in the wetland survey. Bryan Swamp, a shallow fresh-water marsh of 640 ha, holds water for 6--7 months each year on average. Freshwater Lake is 30 ha of permanent open water.

The reservoirs and slow-flowing streams (Green Creek, Glenelg River, Wannon River) in this block support several native fish species, and the platypus, eastern water rat, long-necked tortoise, and amphibians. The fast-flowing streams (MacKenzie River and many short creeks) and channels support different fishes - river blackfish and ornate mountain galaxiids .

B. Present Use and Capabilities

1. Nature conservation

The Grampians are widely recognized as one of the State's most important nature conservation areas. They are managed at present on a multiple-use basis, with nature conservation as one of the major aims. The Grampians are intensively managed, and large areas have been placed into management zones that limit access and human interference to the plants, animals, and land forms.

The ranges have a very high capability for flora conservation. The vegetation is very diverse, in terms of both structural formations and numbers of species. Formations range from tall open forests greater than 30 m high to heaths less than 2 m in height. More than 1,000 species of native plants have been recorded in the Grampians (this would include the Black Range), including 25 endemic species, and three genera and 30 species that are not found elsewhere in Victoria. Appendix 2B lists these and many other isolated records.

The capability of the area for flora conservation is enhanced by its size, and by the absence of grazing throughout most of the block. The high level of protection from wildfires that has been achieved also assists flora conservation.

The great diversity in habitats gives the Grampians a very high capability for fauna conservation. In addition to those that can be described primarily in terms of vegetation, the block also contains large areas of rocky cliff habitats, and a range of aquatic habitats.

The preceding section described the fauna here. Features of particular significance include the only western Victorian colony of the brush-tailed rock wallaby, in the north of the Victoria Range, and the relatively large population of peregrine falcons. Both these species utilize rocky habitats.

The heaths of the Victoria valley are of interest, as they contain the northernmost populations of heath rat and southern emu-wren. A single specimen of the mourning skink, a rare species whose centre of distribution in Victoria appears to be coastal, has been collected from a heathy swamp in the Victoria Range. The large numbers of smoky mice in the low open shrublands of the Major Mitchell Plateau are also significant.

Powerful and barking owls, uncommon species, have recently been recorded in forest habitats. The forests also support the largest western Victorian population of the gang-gang cockatoo and koala.

The block supports large populations of the red-necked wallaby, grey kangaroo, and emu. It is of interest because the eastern and western races of the grey kangaroo overlap here.

The relatively large areas covered by the forests, scrubs, and heaths are important in maintaining viable populations of many western Victorian vertebrate animals. To the west, the public land continues into the Black Range--Dundas block, and the contiguous public land in the two blocks totals 220,000 ha. Thus very large areas are available as wildlife habitat. The retention of large areas as natural or primitive zones in which human alteration of habitat is minimized and the prohibition of shooting throughout the block also enhance the capability for fauna conservation.

Two wetlands in this block - Bryan Swamp and Freshwater Lake, both in the southern Victoria valley - have very high capabilities for water-bird conservation. In addition, dwarf galaxiids, a little-known species with a restricted

The smoky mouse, common in high-altitude open scrub and heaths

A cuesta - Mount Abrupt, Serra Range

distribution, has been recorded in Green Creek (Victoria valley). Another native species, southern pigmy perch, is common in the slow-flowing streams.

The Grampians are the biggest repository of Aboriginal rock art in Victoria. More than 40 sites with painted rock surfaces have been recorded - mainly in the Victoria Range and in the Mount Zero --Mount Stapylton area - and it is likely that more will be found. Rock art sites are comparatively rare in Victoria. The significance of the Grampians sites at present is largely in their potential: very little detailed or systematic research has been done on them, although it may be said that the designs and motifs appear to be simpler than those at art sites in other parts of Australia. There is an urgent need to record the art, as the paintings are disappearing due to fading, flaking, and exfoliation of the rock, and by water flowing over the surface. Excavation of three rock art sites indicates that Aborigines lived there intermittently. The paintings are popular tourist attractions.

Aboriginal mounds, or myrn-yongs, have been recorded near Heifer Swamp, where the Wannon River flows out of the Grampians. Excavation of mounds to the east, near the Hopkins River, and ethnographic evidence, shows that Aborigines probably camped on them, and that they were sometimes used for burials.

The Grampians are a conspicuous feature of landscape over a large area of western Victoria. They rise dramatically from the surrounding flat country, and their high rocky cliffs are visible for many kilometres. The characteristic cuesta shapes of the Mount Difficult and Serra Ranges, and the serrated appearance of the top of the Serra Range, add to the interest of the mountains. The Mount William and Mount Difficult Ranges are readily visible from the Western Highway, and Mount Sturgeon and Mount Abrupt at the southern end of the Serra Range overlook the Glenelg Highway. The Victoria valley, Serra, and Victoria Ranges are viewed from Reid Look-out.

At the local scale, the many areas of rock weathered into a variety of forms and textures, as for example in the Wonderland Range, also have high scenic values.

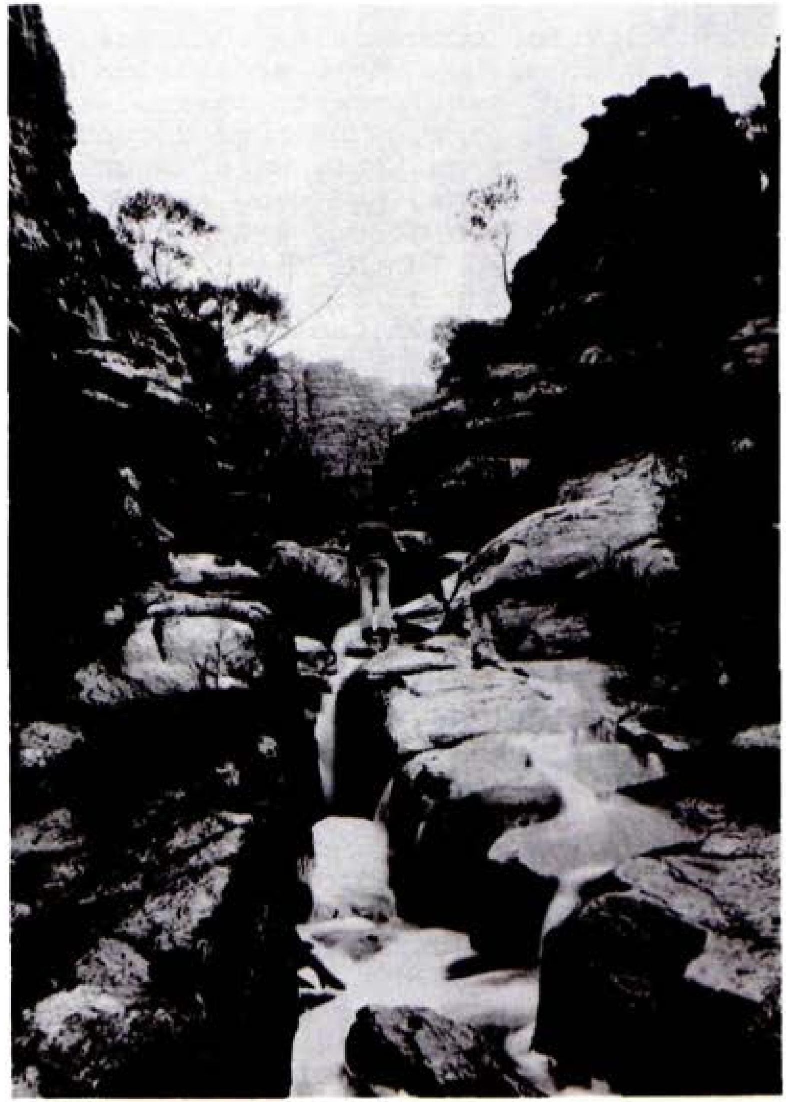
The Grampians have a very high capability for landscape preservation.

The National Trust has recognized the importance of the Grampians by awarding the ranges a Regional Classification. This is granted to areas with a number of "those parts of the physical environment, both natural and man-made, which in the Trust's view are essential to the heritage of Australia and which must be preserved".

2. Recreation

The Grampians receive heavy recreational use. A full account of the results of a recent visitor survey carried out by the Forests Commission is given in the Recreation chapter on page 163. Briefly, it is estimated that 425,000 people visited the Grampians in 1977--78, and that the total number of visitor-days was 930,000. The major activities of visitors were pleasure driving, relaxing, camping, walking on tracks, and picnicking/barbecuing.

The areas around Halls Gap, Boroka Lookout, Wonderland Forest Park, the MacKenzie River Falls, Zumsteins, and Lake Wartook receive most use. These areas are served by sealed tourist roads. A system of gravel roads provides access to the remainder of the Grampians and is used by much smaller numbers of visitors, who are interested in hiking,



Grand Canyon, in the Wonderland Range

climbing, fishing, photography, nature study, or Aboriginal cave art.

Capability for bushwalking and rock climbing is high. These activities have more exacting requirements than pleasure driving or camping. The rugged topography, rock formations, wildflowers, inaccessible areas, and cave art make the Grampians the second most important bushwalking area in the State (after the Alps). The rocky cliffs attract many climbers, and within the State the area is second in popularity only to Mount Arapiles. The diverse and interesting flora and fauna give the area very high capability for nature study.

The Grampians have a very high capability for recreational use.

3. Agriculture

At present the only agricultural use is rough grazing in a few places on the edge of the public land. In general, the capability of the public land in this block for agriculture is low. The ranges are too rocky and steep, while on most of the outwash slopes the soils are deep infertile sands with very low moisture-holding capacities.

The lower slopes of the granite hills in the Victoria valley have low to moderate capability, as the solodic soils have better water-holding capacities. Steep slopes, however, limit the usefulness of this land type. The capability of the flat, swampy land in the Victoria valley varies. The areas carrying red gum or heath have moderate capability, while the sandy soils carrying brown stringybark have low capability.

4. Honey production

Most of the accessible areas of the Grampians are used for honey production. The block contains about 50 permanent bee sites and a similar number of temporary sites. Permanent bee sites are held in the red gum, yellow gum, and yellow box stands in the Victoria valley, at Zumsteins, and at Rose Gap. These areas have a very high capability. Temporary bee sites are located throughout the messmate--brown stringybark forests, which have a moderate capability for honey production and are important in building up the vigour of hives before flows from gum and box are worked.

A stand of yellow box in the Rose Gap area is significant, as it produces a very highly rated honey. Generally, capability for honey production is very high.

Problems for the bee-keeper include lack of water and the removal of valuable nectar-producing trees by timber harvesting.

5. Timber production

Hardwood and softwood timber is harvested from this block. Annual production

Sawmill, driven by steam traction engine, near Fyans Bridge about 1900 of hardwood logs is approximately 4,500 m^3 of mixed species and 480 m^3 of durable species. These volumes are cut from 35,000 ha of mixed-species forests around Lake Wartook, in Fyans Creek and the upper Wannon, and at Mafeking and the eastern fall of the Victoria Range, and from about 10,500 ha of durable species in the Victoria valley, lower Wannon River, and at Zumsteins.

The mixed species have been cut continuously for 100 years, including very heavy cutting to meet the demand for timber for housing after World War II. This has depleted the growing stock and, although regrowth stands have resulted from silvicultural work done in the 1920s and 1930s, more work is needed to regenerate cut-out stands. Current silvicultural operations aim at achieving this. Thus the capability of these forests to supply sawlogs is moderate in the long term, but low in the short term.

Although little resource information is available, the forests of durable species appear to be capable of sustained production at the present level. Their capability is moderate.

The Mount Difficult Plantation, north of Halls Gap, has a gross area of 400 ha and at present contains 106 ha of merchantable stands of radiata pine.

Tree growth here has been very uneven, and has been related to the presence of an impeding layer in the soil. Where this layer is less than 90 cm from the surface it is associated with unsatisfactory growth. The current practice of deep ripping and fertilizing enables satisfactory growth over most of the plantation area.

This plantation and 45 ha of pines at Lake Fyans currently yield 2,250 m^3 of sawlogs per annum.

Surveys have identified several areas capable of growing softwood plantations, including a significant one in the Victoria valley. For environmental and fire protection reasons, however, these areas have not been considered suitable for development. Due to these constraints, the capability for softwood plantations is low.

6. Water production

Most of the surface water resources are harvested and used. The major collecting reservoirs of the Wimmera--Mallee Domestic and Stock Water Supply System - Lake Wartook, Lake Bellfield, and Rocklands Reservoir - impound streams that have their headwaters here (although Rocklands is located in the Dundas--Black Range block). These streams are the MacKenzie River, Fyans Creek, and the Glenelg River respectively.

Catchments in the Grampians block supply water to the following towns situated in and around the ranges: Horsham (Lake

Wartook), Stawell and Ararat (Lake Fyans), Halls Gap (Dairy Creek), Willaura, Glenthompson, Lake Bolac (Stony and Masons Creeks), Dunkeld (Waterfall Gully), and Hamilton (four creeks in the Victoria Range).

This area has great importance for water supply, although in fact the capability of these catchments to yield water is only moderate when compared with that of the mountainous catchments of eastern Victoria. The Grampians catchments are important because they are located on the edge of a vast dry region with a high potential for agricultural production, and water from the Grampians allows this potential to be realized.

There is, however, limited scope for expansion of water supply works. The Wannon River is the only untapped major stream, and even in that case water is diverted from three tributaries of the upper Wannon into Fyans Creek and Lake Bellfield during winter. A scheme to dam the Wannon at Burrah Gap has been proposed, but current evidence indicates that at present it is more economic for farmers in the Wannon valley to develop their private catchment resources than to embark on this scheme.

The Grampians Group sandstones are an excellent source of groundwater. Salinities are always below 100 mg per l. Good-quality water is also available from the outwash scree deposits; bores tapping this source are used to supplement surface water supplies to Willaura, Glenthompson, Wickliffe, Moyston, Dunkeld, and Hamilton. Other good-quality groundwater is available from the Glenelg River alluvial deposits north of Mount Thackeray.

Deep lead gravels running north from the Grampians through Lah-arum contain good quality groundwater. Elsewhere, groundwater quality is low beneath the alluvial plains surrounding the ranges, and the granites that intrude the Grampians Group have demonstrated low yields of poor-quality water.

7. Mineral and stone production

No minerals are taken at present. In the past gold was mined at Mafeking, Stony Creek above Halls Gap, and Wartook. Several shallow shafts were sunk looking for copper near Golton Gorge. Some locally high copper values have been found in rocks along streams associated with the Victoria valley and MacKenzie River granites.

In general, the capability for mineral production is low.

Gravel for road-making has been taken from many pits on the outwash slopes and in the Victoria valley. Most of it is used in roads within the Grampians, although local Shire Councils, especially in the south, also take some material. The Shire of Wimmera works a deposit of buckshot gravel north of Wartook.

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Quarries in the Grampians Group sandstones at Heatherlie and Dunkeld have produced dimension (building) stone that has been used in several important buildings in Melbourne and Stawell. Although these quarries are not being worked at present, it is envisaged that Grampians sandstone will be required in future for repairs and extensions to these buildings. An Extractive Industries Lease is currently held on the Heatherlie quarry.

The capability for stone production is moderate.

8. Utilities

Existing utilities in the Grampians are a radio-telephone repeater station near Mount Zero and an aircraft navigational aid on Mount William. The Forests Commission uses a site 1 km south of Mount William for a radio repeater station, has an airstrip at Forest Lodge in the Victoria valley, and has a fire look-out station at Reid Look-out. The Australian Army uses 30,000 ha of land south-west of Mount Victory for military training.

The Postal and Telecommunications Department proposes to erect a small television translator near the Boroka Look-out to improve television reception in Halls Gap and Bellfield Village. The installation would consist of two antennae on a 6-m wooden pole within a 3 m x 3 m enclosure.

C. Hazards and Conflicts

The Grampians have a low hazard of soil erosion so long as the cover of native vegetation is retained. Soil stability problems are confined to minor gullying along some roads and walking tracks, and occasional instances of soil slumping on the outwash slopes after very wet winters.

Wildfire hazard is high, and fires may occur over much of the year. Lightning is a prominent cause. Most of the vegetation burns readily, and the rugged topography makes early detection and rapid attack essential to control. Look-outs, access roads, radio communications, water storages, firebreaks, aircraft for reconnaissance and fire-bombing, and men and a fleet of fire-fighting vehicles are employed to bring wildfires under control.

A programme of fuel-reduction burning, which aims at reducing fuel levels in strategic zones by the use of low-intensity fires at intervals of 5--7 years, is carried out in heathland and eucalypt scrub and low open forest. This programme undoubtedly affects the animals and plants in the areas burnt - it would be advantageous to some and disadvantageous to others.

The fungal pathogen *Phytophthora cinnamomi* is a serious threat to the vegetation in this block. At present this organism is affecting the native vegetation on approximately 2,500 ha in the Grampians, mostly alongside roads and tracks. Effects vary from rapid death of all susceptible species to chronic chlorosis and fluctuating dieback and partial recovery. The areas most affected to date (and those most susceptible to damage in the future) are the shorter open forests and shrubby woodlands on poorly-drained flat to gently sloping areas with northerly to easterly aspects. Attack by the fungus can be expected to spread depending largely on weather conditions.

Problem animals such as rabbits, foxes, feral cats, and goats are present, but are not major hazards. Rabbit populations within the public land have been kept low, although higher numbers can exist on the fringes. Fox numbers are also low. Poisoning appears to have controlled a group of feral pigs, or pigs run wild, which occupied some public land near Dunkeld in 1973.

Feral goats have been reported from throughout the southern parts of the Grampians. They have often been seen in the south of the Victoria Range. If numbers increase, these animals could be a threat to the native vegetation. Feral cats are found throughout the block, and prey on native mammals and birds.

Weeds do not pose a serious threat at present. There are a few small patches of blackberries north of Halls Gap, and patches of arum lily have occurred in this area, and along the MacKenzie River at Zumsteins. Arum lily is not a proclaimed noxious weed, but is poisonous and readily spreads along creeks.

Recreation use of the Grampians conflicts with wildlife conservation, but careful management can minimize this. Logging as currently practised in the block would have little impact- although removal of old hollow trees would destroy the nesting sites of many birds and mammals.

Tourism conflicts with the preservation of Aboriginal rock art. There has been some interference with the rock art in most of the shelters that are popular with tourists, even those protected by steel mesh screens. More control over tourism to rock art sites may be necessary if the sites are to be preserved.

The extraction of stone and gravel from pits and quarries for road-making often conflicts with landscape conservation. This is a serious conflict in the Grampians, where landscape values are very high. Unsightly pits are located on the edge of tourist roads, and several major quarries are visible for many kilometres. On the other hand, many smaller quarries have been successfully regenerated. In a recent visitor survey in the Grampians, a significant number of respondents said that evidence of gravel extraction had detracted from their enjoyment of the area.

3. DUNDAS--BLACK RANGE

A. Tenure and Nature of the Land

The major areas of public land in this block are the western Black Range and the flat country around Rocklands Reservoir. In addition, scattered pockets occur on the Glenelg River near Balmoral, and on the Dundas Range west of Cavendish. The Dundas Tablelands and the Wannon Valley to the south have almost no public land.

An area of 40 ha near Coleraine is reserved as a racecourse and another of 72 ha on Den Hills Creek is reserved for recreation and public purposes.

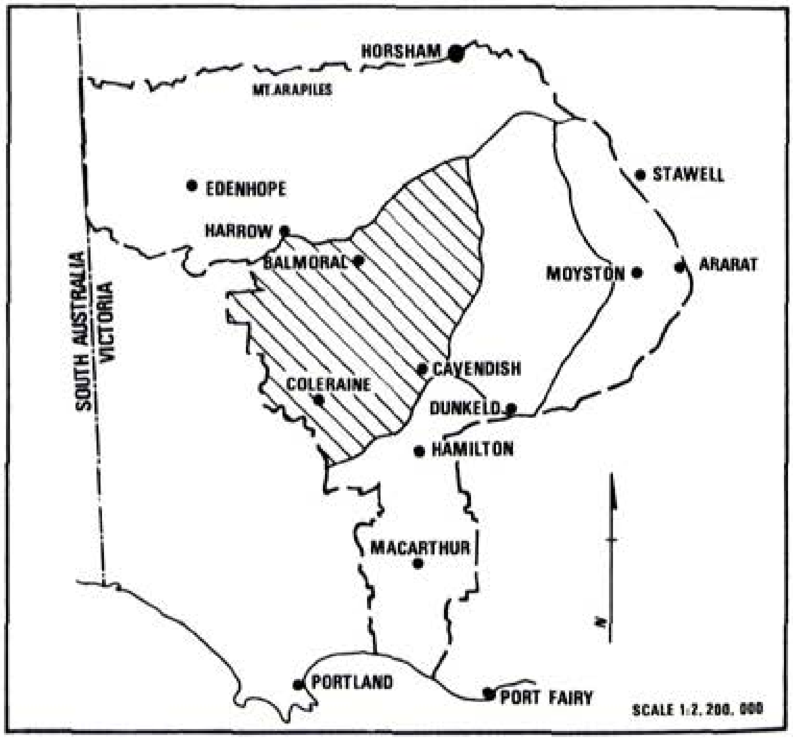
The public land totals 78,600 ha, of which 45,000 ha is reserved forest. Rocklands Reservoir, when full, occupies 6,560 ha. Konong Wootong Reservoir, north of Coleraine, occupies 60 ha.

2. Climate

Average annual rainfall is 650--700 mm over most of this block, and 600 mm in the north. The rainfall pattern is affected by the Dundas Tablelands and the Dundas, Black, and Victoria Ranges. Most of the rain falls during the winter and spring.

Average annual evaporation is around 1,000 mm. Evaporation is highest in January, when values reach 150 mm, and lowest in July (30 mm).

Maximum temperatures average $30^{\circ}C$ in summer and 14° in winter. Minima average 10° in summer and 4° in winter. On



average, the temperature exceeds 38° on 5--6 days each year.

3. Geology and physiography

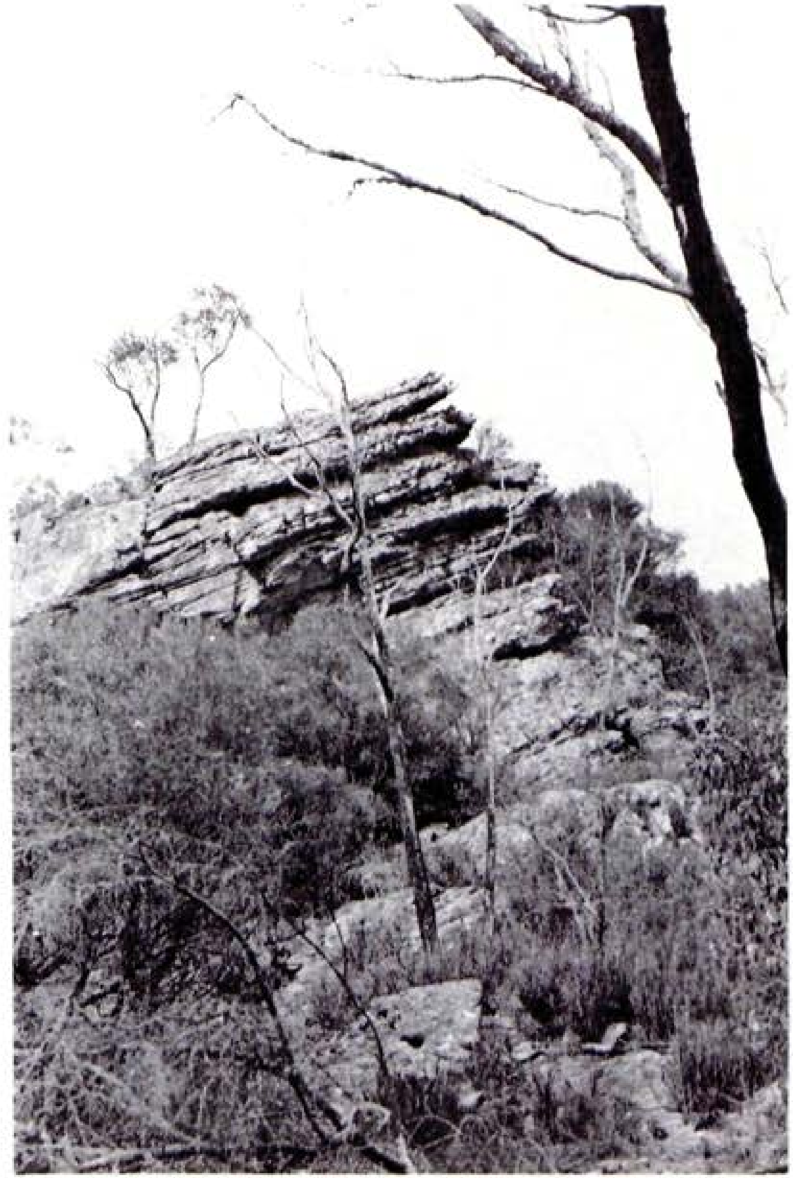
The Dundas Tablelands consist of Palaeozoic and Tertiary rocks capped by laterites of late Tertiary age. The tablelands are deeply dissected by streams, exposing many different types - marine and glacial sediments, trachyte, rhyolite, granodiorite, and metamorphic rocks. The Rocklands Rhyolites, of Silurian age, outcrop extensively over the eastern part of the tablelands.

The softer Lower Cretaceous sediments of the Merino Dissected Tablelands in the south-west have been deeply eroded to a characteristic landscape of rounded hills and ridges.

The Black Range and the Dundas Range are steep-sided outcrops of the Grampians Group quartzose sandstones. They reach elevations of 520 m and 460 m respectively. Mount Bepcha, on the eastern side of Rocklands Reservoir, is a small outcrop of Grampians Group sandstone rising to 340 m elevation.

Cambrian cherts, shales, and greenstone, and Cambro-Ordovician sandstones and mudstones outcrop along the eastern edge of the Grampians Group sediments in the Black Range.

The block drains into the Glenelg River in the north and the Wannon River in the



Grampians Group sandstone outcropping in the north of the Dundas Range south. The Glenelg and Wannon join to the west of the study area.

3. Soils

Shallow stony gradational soils predominate on the Black and Dundas Ranges, with leached sands common on their outwash slopes. Leached sands and weakly differentiated pale sands occur on sand sheets east of the Black Range and on alluvial deposits north of Woohlpooer. Calcareous sodic duplex soils also occur in these areas in locations where the sand sheet is thin.

Mottled duplex soils with ironstone predominate in the areas around Rocklands Reservoir, with yellow sodic duplex soils in the area west of Cherrypool.

Mottled duplex soils with ironstone predominate over the Dundas Tablelands, with yellow sodic duplex soils the most common type in the valleys cut in the tablelands. Grey-brown gradational soils occur along the rivers.

On the dissected tablelands in the south, black cracking clays are the most common soil types, with mottled duplex soils with ironstone on laterite remnants and grey-brown gradational soils along the main drainage lines.

4. Vegetation

Open forest I occupies most of the parcels of public land - on sandy soils in the outwash slopes of the Black Range and Dundas Range, or on windblown sands. Brown stringybark is the most common species, with messmate, manna gum, scent-bark, and swamp gum in wet locations. Very sandy sites, as in the Black Range and the land east of Balmoral, have a heathy understorey with a rich flora. In the Dundas Range bracken is a conspicuous plant in the understorey. The area on the Glenelg River at Kanagulk has more gravelly soils and the understorey consists of austral grass-tree and sparse grasses.

Woodlands are also widespread. The largest single area of woodland in the study area occurs around the Black Range and Rocklands Reservoir, and extends to the eastern boundary of the block. Other extensive stands occur in the public land along the Glenelg River.

Two broad types can be distinguished. The lowest sites, with heavy clay soils, carry red gum, with some yellow gum and yellow box, over low grasses and sedges. Shrubs are usually absent. Slightly higher sites support yellow box, yellow gum, brown stringybark, manna gum, red gum, and drooping she-oak, with a shrubby understorey of varying density.

Open scrub occupies the lower slopes and outwash slopes of the Black Range. The dominant species here are brown stringybark and messmate, with some long-leaf box. Oyster Bay pine is prominent, and the ground flora is heathy.

Heath occurs where the streams draining the western fall of the Victoria Range - Cultivation, Tea Tree, and Scott Creeks - discharge into a large area of flat swampy land that runs into Rocklands Reservoir.

A small remnant of native grassland still occupies the public land west of Nigretta Falls.

There are 700 ha of radiata pine plantations at Billywing in the north-east.

The large old red gums (and manna gums and swamp gums in some areas) retained in farm paddocks are a major feature of the landscape in this block.

5. Fauna

The major habitats found in this block are woodland, open forest, open scrub, and wetland.

The block contains the largest remaining area of the gum--box woodlands that were the dominant vegetation type on the plains of the study area before settlement. These woodlands occur on the public land adjacent to the Black Range and Rocklands Reservoir, and extend eastwards to the foot of the Victoria Range and the Wallaby Rocks. Further areas occur on the Glenelg River downstream from Balmoral.

The account of the species present in this habitat (including some whose populations may be declining) given in the description of the South-west Wimmera Plains block also applies here.

The low open forest and scrub areas of the Black Range and Dundas Range resemble the large areas of these habitats that occur in the Grampians, and as far as is known contain similar wildlife.

Six wetlands in this block were described and evaluated by the wetland survey.

Woodlands of gum and box east of Balmoral

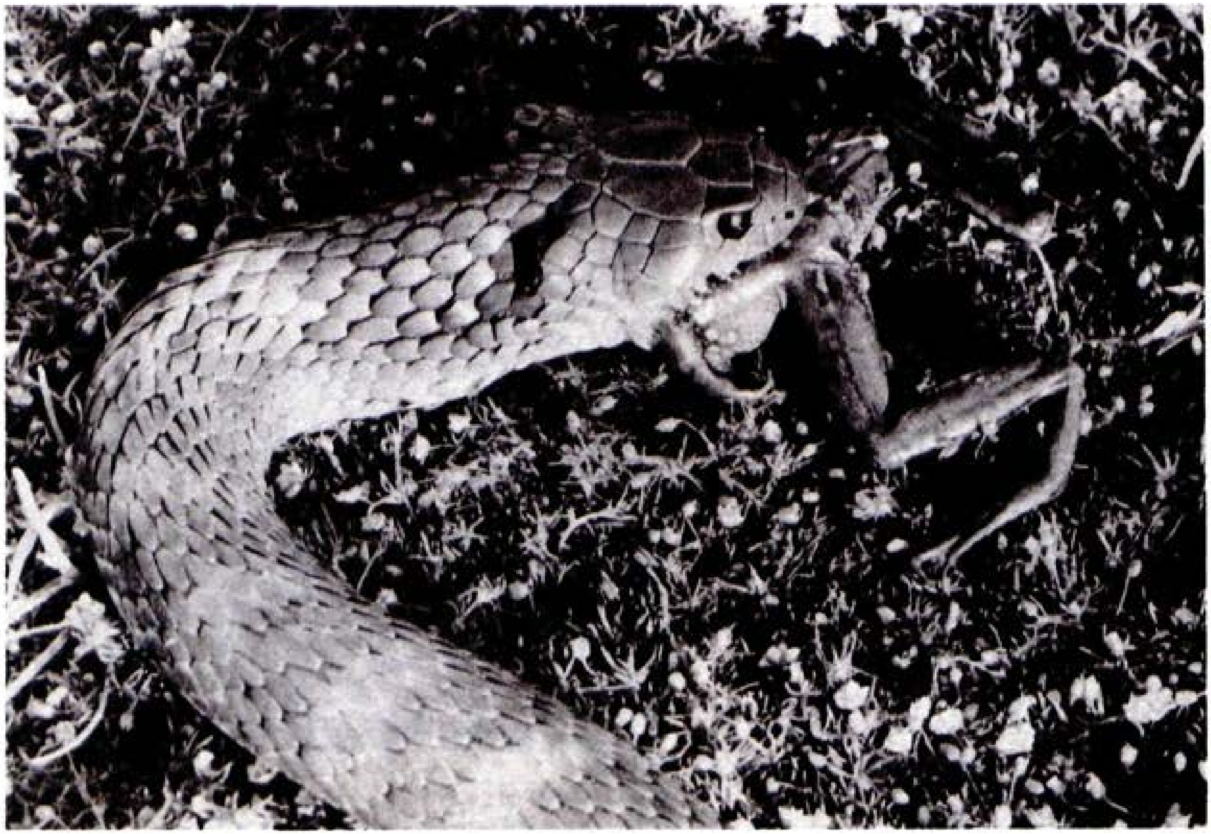
One - Black Swamp, north-west of Balmoral - was placed in the top rating for conservation of wetlands. Rocklands Reservoir was placed in rating 3. Its particular values are areas of shallow water and many dead red gums in the water, which provide nesting sites for sea eagles, darters, and cormorants. It probably provides habitat for mammals such as the *eastern water rat* and reptiles such as the long-necked tortoise. Amphibians occur along its margins.

Rocklands Reservoir contains redfin, brown and rainbow trout, tench, blackfish, and carp. Konong Wootong Reservoir contains abundant brown trout, and carp and tench.

B. Present Uses and Capability

1. Nature conservation

No substantial areas in the block are reserved specifically for nature conser-



Tiger snake and frog

vation, although small areas in the townships of Wannon and Balmoral have been reserved for conservation of flora. Under present management much of the public land in the Black Range and contiguous areas is zoned as "special feature" or "natural", and nature conservation is a major aim of management in these zones.

The Black Range has a high capability for flora conservation. It is similar in character to the Grampians, and has a rich flora.

Pultenaea patellifolia is endemic to this range, although it has been recently found at Mount Arapiles (where it may have been planted). The only Victorian record of *Asterolasia asteriscophora* is also from the Black Range.

Three of the endemic Grampians species occur in this block - *Calytrix sullivanii*, *Lepyrodia flexuosa*, and *Stylidium soboliferum*. It also contains *Pultenaea d'altonii*, whose only other occurrence is in the Little Desert, and the southern-most occurrence of *Santalum acuminatum* (sweet quandong).

Other parts in which large numbers of native species have been recorded are the heaths along the Henty Highway, and the low open forest and woodland south of Rocklands and north of Glendinning.

This block contains the largest areas of gum--box woodland remaining in western Victoria. These, to the south and east of the Black Range and Rocklands Reservoir, and along the Glenelg River, have a very high capability for fauna conservation.

The block description for the South-west Wimmera Plains discusses the importance of the woodlands for maintaining a large number of birds and mammals.

The Black Range also contains forest, scrub, and rocky habitats. The link between this block and the Grampians block to the east is very significant for fauna conservation, as it greatly increases the total area and the diversity of the various habitats available. Animal populations are more likely to remain viable if large areas are available.

The valley of the Wannon River between the township of Wannon and Diprose Bridge (50 km upstream) has high nature conservation values. There are several Crown reserves on the river, including those at Wannon and Nigretta Falls, linked by public land frontages.

The river valley contains a rich flora (332 native species have been recorded there), including many uncommon species near Hamilton. It also provides habitats for birds and mammals (more than 140 birds have been recorded there).

The reserve on the western side of the river at Nigretta Falls contains a significant remnant of native grassland, although it is being damaged by grazing.

The reserve at Wannon carries red gum--manna gum woodland containing about 200 plant species. Koala, kangaroo, feathertail glider, sugar glider, echidna, swamp rat, platypus, water rat, and ring-tailed and brush-tailed possum have been recorded in this reserve and along the river nearby.

Black Swamp, north of Balmoral, has high capability for conservation of waterbirds. Similarly, areas of the Glenelg River, where the native vegetation on the banks has not been greatly altered and where deep pools retain water in summer, have a high capability. Rocklands Reservoir has a moderate capability for conservation of birds.

There are at least five known Aboriginal rock art sites in the Black Range (one of these has been excavated). Thus the range, along with the Grampians, is of great archaeological significance.

The Black Range and its surrounding woodlands are of moderate landscape significance.

The Dundas Range has high significance, as it rises steeply from the cleared tablelands and is visible for many kilometres.

The woodlands along the Henty Highway, especially those at Woohlpooer, are a very important part of the immediate landscape viewed from the highway.

2. Recreation

Present recreation use in this block is centred on Rocklands Reservoir, which is used for boating, fishing, camping, picnicking, and duck-shooting. Rocklands is very important to local people, and was placed in the top rating for recreation by the wetland survey.

The Black Range receives light recreational use, as the Grampians nearby - being more spectacular and closer to the main centres of population - attract large numbers of visitors. Access to the Black Range and the adjacent public land is by a sparse system of fairly rough roads and tracks. Access has been built to one of the painted Aboriginal shelters. The area is not popular with bushwalkers, although it is often visited by naturalists from Hamilton and Coleraine.

Recreational use of the Dundas Range is low, although the Coleraine branch of the Victorian Field and Game Association uses the northern end of the range as a shooting ground.

The Balmoral golf course is located on a large area of public land to the east of the town. The public land fronting the Glenelg River receives light use for fishing, picnicking, camping, and duck-shooting.

The Nigretta and Wannon Falls, on the Wannon River downstream from Cavendish, attract local people and tourists using the Glenelg Highway. The reserves adjacent to the falls are used for picnicking and walking, and the reserve at Wannon contains an oval.

A major arboretum is being developed on municipal land south of Coleraine. The area of about 20 ha is known as "The Points". Some 6,000 trees, representing several hundred native species, have been planted there, and planting is continuing. It is also a look-out.

The Nigretta Falls, on the Wannon River, attract tourists

3. Agriculture

At present grazing licences cover about half of the areas of woodland around the Black Range and Rocklands Reservoir, some of the public land on the Glenelg River, and the northern part of the Dundas Range.

The farmlands in this block, especially in the central and northern areas, mainly carry sheep. Beef cattle are also raised on most farms, and small areas are cropped, mainly for oats.

The capability of the Black and Dundas Ranges and their outwash slopes for agricultural development is low, due to steepness, rockiness, and deep infertile sandy soils.

The capability of the land carrying woodland is moderate - that is, it could be developed into pastures similar in productivity to those on the farms in the district. The costs of development, however, are very high in relation to the returns that could be expected. In addition, there is a severe salting hazard associated with clearing this land.

4. Honey production

More than 50 permanent, and a large number of temporary, bee sites cover all the public land in the north-east of the block except the rocky parts of the Black Range. The gum--box woodlands here have a very high capability for honey production, and are the most important area for honey production in western Victoria.

No bee sites are held in the Dundas Range.

5. Timber Production

Logs, sleepers, poles, fence posts, and firewood are cut from the woodlands. Red gum is the most important commercial species and some yellow gum is also taken. Yellow box is reserved from harvesting because of its value for honey production.

Beehives in yellow gum

The large areas of even-aged stands of red gum at Woohlpooer are a feature of this block. The Crown purchased 2,000 ha of land carrying red gum regeneration in 1913. After settling the land in the 1880s, the settlers killed the old trees to encourage grass growth. They fell on hard times, however, and eventually abandoned their farms. Prolific regeneration of red gum followed. Since returning to public ownership the stands have been thinned - in the 1920s, '30s, and '50s. Although they grow slowly compared with mixed-species forests, the red gum stands have a high capability to provide durable timber in the future. At present thinnings in these stands produce fencing material and firewood.

The capability of the brown stringybark stands is low.

Since 1964, 700 ha (gross) of plantations of radiata pine have been established at Billywing, on the north-eastern boundary of the block. This has a potential sustained production of the order of 12,000 m^3 per annum. An annual allocation of 1,270 m^3 of small material for preservative treatment has been made, and by 1983 thinning operations will be producing sawlogs. The Forests Commission does not intend to extend the plantation area at Billywing.

6. Water production

Rocklands Reservoir impounds all the flow of the upper Glenelg River, although flushes of water from the reservoir are sent down the river in summer to maintain the quality of water in pools for stock. The Rocklands catchment includes all the public land in the north-east of this block, except for the northern and western falls of the Black Range. The most productive part of the catchment, however, is in the Grampians, where the high rainfall on the Victoria and Serra Ranges drains into the upper reaches of the Glenelg. While no figures are available, the contribution of the part of the catchment in this block would be much less, as it is smaller and the rainfall is lower.

In the western Victorian context, however, the land has a high capability for water production.

The catchment of the Konong Wootong Reservoir is entirely on cleared private land.

7. Mineral and stone production

No minerals are taken at present. In the past, small quantities of gold were extracted from creeks south of Balmoral, from Mouchong Creek, and around Glenisla and Glendinning. Tin was discovered in Mather Creek near Balmoral, and west of Glendinning. Gemstones (topaz, ruby, garnet, and quartz crystals) have also been found near Glendinning. Opaline quartz outcrops in spurs along Mouchong Creek, and diamonds were alleged to have occurred on spurs west of Mather Creek.

The Cambrian volcanics and sediments and the Cambro-Ordovician sediments on the eastern side of the Black Range have high potential for further discoveries of base metals.

Gravel - used on forest and shire roads - and sand are taken from many shallow pits on public land. A large area of public land east of Balmoral has had gravel stripped from it.

The area has a moderate capability for further production of gravel and sand.

Hardrock quarries with crushing plants operate on private land at Coleraine and on the Wannon River north-west of Hamilton.

8. Utilities

Fire look-out cabins are located on Mount Bepcha and Mount Dundas.

The Postal and Telecommunications Department plans to build a T.V. transmitter on Mount Dundas to improve television reception in the Hamilton--Casterton--Coleraine area. A 158-m-high mast will be erected, and a one- or two-storey building constructed near the base of the mast, subject to environmental constraints to preserve the high landscape values of the Range.

The Rocklands--Cherrypool track, which passes around the southern end of the Black Range, is being upgraded to two-wheel-drive all-weather standard for tourist use.

C. Hazards and Conflicts

The public land has not suffered from erosion because it retains its cover of native vegetation. If the woodlands were cleared, however, there would be a moderate hazard of gullying and sheet erosion in the creek valleys.

A severe salting hazard arises if the woodlands on Palaeozoic sediments and volcanics are cleared. The groundwater in these rocks is highly saline. Clearing on private land has shown that removing the deep-rooted native vegetation and replacing it with shallow-rooted pasture species has caused more saline water to flow from the groundwater into streams. The vegetation along the streams is then killed, and this land becomes susceptible to erosion. Increased volumes of saline water moving from cleared areas into Rocklands has raised the salinity of water in the Reservoir.

Although the woodland areas around Rocklands are capable of growing fair-quality pastures, current evidence indicates that clearing these woodlands would lead to stream salting and substantially increase the quantity of salt moving into Rocklands Reservoir.

The open forest and scrub areas have a moderate to high wildfire hazard, while that of the woodlands is lower. Fires can occur over much of the year, with lightning as a major cause.

Eucalypt die-back associated with the fungus *Phytophthora cinnamomi* has been found along tracks in the Black Range, and along the foot of the western scarp of the Victoria Range. The vegetation types affected are open forest I--shrubby woodland, open scrub, and heath. There is a high hazard of *P. cinnamomi* spreading along these vegetation types growing on flat to gently sloping sites. The disease has not caused die-back in the gum woodlands.

Pest animals constitute a low hazard in this block. Small populations of rabbits are present, especially on the fringes of the public land, and regular control work is carried out. Similarly, weeds do not constitute a serious hazard at present.

Grazing sheep in and around the Black Range conflicts severely with flora conservation. There is evidence to suggest that grazing reduces both the number of species and the number of plants present.

The conflicts between recreation and wildlife conservation and preservation of Aboriginal rock art (which were described for the Grampians) also occur here, although they are less intense because smaller numbers of people visit the Black Range.

4. MIDLANDS

A. Tenure and Nature of the Land

1. Present tenure

Public land in Midlands block is widely scattered. It includes lakes and areas of forest and woodland on the plains and hills on the eastern boundary of the study area. It covers a total of 13,700 ha, including 3,000 ha of reserved forest. McDonald Park (60 ha) at Ararat is reserved under section 50 of the *Forests Act* as a special purposes reserve. Lake Lonsdale (1,320 ha) and Lake Fyans (526 ha) are water storages in the Wimmera--Mallee Stock and Domestic Water Supply System.

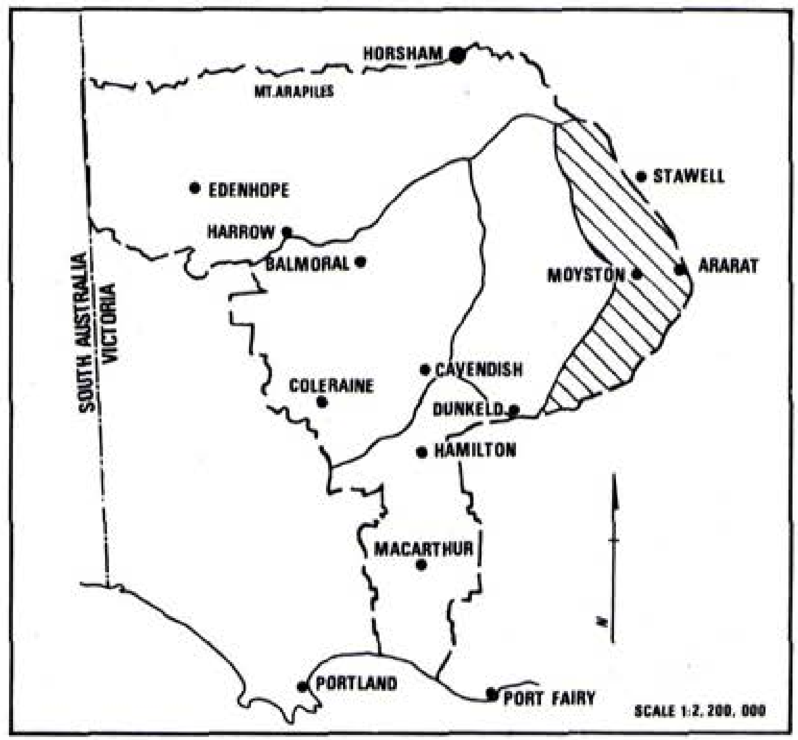
2. Climate

The block lies in a rain-shadow area in the lee of the Grampians ranges. Average annual rainfall varies from 650 mm on the outwash slopes of the Grampians in the west to 550--600 mm elsewhere. It increases east of Ararat due to the effect of Mounts Langi Ghiran, Cole, and Lonarch. Most rain falls in winter and spring.

Average annual maximum temperature is 30°C in summer and 13--14° in winter. Average minima are 10° in summer and 4° in winter. Temperatures of 38° or more occur on an average of 5 days a year.

3. Geology and physiography

Cambrian chert, shale, and greenstones outcrop in a series of low hills stret-



ching in a line from Willaura to Lake Lonsdale. Mount Dryden, west of Lake Lonsdale, is the largest outcrop, and reaches 382 m in elevation. Cambro-Ordovician sediments - sandstones and thinly bedded shales - occur in the eastern half of the block as rolling hills and plains. Immediately east of Ararat a long ridge of these sediments aligned NNW--SSE rises steeply to an elevation of 579 m at One Tree Hill, and in the south Mount Moornambool rises steeply to 522 m.

The Cambro-Ordovician sediments have been intruded and metamorphosed by granites and granodiorites of Devonian age. Granite forms the Black Range south of Stawell (maximum elevation 290 m), and granodiorite and associated metamorphic rocks form a ridge south-west of Ararat, which reaches 618 m at Mount Ararat.

Over the remainder of the block Tertiary marine and non-marine sands and gravels, basalt of the Newer Volcanics, and Quaternary alluvial deposits form rolling plains.

Most of the block drains to the north, via tributaries of the Mount William Creek. The Hopkins River drains the south-east, while the south-west drains into Lake Muirhead and Mount William Swamp.

The streams are intermittent, with the exception of the Hopkins River and Mount William Creek.

4. Soils

On the rolling plains, the main soil types are yellow-brown calcareous sodic duplex soils and calcareous sodic duplex soils. The hills and ridges in the east carry shallow stony gradational soils or red duplex soils on the upper slopes and yellow sodic duplex soils on lower slopes.

5. Vegetation

Open forest I occurs in the public land north-west of Ararat, in mixture with woodland. The dominant species in the forest are messmate, red stringybark, and long-leaf box. An open shrub layer contains golden wattle and hedge acacia, over low heathy plants and tussock grass. Some areas of messmate and red stringybark on the top of the One Tree Hill ridge have never been logged and contain very large old trees.

The flatter areas along the Western Highway, and near Norval, carry a shrubby woodland of yellow gum, with red stringybark, long-leaf box, and some yellow box. Red gum occurs in gully bottoms. The shrub layer contains golden wattle, hedge acacia, tea-trees, silver banksia, and sparse heathy plants and grasses.

The public land north of Lake Lonsdale carries a very open woodland of yellow gum and yellow box, with some long-leaf box, over sedges and low grasses. The

Ledcourt forest carries fine tall stands of red gum, with some areas of box. The Illawarra forest carries lower woodland of yellow gum, with areas of grey and

Roadside vegetation near Mafeking

long-leaf box. The public land at Jallukar is similar. That west of Moyston carries low shrubby woodland of red gum, yellow gum, scent-bark, and some drooping she-oak. Golden wattle and daphne heath are prominent in the understorey.

Peppermint and scent-bark form woodlands with a heathy understorey on the higher parts east and north-east of Halls Gap. Red gum occupies the lowest sites, with some scent-bark and yellow box.

Of the wetlands, Lake Lonsdale is fringed with red gum while Lake Fyans is surrounded by yellow box--red gum woodland. The aquatic vegetation varies considerably - cane grass in Lake Muirhead and Mount William Swamp, water milfoil in Lake Buninjon, and sedges and rushes in the Green Swamp.

Forest in the Ararat hills

On the northern edge of Lake Fyans, 45 ha of radiata pine plantations have been established.

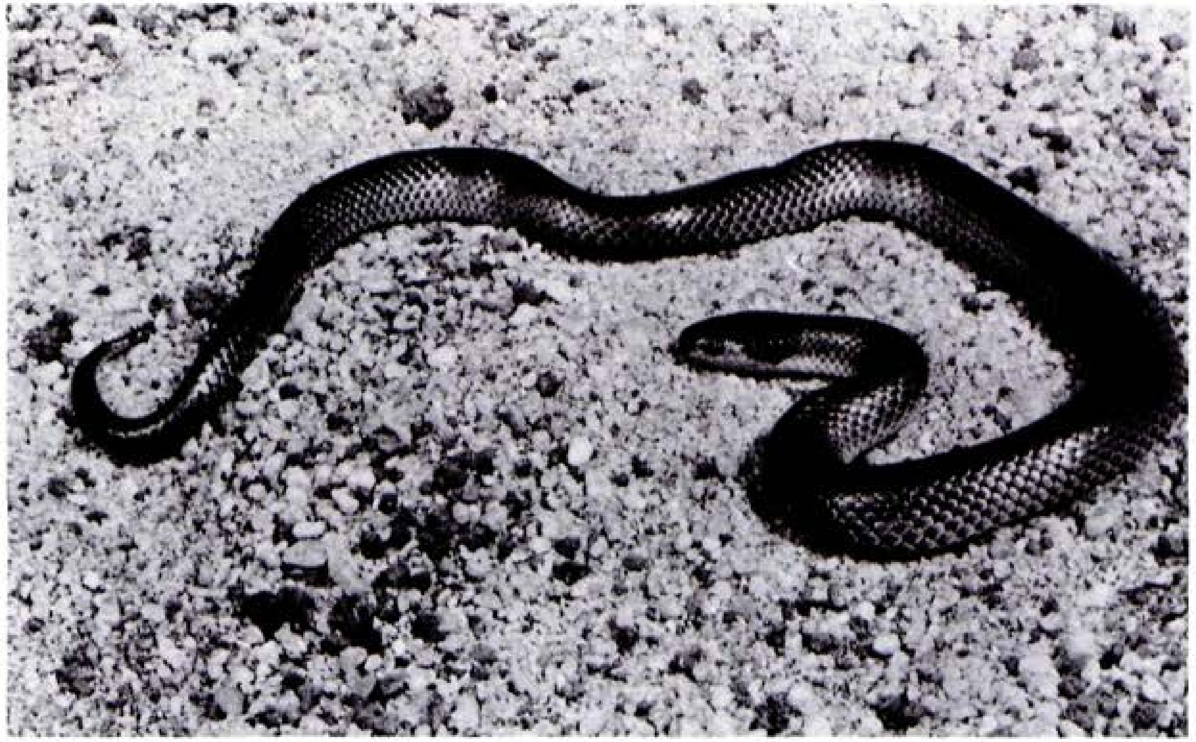
6. Fauna

Woodland habitats occur around Lake Lonsdale, Illawarra, Mokepilly, and Jallukar. Similar habitats once existed on large areas around the Grampians, but have been cleared for agriculture. These woodlands contain most of the approximately 100 species of vertebrate animals that have been recorded in this habitat in the study area.

The woodlands of yellow box, long-leaf box, and yellow gum at Jallukar also contain some birds (such as speckled warbler, fuscous honeyeater, and yellow-tufted honeyeater) that mainly inhabit the box--ironbark forests to the east (in the North Central study area). The populations of these species are higher in Jallukar than in other public land in this study area.

The squirrel glider, which is uncommon in Victoria, has been recorded near Stawell and Dadswells Bridge. The last recording was in 1970. The tree goanna has been recorded in the woodlands at Illawarra.

The low open forests and woodlands that originally covered the eastern part of



Little whip snake

the block are now restricted to public land west of Ararat. While similar habitats exist in other parts of the study area, more detailed survey may show that the differences in floristics here are reflected in the composition of the fauna. Most of the wildlife species in this block occur in the other areas of open forest in the study area.

Wetland habitats consist of Lakes Lonsdale and Fyans, which are storages, Lakes Muirhead and Buninjon, Mount William Swamp (or the Big Swamp), and some smaller areas in the south of the block. The wetland survey placed two of these areas - Lake Muirhead and the Green Swamp (north-west of Glenthompson) - into the top rating as water-bird habitat. Lake Muirhead consists of 330 ha of public land and 280 ha of private property, and is a permanent brackish wetland. The Green Swamp, a shallow freshwater marsh, contains 81 ha of public and 20 ha of private land. Lake Lonsdale is now emptied early in the summer.

Some of the reservoirs still have many dead trees standing around their margins. These trees are important roosting and nesting structures for some parrots and cockatoos (for example, musk lorikeets, sulphur-crested cockatoos, long-billed corellas, galahs, and eastern rosellas) and some birds of prey. This is a temporary situation, however, and once the trees decay and fall they will not be replaced. Platypus, eastern

Black duck and ducklings

water-rats, long-necked tortoises, and several species of amphibians probably live in some of the permanent waters in the region.

B. Present Uses and Capabilities

1. Nature conservation

McDonald Park (60 ha), near Ararat, was reserved for conservation of wildflowers in the 1930s. Recent surveys have recorded 209 species of native plants, and the area also contains planted non-local native species. The remainder of the public land near Ararat has moderate capability for nature conservation, as it contains vegetation types that are uncommon in this area (mainly because of widespread clearing for agriculture). The very large old messmate trees on the top of the One Tree Hill ridge are of particular interest. Little of this public land is licensed for grazing.

The few large parcels of public land scattered through the block also have a moderate capability because they are the only remaining areas of native vegetation in a predominantly agricultural region. Most of these parcels are grazed, however, with the exception of the two near Mokepilly. Surveys have recorded 158 species of native plants in the area between Mokepilly and Halls Gap.

The capability for fauna conservation is also moderate, as the habitats on most of the public land consist of open or scrubby woodlands, which support a rich fauna. The recordings of the squirrel glider near Stawell and at Dadswells Bridge are significant, as is the one of the tree goanna in the Illawarra area.

Lake Muirhead and the Green Swamp, in the south of the block, have a high capability for the conservation of waterbirds. Brolgas and the rare freckled duck are often seen on Lake Muirhead.

Bunjil's Cave is located on a small area of public land 8 km south of Stawell. This small shallow cave, in the side of a granite boulder, contains an Aboriginal painting of Bunjil, the "Great Man" or "creator" of the Aborigines, and his two dogs. Bunjil is pictured as a fat man sitting on his haunches. The painting is very clear, and is protected by a wire screen. It is a significant relic of the Aboriginal occupation.

The One Tree Hill ridge to the west of the town of Ararat is an important landscape feature, as it forms the backdrop to the town. Public land carrying native vegetation lies adjacent to the Western Highway at Ararat and between Deep Lead and Dadswells Bridge, and provides diversity in the immediate landscape viewed from the Highway.

2. Recreation

Most recreational activity occurs around the lakes. Lakes Lonsdale, Fyans, and

Buninjon (near Willaura) are used for boating, swimming, fishing, camping, and picnicking and have a high capability for recreation. Lake Lonsdale has limited usefulness, as it is emptied early in the summer to prevent excessive water losses through evaporation. All the lakes are shot over by duck-hunters, and Lake Muirhead is especially popular.

McDonald Park, near Ararat, is used for picnicking and nature study by local people and has a moderate capability for these uses. The Pioneer Memorial Lookout at One Tree Hill offers spectacular views of the Grampians to the west and Mount Langi Ghiran and Mount Cole to the east.

The rest of the public land receives little use, due to its lack of special features and the proximity of the Grampians.

3. Agriculture

At present about half of the public land is held under annual grazing licence (see Map 9).

The areas in the eastern Black Range (south of Stawell) are steep and rocky, and have a low capability for development for agriculture. Similarly, the steeply sloping parts of the public land at Ararat have low capability. The land at Illawarra, west of Stawell, has difficult duplex soils, and has low to moderate capability.

The remaining areas of public land, excluding land in lakes and swamps, have a moderate capability. This means that technically the land can be cleared and sown to improved pastures of a similar standard to those commonly found on farms in this block. Such development, however, is likely to be uneconomic at present because of the high costs of development and the relatively low returns that can be expected.

4. Apiculture

At present there are 19 permanent and temporary bee sites in this block, covering almost all the public land. As this indicates, the widespread occurrence of red gum, yellow gum, and yellow box gives the area a high capability for honey production.

5. Timber production

Current production from these areas is low. Small quantities of red gum and yellow gum logs are cut in the Ledcourt and Illawarra forests by a mill at Stawell. Small volumes of farm timbers - posts, poles, and rails - and firewood are cut from the other areas of public land.

The best timber stands are in the Illawarra and Ledcourt forests, although growth rates are low. Capability here for production of durable species is moderate, and higher at Ledcourt than at Illawarra. Capability elsewhere is low.

The 45-ha softwood plantation at Lake Fyans is managed and harvested in conjunction with the Mount Difficult plantation. About half the stand has been clear-felled and replanted. The block has a low capability for expansion of softwood plantations.

6. Water production

The block contains two storages - Lake Fyans and Lake Lonsdale - which are part of the Wimmera--Mallee Domestic and Stock Water SupplyScheme. Lake Fyans also supplies part of Stawell and Ararat's water requirements. The main function of these storages is to hold water that flows in through channels from Lake Bellfield, although Lake Lonsdale stores water from Mount William (Mokepilly) Creek, which rises in the Grampians.

The other streams dry up in summer. The block as a whole has a low capability for water production, although it is important for the storage and distribution of water coming from the Grampians.

The alluvium of the Mount William Creek valley contains good-quality groundwater. Elsewhere its quality is low.

7. Mineral and stone production

No minerals are extracted here at present. Clay is taken from pits (on private land) at Glenthompson and Ararat for brick-making, and the C.R.B. operates a large quarry and crushing plant (on private property) near Stawell. Shallow gravel-stripping has been carried out on public land at Lake Lonsdale, Mokepilly, Jallukar, and west of Moyston. Very large areas have been stripped on the public land west of Moyston.

The block contains part of the large Stawell and Ararat (including Great Western) gold-fields, and smaller fields at Moyston and Rhymney Reef. The Stawell and Ararat fields include substantial areas of public land.

In the section stretching from Glenorchy to Maroona, three areas are held under exploration licence, and another three have been applied for. Interest is concentrated on the Cambro-Ordovician sediments.

Prospecting by individuals and small companies continues to take place on the gold-fields. One gold lease is current and covers 77 ha south of Ararat, including some public land.

The areas on or near the Palaeozoic rocks have a moderate potential for the discovery of minerals. The block has a low to moderate capability for further gravel production.

8. Utilities

At present a radio-telephone repeater station, and C.F.A., S.E.C., and Shire of Ararat radio masts are located on the

One Tree Hill ridge west of Ararat. No plans to use other public land as sites for utilities are known.

C. Hazards and Conflicts

A moderate to high erosion hazard exists on the cleared land on rolling or hilly topography, and salting is occurring on the granitic country near Moyston. The public land has suffered little erosion because it retains its cover of native vegetation. Erosion problems and salting on the lower slopes could be expected if undulating to hilly land is cleared. The hazard is low for the flat public land.

The wildfire hazard is high in the forests and scrubby woodlands, and lower in the grassy woodlands. In general, however, it is moderate compared with the high hazard in the Grampians.

Small populations of rabbits and foxes live in the public land, especially near the boundaries with farmland. Regular control work is carried out, and the hazard is low. The hazard of weeds is also low.

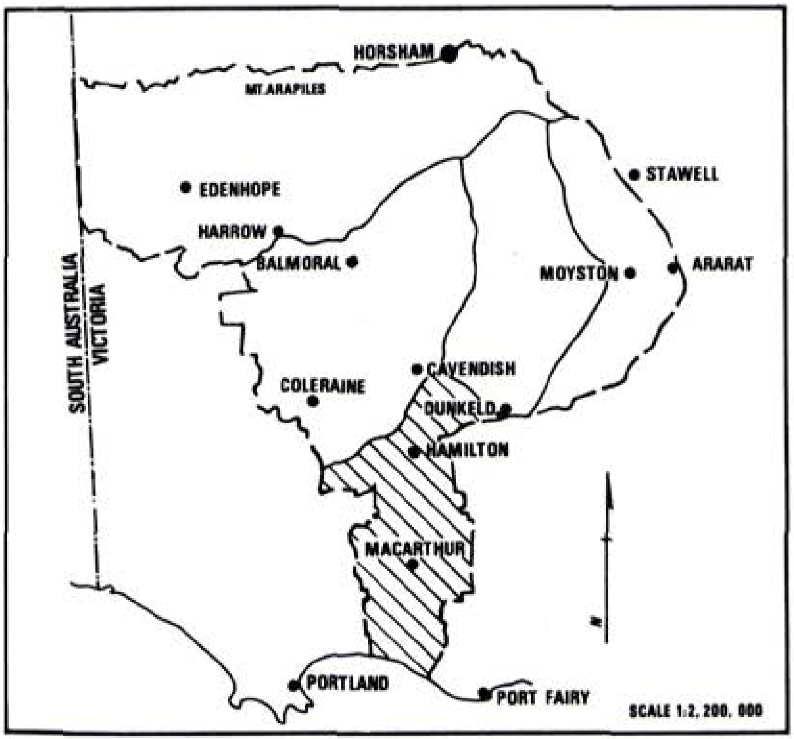
As discussed in other blocks, conflicts arise between grazing and flora conservation, and between tourism and preservation of Aboriginal rock paintings.

5. EUMERALLA

A. Tenure and Nature of the Land

1. Present tenure

The lava flows of Mounts Napier and Eccles make up most of the public land in this block. That at Mount Napier comprises 140 ha of Crown reserve, 620 ha of reserved forest, and 2,100 ha of unoccupied Crown land. On the Mount Eccles lava plain, "The Stones" wildlife reserve occupies 5,240 ha, and the Mount Eccles National Park occupies 400 ha. The Department of Agriculture's Pastoral Research Institute occupies 1,215 ha of public land south of Hamilton.



Three areas of public land lie across the boundary between Districts 1 and 2 of the South-western study area. They are Lake Condah and two areas between Lake Condah and the coast. Recommendations on the future use of these areas were made in the Final Recommendations for District 1 in April 1973, and have been accepted by the government. Lake Condah is now a wildlife reserve, and the two areas to the south are recommended to be reserved forest. These areas are not considered further here.

Public land in the block totals 10,600 ha.

2. Climate

Average annual rainfall declines from 800 mm on the coast to 650 mm north of Hamilton. The gradation is even, as the block is an area of low relief. Most rain falls during winter and spring, and January is the driest month.

Average annual evaporation is 750--1,000 mm. Evaporation is highest in January (110--150 mm). Values in winter are 40 mm per month.

The ocean exerts a moderating influence on temperatures. Average maxima in summer are 25--26°C at Macarthur and up to 30° in the north, but only 20--22° on the coast. Summer minima average 12--13° on the coast and 11--12° inland. In winter maxima are 12--14° along the coast and 10--12° inland, with minima of 6° and less than 4° respectively. Temperatures of 38° or more may occur from November to March - usually on 1--2 days a year on the coast and up to 6 days in the north.

3. Geology and physiography

Most of this block is covered by the basaltic rocks of the Newer Volcanics. Two phases of volcanic activity are apparent. The earlier flows (Plio-Pleistocene - 1.5--4 million years ago) have been deeply weathered and form a landscape of undulating plains. These rocks outcrop from the southern tip of the Grampians almost to the coast. Stream dissection of these basalts has exposed Tertiary limestones and marls of the Heytesbury Group.

Younger volcanic rocks (6--7,000 years old) occur at Mount Napier and Mount Eccles, and part of a slightly older flow that issued from Mount Rouse passes through the eastern part of the block.

Mount Napier (440 m elevation) is a scoria cone, surrounded by a plateau of broken and fractured lava (stony rises country). In total, 28 eruption points have been located on the lava plateau. Lava flowed down Harman Valley, Scott Creek, and Weerangourt Creek - the lower reaches of these flows now disappear beneath the peaty deposits of the Condah Swamp. No surface streams remain in these valleys and drainage takes place under the basalt.

The Harman Valley flow contains a number of interesting volcanic features - caves, barriers, and tumuli.

The Byaduk Caves, on the western edge of the public land, consist of 12 lava caves. These are thought to have been formed when the surface crust of the lava solidified but the still-liquid interior flowed out, leaving a cavern. In many places the roofs of the caverns have collapsed, leaving long sinuous and deep-sided depressions in the lava.

The Great Barrier, to the east of the caves, is a ridge lying across the direction of flow of the lava. It extends for 150 m, and projects about 6 m above the flow. Behind it is a trough 14 m deep. Smaller twin barriers longitudinal to the Harman Valley stand 3--6 m high and 17--18 m apart.

Tumuli are lumps in the lava sheet where localized pressure from underlying liquid lava has forced up the solidifying lava skin without rupturing it. They are downstream from the caves, on private property. These features have been confused with lava blisters, which are formed on the surface by steam generated when the flow passes through water in a stream or swamp.

Mount Eccles - a low scoria mound - reaches an elevation of 179 m. Lake Surprise, which lies immediately to the north-west, appears to consist of three coalescing craters surrounded by layered basalt walls 30 m high. A canal leads from the northern end of the lake, turns to the south-west, and divides. A smaller canal leads from a small hill to the south of the lake. These canals were the main conduits for the large quantities of lava that formed the 12,000-ha lava plain to the south and west of Mount Eccles; it also flowed down the Darlot Creek valley for 30 km to the coast and extends for a further 16 km into Portland Bay. The Tunnel Cave in the northern canal and the Gothic Cave in the southern canal are of geological interest.

The flooded crater at Mount Eccles (Lake Surprise) is aligned with a number of small spatter cones and scoria cones stretching away to the south-east. These are on private land. Two of the cones, known as the Shaft and the Pit, have open vents. The Shaft is about 3 m

Lake Surprise

wide and 30 m deep. These caves are of very great geological interest.

Tertiary limestones of the Heytesbury Group outcrop on the coastal plains in the south of the block, although they are covered in part by Quaternary sands and alluvial deposits. A thin line of calcareous sand dunes, backed by a narrow strip of dune limestone, runs along the coast.

4. Soils

Red-brown shallow stony gradational soils occur on the stony rises with peaty soils where the basalts have dammed streams. Mottled duplex soils with ironstone are widespread on the earlier basalts, with some areas of red duplex at Branxholme.

Manna gum woodland, with Mount Napier in the background

Yellow gradational soils are common on the coastal plains, although many other types, notably leached sands and grey clays, occur there.

Weakly differentiated pale sands are found on the coastal sands, and red and black gradational soils on limestone occur on the indurated limestone dunes behind the coast.

5. Vegetation

Tall woodland (about 20 m high) of manna gum occupies the stony rises associated with Mount Eccles and Mount Napier, and is the most widespread formation in the block. Blackwood is the only other tree species present, and tree everlasting and tree violet occur sparsely as shrubs.

The ground cover is dense bracken over grasses and small herbaceous plants. This is all that remains in some places (mainly at Mount Napier), where repeated firing has removed the trees. Swamp gum occur to the south of Mount Napier on soils derived from an earlier basalt flow.

Twenty species of ferns, and many mosses, have been recorded at the Byaduk Caves.

The small area of public land on the coast carries dry coastal scrub of coast beard-heath, saw sedge, and marram grass.

The small areas of public land near Hamilton carry grassland and pine plantations, with some remnants of the original swamp gum woodland.

The Pasture Research Institute south of Hamilton carries improved pasture.

6. Fauna

The major habitats on the public land are the manna gum forests and woodlands growing on stony rises country. "The Stones", south-west from Macarthur, supports a large number of bird species, most of which occur in other forest habitats. The mammal fauna, however, is distinctive, as the ground fauna includes the tiger cat, brown antechinus, Swainson's antechinus, eastern grey kangaroo, and the bush rat. The arboreal fauna is believed to include the koala, yellow-bellied glider, brush-tailed possum, sugar glider, and feathertail glider. "The Stones" also supports a large reptile population.

The vegetation of the Mount Napier area appears to have been modified, mainly by fire, to a greater extent than that in "The Stones", and it may not support all of the species recorded there.

A large amount of sub-fossil bone material has been taken from the Byaduk Caves - presumably deposited there by predators. The deposits have been formed since the last eruption of Mount Napier, about 7,300 years ago. From these, 25 species of mammals have been identified, six of which are no longer found in Victoria.

Recent surveys in the Mount Napier area have recorded 10 species of native mammals. Relatively large numbers of dusky phascogale and bush rat have been recorded. It is possible that more species may be found there.

Bent-wing bats occupy the Byaduk Caves. Although it appears that only small numbers use the caves now, the big deposits of guano in some of them show that large numbers of bats have used them in the past.

Local field naturalists have recorded about 100 species of birds at Mount Napier, although the list is not complete.

Three wetlands were surveyed in this block: none were placed in the top rating for water-bird conservation.

The Eumeralla River flows through pasture land and has both a mud and a gravel bottom. Its upper reaches have been modified into a steep-sided deep channel by river improvement works. It contains brown trout, eels, tench, crucian carp, tupong, and blackfish. The Shaw River carries a small population of brown trout. Lake Yambuk, which is formed by the joining of the Eumeralla and Shaw Rivers, is surrounded by sand dunes and has a sand and mud bottom. Species of fish that are commonly caught include bream, mullet, salmon, and estuary perch. Brown trout, which enter the lake from the Eumeralla and Shaw Rivers, are sometimes taken.

B. Present Uses and Capability

1. Nature conservation

Almost all the public land associated with the Mount Eccles lava plain is reserved for nature conservation. Mount Eccles National Park, of 400 ha, is in the north-east and includes Mount Eccles and Lake Surprise. "The Stones" Wildlife Reserve, of 5,240 ha, occupies almost all the rest of the public land.

The block has a high capability for flora and fauna conservation. The large areas of manna gum woodland and the grassland and fernland on the stony rises country are the only examples of these land types on public land in Victoria. While the vegetation is not especially diverse (about 200 native vascular species have been recorded at Mount Napier and about 140 in the Mount Eccles National Park), its structure and the composition of the ground flora are quite unusual. The fern flora of the Byaduk Caves is significant.

The capability of the Mount Eccles and Mount Napier stony rises country for fauna conservation is high. The stony woodland habitat supports a distinctive mammal fauna, the presence of the tiger cat in "The Stones" being especially

The tiger cat, an inhabitant of the Mount Eccles stony rises significant. The stony habitats also support many reptiles.

Lake Yambuk, an estuarine lagoon fed by the Shaw and Eumeralla Rivers, is significant as the stronghold of the dwarf galaxiids, and has some value as bird habitat for waders and marsh species.

The block contains significant Aboriginal relics. At Lake Condah there are a number of fish traps, made from the rough blocks of stone found in the stony rises. The traps consist of walls designed to channel rising water to where eels could be more easily taken. Close to these traps are groups of Aboriginal stone houses - small circular or horseshoe-shaped structures, which were probably roofed with bush.

Aboriginal middens occur along the coastline, and one near the entrance to Lake Yambuk has been excavated.

The geological features created by the recent volcanic activity at Mount Napier and Mount Eccles are of great significance. The most interesting features are the Byaduk Caves, the barriers and tumuli associated with the Harman Valley flow, and the canals and caves at Mount Eccles. The small cones with open vents that lie on private land south of Mount Eccles are especially significant.

Mount Napier has a high capability for preservation of landscape, as the cone is visible for many kilometres from the surrounding plains. Mount Eccles is much lower, and is not a conspicuous landscape feature except in its immediate vicinity. The eastern side of Mount Eccles is private land, and is disfigured by a large quarry.

2. Recreation

Mount Eccles and Lake Yambuk are the main areas used for recreation. About 11,000 people a year visited Mount Eccles National Park during 1976 and 1977. The major activities are picnicking, walking, and nature study. In 1977, 48 school groups visited the park as part of their studies. Lake Yambuk is used for boating, fishing, and swimming. Mount Napier attracts small numbers, mainly field naturalists, although some tourists visit the Byaduk Caves. The public land on the northern boundary of the City of Hamilton is used for a variety of organized sports, and is managed as community parkland.

The capability of the public land at Mount Napier, Mount Eccles, and Lake Yambuk for recreation is moderate. Due to their geological features, Mounts Napier and Eccles have high capability for education.

3. Agriculture

At present a grazing licence applies on the public land south of Mount Napier. In the past all the stony rises were grazed, and the stone fences that divided the runs can still be seen. The accounts of early settlers indicate that the stony rises used to be much grassier than they are now - repeated burning has favoured bracken growth, and the value of the land for grazing has fallen.

The capability of the land for agricultural development is low. Because the lava flows are so young, the soils are very shallow (although fertile) and the surface of jumbled rocks makes access by farm machines impossible in many places. Some areas of stony rises on private land have been cleared and used for rough grazing.

The Pastoral Research Institute of the Department of Agriculture occupies 1,215 ha of public land south of Hamilton. The land is used for research into the breeding, husbandry, feeding, and management of sheep and cattle, and the development, maintenance, and utilization of pastures.

4. Apiculture

The public land has a low capability for honey production, and at present there are no bee sites in this block.

5. Timber production

Hardwood timber production is limited to very small quantities of farm timbers such as fence posts and poles, which are cut from the manna gum stands at Mount Napier. Although logs could be cut from some of the trees, manna gum is not a preferred timber species, and extraction of logs across the stony ground would be difficult.

The capability of the land for timber production is low.

The Hamilton Water Trust has established 42 ha of radiata pine plantations on land under their control to the north of the city. The stands have been thinned, and will be harvested when mature.

The stony rises are considered unsuitable for establishment of pine plantations.

6. Water production

The block contains part of the catchments of the following streams: Wannon and Crawford Rivers, Darlot Creek, and Eumeralla, Shaw, and Moyne Rivers. Its relatively flat plains are not productive catchments and these streams - with the exception of the Wannon, which rises in the Grampians - carry small flows, especially in summer. No dams have been constructed on them, although diverters draw water from the Wannon, Eumeralla, and Moyne Rivers.

The capability of the block for water production is low.

Storage basins for Hamilton's water supply are located on public land to the north of the town.

Good-quality groundwater is available from the Recent basalts and at depth from the Otway Group sediments. South of Hamilton, 300 stock and domestic bores and 10 irrigation bores tap these sediments.

7. Mineral and stone production

No minerals are known in this block. Thin seams of black coal have been intersected by drilling in the Mesozoic sediments, and considerable exploration seeking oil and gas in the Otway Basin has been undertaken.

Scoria is taken from several pits on private land at Mount Napier and Mount Eccles. Large reserves of material suitable for road-making remain on public and private land. Scoria has also been taken from a pit on public land to the north-west of Mount Napier, but it is not worked at present.

Tertiary limestone and Quaternary dune limestone (near the coast) are extracted from private land for road-making. Small amounts of the Tertiary limestone have been used for agricultural lime.

The public land in this block has a moderate capability to supply scoria for road-making, but current production of this material is from private land.

8. Utilities

Four radio masts are located on Mount Bainbridge, to the north of Hamilton.

C. Hazards and Conflicts

The soil erosion and salting hazards are low except on the coastal land, where a high wind-erosion hazard follows disturbance of the vegetation.

The hazard of wildfire in the stony rises is high. The bracken and grassy understorey burn readily, and the rough stony terrain makes control difficult. The adjoining landholders regard fires coming out of the public land as a threat during summer, and deliberately lit fires often burn in the public land in spring and autumn.

Pest animals constitute a moderate hazard. The stony rises provide food and shelter for rabbits, and aerial baiting is carried out around the edges of the public land at Mount Napier. No other pest animals or weeds pose a serious problem at present.

Grazing at Mount Napier conflicts with nature conservation, and especially with regeneration of manna gum. Tourism at the Byaduk Caves has led to trampling of the cave fern flora, and littering.

APPENDICES

Appendix 1

METRIC CONVERSION FACTORS

Quantity	Metric unit	Imperial unit	Metric to Imperial	Imperial to Metric
Length	millimetre (mm)	inch (in)	1 mm = 0.0394 inch	1 inch = 25.4 mm
	centimetre (cm)		1 cm = 0.3937 inch	1 inch = 2.54 cm
	metre (m)	foot (ft)	1 m = 3.281 feet	1 foot = 0.30 m (30.5 cm)
	kilometre (km)	mile	1 km = 0.6214 mile	1 mile = 1.61 km
Area	hectare (ha)(= 10,000 m^2)	acre (ac)	1 ha = 2.47 acres	1 acre = 0.405 ha
	square kilometre (sq km) (= 100 ha)	square mile (sq mile)	1 sq km = 0.3861 sq mile (247 ac)	1 sq mile = 2.592 sq km
Mass	kilogram (kg)	pound (lb)	1 kg = 2.20 lb	1 lb = 0.454 kg
	tonne (t)(= 1,000 kg)	ton	1 t = 0.984 ton	1 ton = 1.02 t
Volume	cubic metre (m^3)	cubic foot (ft^3)	1 m^3 = 35.31 ft^3	1 ft^3 = 0.0283 m^3
		super foot (timber)	= 423.7 super feet true	1 super foot true = 0.00283 m^3
			= 332.6 super feet (Hoppus log volume)	1 super foot HLV = 0.003 m^3
	megalitre (Ml) (= 1,000,000 litres)	acre-foot (ac ft)	1 Ml = 0.8098 ac ft	1 ac ft = 1.235 Ml
Temperature	degree Celsius (°C)	degree Fahrenheit (°F)	1°C = 5/9 (°F - 32)	1°F = 9/5 (°C + 32)
Compound units	tonnes per hectare (t/ha)	bushels/acre	1 t/ha = 14.9 bushels/ac (wheat)	1 bushel/ac = 0.087 t/ha
			= 17.9 bushels/ac (barley)	= 0.056 t/ha
			= 22.2 bushels/ac (oats)	= 0.045 t/ha
	milligrams per litre (mg/l)	parts per million (ppm)	1 mg/l = 1.000 ppm	1 ppm = 1.000 mg/l
	litres per second (l/s)	gallons per hour (gph)	1 l/s = 791.7 gph	1 gph = 0.00126 l/s

Appendix 2A

PLANTS

Common name	Scientific name
austral grass-tree	*Xanthorrhoea australis*
beaded glasswort	*Salicornia quinqueflora*
beaked hakea	*Hakea rostrata*
black box	*Eucalyptus largiflorens*
black mallee box	*E. porosa*
black wattle	*Acacia mearnsii*
blackwood	*A. melanoxylon*
blue mallee	*Eucalyptus polybractea*
bracken	*Pteridium esculentum*
bridal veil creeper	*Asparagus asparagoides*
broom baeckea	*Baeckea behrii*
broom honey-myrtle	*Melaleuca uncinata*
brown stringybark	*Eucalyptus baxteri*
bull mallee	*E. behriana*
buloke	*Casuarina luehmannii*
bush-pea	*Pultenaea* spp.
Canary Island pine	*Pinus canariensis*
candlebark	*Eucalyptus rubida*
cane grass	*Eragrostis australasica*
clematis	*Clematis* spp.
coast banksia	*Banksia integrifolia*
coast beard-heath	*Leucopogon parviflorus*
coast spear-grass	*Stipa teretifolia*
coast wattle	*Acacia sophorae*
daphne heath	*Brachyloma daphnoides*
desert banksia	*Banksia ornata*
desert hakea	*Hakea muellerana*
drooping she-oak	*Casuarina stricta*

dumosa mallee	*Eucalyptus dumosa*
dwarf she-oak	*Casuarina pusilla*
eel-grass	*Vallisneria spiralis*
fringe-myrtle	*Calytrix* spp.
golden wattle	*Acacia pycnantha*
Grampians fringe-myrtle	*Calytrix sullivanii*
Grampians gum	*Eucalyptus alpina*
grey box	*E. microcarpa*
grey glasswort	*Arthrocnemum halocnemoides*
guinea flowers	*Hibbertia* spp.
hairy spinifex	*Spinifex hirsutus*
hazel pomaderris	*Pomaderris aspera*
hedge acacia	*Acacia armata*
jointed twig-rush	*Baumea articulata*
Kamarooka mallee	*Eucalyptus froggattii*
kangaroo grass	*Themeda australis*
knobby club-rush	*Scirpus nodosus*
lavender grevillea	*Grevillea lavandulacea*
lightwood	*Acacia implexa*
lignum	*Muehlenbeckia* spp.
long-leaf box	*Eucalyptus goniocalyx*
mallee honey-myrtle	*Melaleuca acuminata*
manna gum	*Eucalyptus viminalis*
marram grass	*Ammophila arenaria*
moonah	*Melaleuca lanceolata*
mountain grey gum	*Eucalyptus cypellocarpa*
narrow-leaf wattle	*Acacia mucronata*
native cherry	*Exocarpos cupressiformis*
Oyster Bay pine	*Callitris rhomboidea*

paperbark	*Melaleuca* spp.
parrot-peas	*Dillwynia* spp.
peppermint-box	*Eucalyptus odorata*
pink-bells	*Tetratheca ciliata*
pink gum	*Eucalyptus fasciculosa*
pithy sword-sedge	*Lepidosperma longitudinale*
pondweed	*Potamogeton* spp.
prickly moses	*Acacia verticillata*
prickly tea-tree	*Leptospermum juniperinum*
radiata pine	*Pinus radiata*
red gum	*Eucalyptus camaldulensis*
red stringybark	*E. macrorhyncha*
sallow wattle	*Acacia longifolia*
salt paperbark	*Melaleuca halmaturorum*
saw-sedge	*Gahnia* spp.
scarlet bottlebrush	*Callistemon macropunctatus*
scent-bark	*Eucalyptus aromaphloia*
sea tassel	*Ruppia maritima*
shining peppermint	*Eucalyptus nitida*
shiny tea-tree	*Leptospermum nitidum*
scrub she-oak	*Casuarina paludosa*
silky tea-tree	*Leptospermum myrsinoides*
silver banksia	*Banksia marginata*
slaty she-oak	*Casuarina muellerana*
slender cypress pine	*Callitris preissii*
slender-leaf mallee	*Eucalyptus foecunda*
small grass-tree	*Xanthorrhoea minor*
snow grass	*Poa* sp.
snow gum	*Eucalyptus pauciflora*
spear-grass	*Stipa* spp.
spiny flat-sedge	*Cyperus gymnocaulos*
spyridium	*Spyridium* spp.
swamp gum	*Eucalyptus ovata*
sweet quandong	*Santalum acuminatum*
tea-tree	*Leptospermum* spp.
tree everlasting	*Helichrysum dendroideum*

tree-fern	*Dicksonia antarctica*
tree violet	*Hymenanthera dentata*
tussock grass	*Poa australis*
wallaby grass	*Danthonia* spp.
water buttons	*Cotula coronopifolia*
water milfoil	*Myriophyllum* spp.
water-ribbons	*Triglochin procera*
wild cherry	*Exocarpos cupressiformis*
woolly tea-tree	*Leptospermum lanigerum*
yellow box	*Eucalyptus melliodora*
yellow gum	*E. leucoxylon*
yellow mallee	*E. incrassata*

Appendix 2B

SIGNIFICANT PLANT SPECIES

1. Species endemic to South-western Area, District 2, (all in the Grampians).

Species	Occurrences
Bauera sessiliflora	Widespread
Boronia latipinna	Widespread
Bossiaea rosmarinifolia	Widespread
Calytrix sullivanii	Widespread
Dillwynia oreodoxa	Widespread
Eucalyptus alpina	Widespread
Grevillea confertifolia	Widespread
Grevillea dimorpha	Widespread
Grevillea microstegia	Mount William
Grevillea williamsonii	Mount Abrupt (Serra Range)
Hibbertia humifusa	Widespread
Lepyrodia flexuosa	Widespread
Prasophyllum subbisectum	Pomonal
Pultenaea costata	Widespread
Pultenaea maidenii	Widespread
Pultenaea patellifolia	Black Range (W) (Mount Arapiles?)
Pultenaea subalpina	Mount Rosea and Mount William
Pultenaea williamsoniana	Mount Stapylton - Rose Gap
Stylidium soboliferum	Widespread
Thryptomene calycina	Widespread
Trymalium d'altonii	Widespread
Trymalium ramosissimum	Widespread
Zieria sp. (undescribed?)	Widespread

2. Species endemic except for one or two other records.

Species	Locality in S-W 2 area	Other localities
Eriocaulon australasicum	Meereek	Near Yungera (Murray River)
Goodenia lineata	Widespread in Grampians	Lower Glenelg
Leucopogon neurophyllus	Victoria Range, Mount Thackeray and Mount William	Mounts Langi Ghiran and Ben Nevis
Platylobium alternifolium	Widespread	Central Victoria
Pultenaea d'altonii	Black Range (W)	Little Desert
Spyridium cinereum	Mount Stapylton area	Mallacoota area

3. Only Victorian records (excluding species listed under 1. above).

Species	Locality
Acacia rupicola	Tooan, Mount Arapiles, and Lake Wartook
Asperula minima	Mount William
Asterolasia phebalioides	Black Range (W), Grampians
Borya nitida	Grampians (Mackey Peak)
Casuarina monilifera	Widespread in Grampians
Crassula sp.	Mount Arapiles and Black Range (W)
Danthonia sp.	Victoria and Serra Ranges
Davillia pyxidata	Black Range (W), Glenisla
Gahnia ancistrophylla	Central Grampians - one colony only
Gahnia deusta	Dadswells Bridge
Haloragis meziana	Widespread in Grampians
Hibbertia cistiflora	Widespread in Grampians
Marianthus bignoniaceus	Widespread in Grampians
Pomaderris apetala	Widespread in Grampians
Prostanthera spinosa	Mount Arapiles, Grampians
Pultenaea luehmannii	Widespread in Grampians
Scirpus congruus	Mount Arapiles
Senecio hypoleucus	Mount Arapiles and Black Range (W)
Sphaerolobium daviesioides	Grampians
Swainsona brachycarpa	Mount William Range

4. Other extremely isolated records.

Species	Locality
Anthocercis frondosa	Mount Arapiles, Black Range (W), and northern Grampians
Asplenium adiantoides	Byaduk Caves and Victoria Range
Banksia integrifolia	Widespread in Grampians; coastal species
Bertya findlayi	Billywing area
Celmisia asteliifolia	Mount William and Major Mitchell Plateau
Correa lawrenciana	Grampians
Danthonia monticola	Mount Arapiles, Victoria Range, Grampians
Deyeuxia rodwayi	Grampians
Dodonaea truncatiales	Mount Zero area
Drimys lanceolata	Major Mitchell Plateau
Epacris lanuginosa	North of Lake Wartook
Eriostemon verrucosus	Mount Arapiles and Lake Wartook area
Eucalyptus dalrympleana	Major Mitchell Plateau
E. froggattii	John Smith Reserve (Wonwondah North)
Gahnia microstachya	Widespread in Grampians
Galium binofolium	Golton Gorge
Goodia medicaginea	Mount Arapiles, Bringalbert
Helichrysum rosmarinifolium	Mount William Range, Wannon River
Hibbertia sp. nov.	Kalingur, White Lake
Hovea rosmarinifolia	Lake Wartook area
Howittia trilocularis	Mount Arapiles
Juncus sandwithii	Grampians
Lasiopetalum dasyphyllum	Grampians
Lepidosperma canescens	Toolondo
Lepidosperma forsythii	Victoria Range, Victoria Valley
Lepyrodia tasmanica	Widespread in Grampians
Leptospermum nitidum	Widespread in Grampians
Lycopodium serpentinum	Victoria Range, Victoria Valley
Lycopodium varium	Victoria Range
Marsilea angustifolia	Victoria Valley
Microtis orbicularis	Kadnook, Connewirrecoo, Yallakar, Woohlpooer
Opercularia hispida	Serra Range (Mount Sturgeon)
Persoonia chamaepeuce	Lake Wartook area and Mount William Range

Species	Locality
Poa crassicaudex	Mirranatwa Gap
Poa fawcettiae	Mount William and Major Mitchell Plateau
Prostanthera hirtula	Widespread in Grampians
Prostanthera saxicola	Grampians
Psilotum nudum	Mount Arapiles and Mount Zero area
Ptilotus erubescens	Mount Arapiles
Pultenaea acerosa	Grampians
Pultenaea benthamii	Widespread in Grampians
Pultenaea graveolens	Rose Gap
Rutidosis leptorhynchoides	Ararat (McDonald Park)
Schoenus carsei	Glenelg River (Big Cord area)
Schoenus fluitans	Kay Swamp, Meereek, Black Range (W), Wannon River
Schoenus nanus	J.J. Kingston Reserve, Mount Arapiles, northern Grampians
Schoenus sculptus	Grampians
Schoenus turbinatus	Grampians
Scirpus wakefieldianus	Grampians
Stipa macalpinei	Black Range (W) (private property), Mount Arapiles, Mount Sturgeon
Stipa setacea	Mount Arapiles
Tetrarrhena sp. nov.	Grampians
Thelymitra canaliculata	John Smith Reserve and Glenisla area
Thelymitra chasmogama	Jilpanger
Thelymitra holmesii	Kadnook--Connewirrecoo, Yallakar, Victoria Range
Thelymitra matthewsii	Grampians
Thelymitra mucida	Kadnook--Connewirrecoo
Tripogon loliiformis	Mount Arapiles
Utricularia violacea	Glenisla area
Veronica sp. nov.	Upper Wannon River
Westringia glabra	Mount Zero area

Compiled from surveys undertaken by Mr. A.C. Beauglehole for the Land Conservation Council.

Appendix 2C

PRINCIPAL TREE SPECIES FOUND IN SOUTH-WESTERN AREA, DISTRICT 2

Eucalyptus alpina (Grampians gum)	Related to *E. baxteri* and endemic to the southern half of the Grampians, including the Victoria Range. Grows on exposed stony sites as a low scrub except near Mount Thackeray where it reaches tree size.
E. aromaphloia (scent-bark)	Found in the Grampians, on the surrounding outwash plains and at Nareen where it forms a low woodland. Also in the hills near Ararat.
E. baxteri (brown stringybark)	Widespread throughout the study area north of Hamilton; to the south found only at Bessiebelle. Grows on sandy soils forming forest, woodland, or open scrub, depending on rainfall and soil fertility.
E. camaldulensis (red gum)	Grows throughout the study area, except south of Macarthur. Found along streams, around the shores of lakes and swamps and, as at Woohlpooer, where gravelly subsoils cause high moisture levels to be maintained in upper horizons.
E. cypellocarpa (mountain grey gum)	Found only on sheltered sites, mainly moist gullies, in the Grampians.
E. dives (broad-leaf peppermint)	Wartook, Victoria Valley.
E. dumosa (dumosa mallee)	Mallee sp. found at Mount Arapiles and Tooan.
E. fasciculosa (pink gum)	Associated with yellow gum at Meereek.
E. foecunda (slender-leaf mallee)	Mallee sp. found at Mount Arapiles and Tooan.

E. frogattii (Kamarooka mallee)	Mallee sp. from Lower Norton.
E. goniocalyx (long-leaf box)	Found on poorer soils in the midlands, the Grampians, and western Black Range and their outwash plains, and at Mount Arapiles.
E. incrassata (yellow mallee)	Mallee sp. found at Mount Arapiles and Tooan.
E. largiflorens (black box)	Found on heavy clay soils on the plains in the north of the study area.
E. leucoxylon (yellow gum)	Widespread on the plains of the midlands and the south-west Wimmera.
E. macrorhyncha (red stringybark)	Grows only in the hills between Ararat and Moyston, except for small stands in Wonderland Forest Park.
E. melliodora (yellow box)	Found mainly on the outwash slopes and plains of the Grampians and the western Black Range west to Toolondo; also found on the low hills of the midlands; grows on deeper, more fertile soils.
E. microcarpa (grey box)	Found on heavy soils on the plains in the north of the study area, also along the Henty Highway north of Woohlpooer, near Mount Zero and on the lower western slopes of the western Black Range.
E. nitida (shining peppermint)	A generally low tree found growing in heathlands and on the edges of swamps in the southern Grampians and in the south of the study area.
E. obliqua (messmate)	Forms forest in the wettest parts of the Grampians and in the far south of the study area on well drained gravelly soils, and woodland on the outwash slopes and plains of the Grampians.

E. odorata (peppermint box)	Mallee sp. from Mount Arapiles and Lower Norton.
E. ovata (swamp gum)	Grows on swampy flats in the Grampians and in the south; also common south of Edenhope and in the Dundas Tablelands.
E. pauciflora (snow gum)	Found in scattered localities on the plains in the south of the study area, also on the Major Mitchell Plateau.
E. polyanthemos (red box)	A small occurrence only along the Western Highway between Ararat and Stawell.
E. rubida (candlebark)	Limited to higher-rainfall areas in the Grampians; absent elsewhere.
E. viminalis (manna gum)	A very variable species - smooth-barked form in parts of the Grampians, Mount Napier, and Mount Eccles; rough-barked form widespread in southern and western parts - e.g., at Heywood, Apsley. Occasionally hybridizes with red gum.
Casuarina luehmannii (buloke)	Grows on the heavy soils of the Wimmera plains in the far north; usually allied with yellow gum and grey box.
C. stricta (drooping she-oak)	Occurs in the Grampians, and throughout most of the study area from Edenhope and Stawell southwards, but not common. Formerly very widespread on the lava plains and coast.
Acacia mearnsii (black wattle)	Widespread except in the north of the study area.
Callitris preissii (slender cypress pine)	Grows at Mount Arapiles, Tallageira, Bringalbert, Karnak, Wombelano, also on creek frontages below Mount Zero.
C. rhomboidea (Oyster Bay pine)	Found in the Grampians, western Black Range; also at Mount Arapiles, Karnak.
C. columellaris (white cypress pine)	Mount Arapiles.

Appendix 3A

BIRDS

These lists apply only to the study area. Neighbouring regions are not considered.

Distribution		Habitat		Status	
T	Throughout the study area	W	Wetlands	M	Migrant
W	Wimmera plains	S	Saline lakes	N	Nomadic - numbers fluctuate
G	Grampians	A	Agricultural land	C	Common
M	Midlands	F	Forest	F	Frequent in favoured habitat
D	Dundas tablelands	Wo	Woodland	U	Uncommon
V	Volcanic plains	O	Open scrub	V	Very unusual
C	Coastal plains	H	Heath	R	Rare
		C	Coastal	B	Known with certainty to breed in study area
		Ae	Aerial		
		T	Towns		

* Indicates exotic species.

Note: Common names and their sequence taken from:

Royal Australasian Ornithologists Union. Recommended English names for Australian birds. *The Emu*, 77, Supplement, May 1978.

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NON-PASSERINES

Common name	Distribution	Habitat	Status	Remarks
Emu	WGMD	AFWoOH	FB	
Great crested grebe	WGD	W	UB	Southern limit of breeding - important colony Lake Wallace
Hoary-headed grebe	T	WS	UB	
Australasian grebe	T	W	UB	
Australian pelican	T	W	N	
Darter	WGM	W	UB	
Little pied cormorant	T	WS	CB	
Great cormorant	T	W	UB	
Little black cormorant	T	W	UB	
Pied cormorant	M	W	UB	
Pacific heron	T	WA	UB	
White-faced heron	T	WSA	CB	
Cattle egret*	WGVD	WA	U	
Great egret	T	WA	U	
Intermediate egret	WD	WA	U	
Rufous night heron	T	WF	UB	
Australasian bittern	WMVD	W	RB	
Glossy ibis	WG	W	R	
Sacred ibis	T	WA	FB	
Straw-necked ibis	T	WSA	CB	
Royal spoonbill	WGD	W	R	
Yellow-billed spoonbill	T	WS	FB	
Plumed whistling-duck	W	W	R	
Black swan	T	WSA	CB	
Freckled duck	WV	WS	R	
Cape Barren goose	WV	SA	R	

Common name	Distribution	Habitat	Status	Remarks
Australian shelduck	T	WSA	CB	
Pacific black duck	T	WSA	CB	
Grey teal	T	WSA	CB	
Chestnut teal	WD	WS	UB	
Australasian shoveler	T	WS	UB	
Pink-eared duck	T	WS	UB	
Hardhead	T	WS	UB	
Maned duck	T	WA	CB	
Blue-billed duck	T	W	U	
Musk duck	T	WS	UB	
Black-shouldered kite	WGVD	A	RB	
Letter-winged kite	WVDC	AAe	V	Nocturnal
Black kite	T	AAe	V	
Whistling kite	T	A	UB	
Brown goshawk	T	AFWoOH	FB	
Collared sparrowhawk	T	AFWoOH	RB	
White-bellied sea-eagle	WGM	W	RB	
Wedge-tailed eagle	T	AFWoOHAe	FB	
Little eagle	T	A	UB	
Spotted harrier	T	A	R	
Marsh harrier	T	WAO	UB	
Black falcon	T	A	R	
Peregrine falcon	T	WFAO	RB	
Australian hobby	T	AH	RB	
Brown falcon	T	WAFWoHC	CB	
Australian kestrel	T	AFWoOH	FB	
Malleefowl	W	O	V	
Stubble quail	T	A	CB	
Brown quail	T	AW	RB	
Painted button-quail	WGMVD	FWoOH	UB	
Little button-quail	T	WH	RB	

Common name	Distribution	Habitat	Status	Remarks
Plains-wanderer	WMV	A	R	Very rare
Buff-banded rail	T	W	NUB	
Lewin's rail	T	W	RB	
Baillon's crake	T	W	UB	
Australian crake	T	W	UB	
Spotless crake	T	W	UB	
Black-tailed native-hen	T	W	NUB	
Dusky moorhen	T	W	UB	
Purple swamphen	T	WSA	CB	
Eurasian coot	T	WS	CB	
Brolga	T	WA	RB	
Bush thick-knee	T	WoO	RB	
Painted snipe	T	W	NVB	
Masked lapwing	T	WSA	CB	
Banded lapwing	T	A	FB	
Red-kneed dotterel	WM	W	UB	
Hooded plover	C	C	UB	
Double-banded plover	V	W	UM	Breeds New Zealand
Red-capped plover	W	S	UB	
Black-fronted plover	T	W	UB	
Black-winged stilt	T	WS	NB	
Banded stilt	W	S	N	Saline lakes, Douglas area of major importance to this species
Red-necked avocet	W	S	N	
Common sandpiper	V	WS	MR	Very rare in Victoria
Greenshank	WMVD	W	MU	Breeds northern Europe, Asia
Latham's snipe	T	WH	MR	Breeds Japan

Common name	Distribution	Habitat	Status	Remarks
Sharp-tailed sandpiper	T	WS	MR	Breeds Siberia
Red-necked stint	WV	WS	MR	Breeds Siberia, Alaska
Curlew sandpiper	W	W	MV	Breeds Asia
Sanderling	C	C	MU	Breeds Arctic
Silver gull	T	WSA	F	
Whiskered tern	WGVD	WS	NB	
Gull-billed tern	V	W	NV	
Feral pigeon*	T	AT	FB	
Peaceful dove	WGMD	FWo	UB	
Diamond dove	W	O	R	
Common bronzewing	T	FWoO	FB	
Brush bronzewing	GVC	FWoH	RB	
Crested pigeon	W	A	U	
Red-tailed black-cockatoo	WGMD	FO	UB	Open scrub and woodlands of south-west Wimmera important to this species
Yellow-tailed black-cockatoo	T	FWoO	MB	
Gang-gang cockatoo	GD	FWo	UB	
Galah	T	AWo	CB	
Long-billed corella	T	AWo	CB	Common in study area but rare elsewhere
Sulphur-crested cockatoo	T	AWo	CB	
Rainbow lorikeet	WGMD	Wo	NR	
Musk lorikeet	T	Wo	NF	
Purple-crowned lorikeet	T	Wo	NF	
Little lorikeet	WGD	Wo	R	
Cockatiel	WMDV	Wo	NR	
Budgerigar	WGMD	A	NR	
Swift parrot	T	Wo	NR	
Crimson rosella	T	AFWoOH	CB	
Eastern rosella	T	AWo	CB	
Red-rumped parrot	T	AWo	CB	

Common name	Distribution	Habitat	Status	Remarks
Blue-winged parrot	WGVD	O	R	
Elegant parrot	WGVD	O	R	
Pallid cuckoo	T	AFWoOH	MB	
Fan-tailed cuckoo	T	AFWoO	FB	
Black-eared cuckoo	WGMD	WoOH	RB	
Horsfield's bronze-cuckoo	T	FWoO	MB	
Shining bronze-cuckoo	T	FWoO	UB	
Powerful owl	G	F	UB	
Southern boobook	T	FWoO	CB	
Barking owl	WGVD	FWo	RB	
Barn owl	T	AWo	NB	
Masked owl	WGVD	F	RB	Recorded breeding in 1902
Tawny frogmouth	T	AFWoO	FB	
Australian owlet-nightjar	T	AFO	RB	
Spotted nightjar	WG	F	R	
White-throated needletail	T	Ae	M	Breeds Asia
Fork-tailed swift	T	Ae	M	Breeds Asia
Azure kingfisher	GM	W	RB	
Laughing kookaburra	T	AFWoO	CB	
Red-backed kingfisher	M	Wo	MB	
Sacred kingfisher	T	FWo	MB	
Rainbow bee-eater	T	AFWoO	MB	

PASSERINES

Common name	Distribution	Habitat	Status	Remarks
Skylark*	T	A	FB	
Welcome swallow	T	WAFWoH AeT	CB	
Tree martin	T	WAFWoAeT	CB	
Fairy martin	T	WAAe	UB	
Richard's pipit	T	A	CB	
Black-faced cuckoo-shrike	T	AFWoO	CB	
White-bellied cuckoo-shrike	WGDVC	FWoO	NB	
White-winged triller	T	AWoO	MUB	
White's thrush	T	FO	UB	
Blackbird*	T	WAT	FB	
Southern scrub-robin	W	O	RB	Mallee scrub
Rose robin	GVD	O	R	
Pink robin	GWVD	F	R	
Flame robin	T	AO	UB	Breeds in highest parts of Grampians
Scarlet robin	T	FWoO	UB	
Red-capped robin	WM	WoO	R	
Hooded robin	WGM	WoO	RB	
Eastern yellow robin	T	AFWoO	FB	
Jacky winter	T	AWoO	UB	
Crested shrike-tit	T	FWo	UB	
Gilbert's whistler	W	O	UB	Mallee scrub
Golden whistler	T	AFWoO	UB	
Rufous whistler	T	FWoO	FB	
Grey shrike-thrush	T	AFWoOT	CB	
Crested bellbird	M	Wo	U	
Satin flycatcher	GV	F	MRB	
Restless flycatcher	T	AFWo	UB	
Rufous fantail	GV	FO	UMB	
Grey fantail	T	FWoO	CB	
Willie wagtail	F	AWo	FB	

Common name	Distribution	Habitat	Status	Remarks
Spotted quail-thrush	G	F	UB	
Grey-crowned babbler	WG	FWo	RB	
White-browed babbler	WGM	FWoO	UB	
Clamorous reed-warbler	T	W	MCB	
Little grassbird	T	W	FB	
Golden-headed cisticola	T	W	UB	
Brown songlark	T	A	MUB	
Rufous songlark	T	WoO	MB	
Superb fairy-wren	R	WAFWoO	CB	
Variegated fairy-wren	W	O	RB	Mallee scrub
Rufous-crowned emu-wren	WG	WoHC	UB	
White-browed scrubwren	T	FWoOHT	CB	
Chestnut-rumped hylacola	WGMD	OH	RB	
Calamanthus	WGV	WH	RB	
Speckled warbler	GMD	WoO	RB	
Weebill	WGMD	Wo	RB	
White-throated gerygone	WGVD	A	NR	1909 breeding record Midlands
Brown thornbill	T	AFWoOH	CB	
Chestnut-rumped thornbill	WM	WoO	UB	
Buff-rumped thornbill	T	FWoO	VB	
Yellow-rumped thornbill	T	AWoO	CB	
Striated thornbill	T	FWoO	UB	
Southern whiteface	T	AWo	RB	
Varied sittella	T	FWoO	UB	
White-throated treecreeper	T	FWoO	CB	
Brown treecreeper	T	AWo	CB	
Red wattlebird	T	AFWoOT	CB	
Little wattlebird	WGVD	FWoO	NRB	
Spiny-cheeked honeyeater	WGD	OH	RN	Mallee scrub
Regent honeyeater	WGMD	WoO	RB	

Common name	Distribution	Habitat	Status	Remarks
Blue-faced honeyeater	WGMD	Wo	RB	
Noisy miner	T	AFWoOT	FB	
Yellow-faced honeyeater	T	AFWoO	MCB	
Singing honeyeater	VC	C	FB	
White-eared honeyeater	T	FWoOH	UB	
Yellow-tufted honeyeater	WGMD	FWo	UB	
Fuscous honeyeater	WGMVD	AWoO	NB	
White-plumed honeyeater	T	AFWoO	CB	
Black-chinned honeyeater	WGMD	FWoO	UB	
Brown-headed honeyeater	T	AFWoOCT	UB	
White-naped honeyeater	T	AFWo	CB	
Painted honeyeater	WGM	F	NRB	
Crescent honeyeater	CD	FOH	VB	
New Holland honeyeater	T	AFWoOHCT	CB	
White-fronted honeyeater	W	O	R	Mallee scrub
Tawny-crowned honeyeater	WGMD	OH	RB	
Eastern spinebill	T	FWoOT	UB	
White-fronted chat	T	WA	FB	
Mistletoebird	T	FWoO	UB	
Spotted pardalote	T	FO	UB	
Striated pardalote	T	AFWoO	CB	
Silvereye	T	AFWoOHT	FB	
European goldfinch*	T	AT	CB	
European greenfinch*	VC	TC	UB	
House sparrow*	T	AT	CB	
Tree sparrow*	V	A	R	
Red-browed firetail	T	AFWoO	CB	
Diamond firetail	WGMD	FWo	UB	
Beautiful firetail	C	HC	RB	

Common name	Distribution	Habitat	Status	Remarks
Common starling*	T	AT	CB	
Olive-backed oriole	WGV	F	MRB	
White-winged chough	T	AFWoO	FB	
Australian magpie-lark	T	WAWoT	CB	
White-breasted woodswallow	M	WF	V	
Masked woodswallow	T	AFWoAe	UNB	
White-browed woodswallow	T	AFWoAe	CNB	
Dusky woodswallow	T	AFWoO	CB	
Little woodswallow	WG	AFWoO	R	
Grey butcherbird	WGMVD	AFWo	RB	
Australian magpie	T	AT	CB	Sp. includes both white-backed and black-backed magpies
Pied currawong	T	AFWoO	UB	
Grey currawong	T	AFWoO	RB	
Australian raven	T	AFWo	CB	
Little raven	T	AFWo	CB	

Appendix 3B

MAMMALS

The code used is the same as employed in the list of birds except for:

HABITAT

R Rocky areas including scarps

STATUS

R	Rare	Re	Restricted
U	Uncommon	W	Widespread
C	Common	S	Survival doubtful

Common names and their sequence have been taken from:

Ride, W.D.L. "A Guide to the Native Mammals of Australia." (Oxford University Press: Melbourne 1970.)

Common name	Scientific name	Distribution	Habitat	Status	Remarks
Great grey kangaroo	*Macropus giganteus*	WGMDV	AFWoH	CW	Known in Victoria as "eastern grey kangaroo"
Western grey kangaroo	*Macropus fuliginosus*	WG	AWoOH	CW	
Red-necked wallaby	*Macropus rufogriseus*	WGDV	FWoOH	CW	
Brush-tailed rock wallaby	*Petrogale penicillata*	G	R	RRe	Victoria Range only
Potoroo	*Potorous apicalis*	G	F	URe	
Brush-tailed possum	*Trichosurus vulpecula*	T	AFWoTR	CW	
Common ringtail	*Pseudocheirus peregrinus*	T	AFWoT	CW	Known in Victoria as "ring-tailed possum"
Sugar glider	*Petaurus breviceps*	T	FWo	UW	
Squirrel glider	*Petaurus norfolcensis*	M	Wo	RRe	
Yellow-bellied glider	*Petaurus australis*	V	F	URe	
Feathertail glider	*Acrobates pygmaeus*	WGMDV	FWo	UW	

Common name	Scientific name	Distribution	Habitat	Status	Remarks
South-western pygmy possum	*Cercartetus concinnus*	W	O	RRe	Known in Victoria as "western pygmy possum"
Eastern pygmy possum	*Cercartetus nanus*	GM	FWoO	URe	Only in highest parts of Grampians
Koala	*Phascolarctos cinereus*	GMV	FWo	CRe	
Short-nosed bandicoot	*Isoodon obesulus*	GMV	FH	CRe	Lowland habitats; also below Mount Napier
Gunn's bandicoot	*Perameles gunnii*	V	A	URe	Known in Victoria as "barred bandicoot"
Tigercat	*Dasyurus maculatus*	V	F	RRe	
Tuan	*Phascogale tapoatafa*	GDV	FWo	RW	
Yellow-footed antechinus	*Antechinus flavipes*	T	FWoO	UW	
Brown antechinus	*Antechinus stuartii*	GV	FH	CRe	Mountain habitats
Swainson's antechinus	*Antechinus swainsonii*	GV	F	CRe	
Common dunnart	*Sminthopsis murina*	WGV	FO	RRe	
Fat-tailed dunnart	*Sminthopsis crassicaudata*	WMDV	AWo	UW	
Eastern bush-rat	*Rattus fuscipes*	V	F	CRe	
Eastern swamp-rat	*Rattus lutreolus*	GV	AFH	CW	Known in Victoria as "swamp rat"
Black rat*	*Rattus rattus*	T	AFWoT	CW	
Sewer rat*	*Rattus norvegicus*	V	AT	URe	
Water rat	*Hydromys chrysogaster*	T	W	WRe	
Grey mouse	*Pseudomys albocinereus*	W	O	URe	Known in Victoria as "silky desert mouse"
Smokey mouse	*Pseudomys fumeus*	G	FH	URe	Also "smoky mouse"
Blunt-faced rat	*Pseudomys shortridgei*	G	WoH	CW	Known in Victoria as "heath rat"
House mouse*	*Mus musculus*	T	AFWoOHT	CW	
Rabbit*	*Oryctolagus cuniculus*	T	AFWoOHC	CW	
Hare*	*Lepus europaeus*	MV	A	UW	
Greater long-eared bat	*Nyctophilus timoriensis*	G(T?)	Ae	UW	
Lesser long-eared bat	*Nyctophilus geoffroyi*	T	Ae	CW	
White-striped bat	*Tadarida australis*	D(T?)	Ae	CW	
Little flat bat	*Tadarida planiceps*	WM	Ae	CW	
Yellow-bellied bat	*Taphozous flaviventris*	?	Ae	RW	
Bent-winged bat	*Miniopterus schreibersii*	VC	Ae	CW	
Gould's wattled bat	*Chalinolobus gouldii*	T	Ae	CW	
Chocolate bat	*Chalinolobus morio*	G(T?)	Ae	UW	
Little Bat	*Eptesicus pumilus*	T	Ae	CW	
Tasmanian pipistrelle	*Pipistrellus tasmaniensis*	G(T?)	Ae	URe	
Large-footed myotis	*Myotis adversus*	?	Ae	RRe	
Little broad-nosed bat	*Nycticeius greyi*	G(T?)	Ae	UW	
Echidna	*Tachyglossus aculeatus*	T	AFWoOH	UW	
Platypus	*Ornithorhynchus anatinus*	T	W	UW	
Fox*	*Vulpes vulpes*	T	AFWoOHC	CW	
Feral cat*	*Felis catus*	T	AFWoOHC	FW	
Feral pig*	*Sus scrofa*	G	FWo	RS	
Feral goat*	*Capra hircus*	GV	R	URe	
Feral sheep*	*Ovis aries*	V	F	URe	
Red deer*	*Cervus elaphus*	G	FWo	URe	

Note: Information on the distribution of bats is incomplete because few surveys have been made in the study area. Mr. H. Parnaby assisted in the compilation of this part of the table.

Appendix 3C

REPTILES

The code used in this list is the same as employed in the list of mammals.

The list has been compiled from information supplied by Messrs. J. Coventry, National Museum, and I. McCann, Stawell. References used were Cogger, H.G., Reptiles and Amphibians of Australia (1975); Rawlinson, P.A., Victorian Year Book No. 85, 1971; Greer, A.E., The Generic Relationships of the Scincid Lizard Genus *Leiolopisma* and its Relatives (1974); Australian Journal of Zoology, Supplementary Series 31, 1--69.

Scientific name	Common name	Distribution	Habitat	Status	Remarks
Chelodina longicollis	long-necked tortoise	T	W	CRe	
Diplodactylus tessellatus	tessellated gecko	W		RS	
Phyllodactylus marmoratus	marbled gecko	WGM	WoOR	CW	
Underwoodisaurus milii	thick-tailed gecko	M		VRe	eastern Black Range
Delma impar	spinifex lizard	WV	A	RS	
D. inornata	mimicking snake-lizard	M	Wo	URe	
Pygopus lepidopodus	common scaly-foot	M	FWoH	Re	Stawell district
Amphibolurus barbatus	bearded dragon	T	AWo	CW	
A. diemensis	mountain dragon	G	FH	RRe	highest parts of Grampians
A. muricatus	jacky lizard	T	FWoO	CW	
A. pictus	painted dragon	W	O	UW	
Varanus gouldii	sand monitor	WM	O	RRe	
V. varius	lace monitor	WM	Wo	URe	
Cryptoblepharus boutoni	wall skink	W	Wo	CW	
Ctenotus robustus	large striped skink	WGM	AWo	UW	
Egernia luctuosa	mourning skink	G	H	RRe	
E. saxatilis	black rock skink	WGV	R	CW	
E. whitii	White's skink	T	FR	CW	
Anotis maccoyi	McCoy's skink	GV	FH	UW	highest parts of Grampians
Hemiergis decresiensis	three-toed skink	W	OR	URe	
H. peronii	four-toed skink	M		URe	Mount Rosea
Leiolopisma coventryi	Coventry's skink	G	FH	URe	highest parts of Grampians
L. entrecasteauxi	grass skink	GV	AFWoH	CW	
L. trilineatum	three-lined skink	GV	AFWo	CW	
Lampropholis delicata	delicate skink	W	Wo	UW	
L. guichenoti	garden skink	T	FWoOHT	CW	
Lerista bougainvillii	Bougainville's skink	WGM	FOWo	UW	
Morethia adelaidensis	Adelaide skink	GM	Wo	RRe	
M. boulengeri	Boulenger's skink	WGM	AWo	CW	
M. obscura	ocellated skink	W	O	CW	
Sphenomorphus tympanum	southern water skink	WGV	F	CW	
Tiliqua nigrolutea	southern blue-tongued lizard	GMV	FH	UW	
T. scincoides	common blue-tongued lizard	WGV	AWo	UW	
Trachydosaurus rugosa	shingle back	T	AFWoH	CW	
Typhlina proxima	blind snake	GM	AFWo	UW	
Austrelaps superbus	copperhead	GV	FH	URe	
Drysdalia coronoides	white-lipped snake	G	AFH	URe	
Notechis scutatus	mainland tiger snake	T	WAFH	CW	
Pseudechis porphyriacus	red-bellied black snake	WG	WFWo	URe	
Pseudonaja textilis	eastern brown snake	T	AFWoOH	CW	
Unechis flagellum	little whip snake	M	AFWoH	URe	

Appendix 3D

AMPHIBIANS

All amphibians found in Australia are members of the order Anura (the frogs).

Family Hylidae

Litoria aurea

Common on the south-western Wimmera plains, but of fragmented distribution elsewhere, this species lives in permanent ponds, creeks, and rivers, especially at lower elevations. The free-swimming larvae prefer open, shaded water; their life span is 12--19 months.

L. ewingi

Common throughout the study area, except on the south-western Wimmera plains, this species lives in permanent and temporary pools and feeds on terrestrial insects, such as beetles, and aquatic insect larvae. Eggs are deposited in clumps or wound around submerged stems.

Family Leptodactylidae

Geocrinia laevis

Within the study area this species is found in the north of the Grampians and in the midlands. Eggs are deposited in batches in small tunnels under litter in areas that will flood in early winter. The larvae subsequently select permanent ponds.

G. victoriana

Found only close to Halls Gap (but also hybridizing with *G. laevis* in a restricted area near Zumsteins), although much more common in central Victoria, this species deposits its eggs in depressions in the soil that will later be flooded.

Limnodynastes dumerili

Although found widely in lowland Victoria, the distribution of this species in the study area is fragmented. It lives in swamps, ponds, and running water. The eggs are laid in a foamy mass, which attaches itself to protruding stems of water plants.

L. peroni

Common in the south of the study area and throughout southern and north-eastern Victoria, this species breeds in permanent pools and swamps. Its eggs develop in the same way as those of *L. dumerili*.

L. tasmaniensis

Found throughout lowland Victoria except in the Mallee, this species is widespread in the study area. It lives in ponds and swamps, and its larvae are free-swimming.

Neobatrachus centralis

Restricted to a couple of locations on the plains surrounding the Grampians, and adapted to life in arid regions, *N. centralis* has a short larval stage. This shortness enables it to utilize temporary ponds. Adults survive drought by burrowing into moist ground and staying there in a state of aestivation until substantial rains fall.

N. pictus

Although found on the plains throughout much of Victoria, this species is apparently uncommon in the study area. It utilizes temporary and permanent pools and its eggs develop in floating foamy masses, which adhere to stems protruding from the water.

Pseudophryne bibroni

Another species uncommon in the study area, this amphibian lays its eggs in the soil in depressions that will later be flooded. Larvae emerge at an advanced state of development after 6--7 months.

P. semimarmorata

This species is found in the Grampians, a contrast to its general coastal distribution in Victoria. Eggs are laid in tunnels under litter, and in grass or under logs, in situations that will later be flooded. The larvae find sheltered shallow pools.

Ranidella parinsignifera

Although found widely in the north-central part of Victoria, this species is restricted in the study area to the midlands and portion of the Wimmera plains. Eggs are attached, in clumps or individually, to submerged vegetation or remain on the bottom of the pond.

R. signifera

Widely distributed in Victoria, except for the Mallee, and common throughout the study area, this species lives in standing and flowing water. Its eggs, which rest on the bottom of the pond or adhere to submerged vegetation, develop within 6--10 weeks.

Appendix 3E

FRESH-WATER AND ESTUARINE FISH SPECIES

Geotria australis

The pouched lamprey is an eel-like cartilaginous parasitic fish that lives in the sea but spawns in rivers, often hundreds of miles upstream. The larvae live there for three or four years feeding on phytoplankton, after which they change into adults and migrate downstream to the sea. Maximum length to around 40 cm.

Retropinna semoni

The Australian smelt is a small fish (maximum length 8 cm) found throughout the study area and an important source of food for larger fish - i.e., it is a typical "forage" fish.

Anguilla australis

The short-finned eel is an important commercial species in Victoria, although not in the study area, where it is probably confined to the Eumeralla River and adjacent short coastal streams. This fish may attain 100 cm in length and live to an age of over 20 years. It spends most of its life in fresh water and spawns once in the sea. Australian eels spawn in the local seas and only the offspring (glass-eels) return.

Aldrichetta forsteri

The yellow-eyed mullet is found in the lower reaches of the Eumeralla. It grows to 35 cm and, although not a recognized sporting fish, is frequently caught.

Philypnodon grandiceps
Hypseleotris compressus
H. klunzingeri

The big-headed gudgeon, carp gudgeon, and western carp gudgeon grow to 12, 8, and 6 cm respectively. Found throughout the study area in lakes and streams these species are important "forage" fish.

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Gadopsis marmoratus

The river blackfish is becoming uncommon because its habitat is being reduced by siltation, regulation, and de-snagging of streams. A sought-after table fish, it is found north and south of the Divide - fish from northern streams were considered to be a separate species, but this is no longer accepted. It grows to 35 cm.

*Tandanus tandanus**

A useful sporting fish, the catfish has been introduced by angling clubs into the Wimmera River system and appears to have become self-sustaining. It can attain a length of 60 cm.

Pseudaphritis urvilli

The tupong is found in the lower reaches of the Eumeralla River and in the sea. It grows to 35 cm.

Nannoperca australis

The pigmy perch is an important bait and "forage" species in fresh water throughout the study area. It rarely exceeds 7 cm in length.

*Plectroplites ambiguus**

The golden perch (yellowbelly, callop) is an excellent sporting and table fish from the Murray--Darling system, which has been introduced with a degree of success to Green Lake and the Wimmera River system. It grows to around 75 cm.

*Maccullochella peeli**

The Murray cod is one of the most important native species for anglers in inland eastern Australia. Most attempts to introduce Murray cod into lakes and streams north of the Divide in the study area have failed, but at Lake Charlegrark, near Goroke, a breeding population was established as a result of a liberation in 1955. Research is being carried out on the species at the lake. The work will be very important in maintaining the cod's status as a sporting fish. The largest fresh-water species in Australia, it is known to have attained 90 kg in weight and 180 cm in length.

Percolates colonorum

Able to exist in fresh or salt water, the estuary perch is a sporting fish that grows up to 50 cm long, and sizeable populations are found in the lower reaches of coastal streams.

Macquaria australasica

The Macquarie perch is one of the best native fresh-water sporting fish. It is becoming rare as various forms of rural land use, and pollution and utilization of water resources, change the character of streams. There is a small population of this species in the Wannon River between the Wannon and Nigretta Falls. Its maximum length is around 45 cm.

Acanthopagrus butcheri

The black bream is an important sporting fish found in the Eumeralla estuary. It can attain 55 cm in length.

Galaxias maculatus
G. olidus
Galaxiella pusillus

The common and ornate mountain galaxiids are important "forage" fish widespread in the study area - from the headwaters of streams to their estuaries, as well as in lakes. *G. maculatus* is one of the species marketed as "whitebait". *G. olidus* is likely to be found in the upper reaches rather than downstream. *G. pusillus*, the dwarf galaxiid, is presumed to be scarce. Its distribution is not well known. The first species can reach 20 cm in length; the others are 10 cm at most.

*Perca fluviatilis***

The English perch or redfin is mainly found north of the Divide, where it is very common. It is an important sporting fish and grows to around 40 cm.

*Gambusia affinis***

The mosquito fish was introduced to Victorian waters on the basis of its stated preference for mosquito larvae when feeding. This has not been adequately proved in Australia and although now a "forage" fish it competes with native "forage" species for food and space. It grows to 4 cm.

*Salmo gairdneri***
*S. trutta***

These are the most important sporting fish south of the Divide in fresh water. Both the rainbow and brown trout populations in the study area must be maintained by liberations of hatchery-produced yearling fish. They have been taken up to 60 cm in length.

*Carassius auratus***
*C. carassius***
*Tinca tinca***

The goldfish, crucian carp, and tench are important "forage" fish species when very young, but of nuisance value only when older. None of these species presents the problem that *Cyprinus carpio*, the common carp - not at present known in the study area - causes in other Victorian inland waters. These species respectively attain 40 cm, 45 cm, and 35 cm in length.

* These native species are presumed to have been absent from the Wimmera River before European settlement. It is, however, possible that the Wimmera once entered the Murray system, in which case it would have had a similar fish fauna. Relict populations may have remained in the Wimmera River after it became a separate inland drainage basin.

** These species were introduced from overseas.

Information taken from: Barnham, Charles. "A Guide to Freshwater Fish of Victoria." (Ministry for Conservation: Melbourne 1978.)

Appendix 3F

FRESH-WATER CRAYFISH

Several species of native crustacean, collectively termed "yabbies", occur extensively throughout the study area. They are important for recreation - yabbying is a popular pastime in western Victoria.

Cherax albidus	Found in farm dams
C. destructor	Found in farm dams - the most common yabbie
Euastacus bispinosus	Found in streams
Geocherax falcata	Found in streams
Granastacus insolitus	Endemic to a few swamps and creeks south-west of Moyston
G. gracilis	Found only in Dwyer Creek
Engaeus spp.	Found near streams draining the Grampians

Appendix 4

WETLAND SURVEY

The study area contains about 140 wetlands. They are shown on Map 12 - most are in the north-west of the study area. Wetlands are especially valuable for nature conservation as they provide specialized habitat for a large group of birds, some mammals, and fish and crustaceans.

Many wetlands in Victoria have been drained, increasing the importance of those that remain. The larger and more permanent wetlands are also important for recreation - fishing, swimming, boating, and water-skiing.

A survey of the wetlands was undertaken during the 1977--78 summer to collect information to help make decisions on the best future use of each area. The survey was done by Lex Thomson (University of Melbourne) under the supervision of John Taylor.

The wetlands on public land were identified using air photos (some small wetlands were grouped), and given serial numbers. Information on each was collected from departmental files and plans, from the literature, and by talking to the field staff of the wildlife, forestry, and lands departments and to farmers and other local people who know and use the wetlands. Each wetland was visited, and physical and biological data were recorded. A full report of the survey is held in the library of the Land Conservation Council.

Wetland classification

The classification is derived from studies of wetlands in other parts of Victoria, and has been constructed to produce natural groupings of wetlands for this region. Table A shows the basis of the classification.

The Survey

The results of the survey are set out in Table B.

Two of the items shown in the table require explanation.

The conservation rating refers to the value of each wetland for the conservation of water-birds. It was calculated by giving each wetland ratings of very high, high, moderate, low, or zero, for:

(i) use for feeding and shelter in normal years
(ii) use for feeding and shelter in dry years
(iii) use for breeding

These ratings were combined to give the conservation rating, as follows:

1. Receives very high water-bird use according to at least one of the three indices.
2. Receives high water-bird use according to at least two of the indices, or high usage according to one index and moderate according to the other two.
3. Receives two ratings of moderate water-bird usage (or equivalent) rating.
4. Receives two ratings of low water-bird usage (or equivalent) rating.
5. Very limited water-bird usage (no breeding; drought refuge).

Recreation rating

This is based primarily on the extent of present use of each wetland for recreation, and thus reflects not only the characteristics of the wetland, but also ease of access and presence of facilities. Most of the forms of recreation use considered here are water-dependent, although picnicking and camping have been included. Many lakes and swamps, especially those located near roadsides, provide scenic amenity, and this too has been taken into account in the ratings.

These recreation ratings are subjective; they were allocated as follows:

1. Often used for two or three forms of recreation.
2. Receives some use for one or two forms of recreation.
3. Little or no recreational use.

Table A

CLASSIFICATION OF WETLANDS

Category	Inundation	Depth (m)	Salinity (mg/l T.D.S.)	Vegetation
Fresh-water meadow	4--6 weeks	< 0.3	< 3500	Short sedges and rushes, grass, scattered trees (red gums)
Shallow fresh-water marsh	3--4 months	< 1.5	< 3500	Often contains cane grass and other emergents
Deep fresh-water marsh	Holds some water throughout most years	1.5--2.5	< 3500	Variable: clear water may contain plentiful submerged aquatics, or emergent spike-rush or water ribbons; growth of submerged aquatics is limited in turbid water
Open fresh water	Permanent, or dries up rarely	> 2.5	< 3500	Submerged aquatic plants, limited in many cases by muddy water; fringing rushes or cane grass
Brackish wetlands	Most are permanent, or dry up in drought years only	2--3	3500--8500	Submerged aquatics - milfoil and sea tassel are the most common; cane grass on edges
Saline wetlands	Most dry up in summer - the deeper ones are permanent	1--2	> 8500	Sea tassel (vegetation is absent from some of the shallow lakes near Douglas and Mount Arapiles)

Table B

WETLANDS

Notes relating to columns 1 to 6

1. In cases where the wetlands extend onto private land, the area of the wetland occurring on private land is shown in brackets.

2. The water regime for wetlands in the study area varies greatly from year to year.

   P - Permanent water bodies (i.e., normally hold water for periods of more than 10 years. Those that dried up in the 1967--68 drought are shown ('67) and/or ('68).

   2--10 - Average frequency of filling, in years. Figures in brackets represent the average period of water-holding, in years.

   A - Annual filling - generally dry up each year. The average period of water-holding in months is shown in brackets.

   D - Drained

   R - Rarely filled - approximately every 20 years.

3. See Table A for the characteristics of each category. Where the lake-bed vegetation covers a substantial area, the dominant plant species is shown in brackets.

4. B = Boating; C = Camping; D = Duck-shooting; F = Fishing; NH = Natural history; P = Picnicking; Sc = Scenic amenity; SW = Swimming; T = Trail-bike riding; W = Water-skiing; Y = Yabbying

   (Brackets indicate minor uses.)

   See preceding for the derivation of the recreation rating.

5. See preceding for the derivation of the conservation rating.

6. G = Grazing; S = Salt collecting; DWS = Domestic water supply; C = Conservation; R = Rubbish dumping (illegal activity); PO = Permissive occupancy; B = Bee-keeping; I = Irrigation; WS = Water supply; P = Plantation (Education Department); T = Timber production

Table B

Serial number	Name	1 Area (public land) ha	2 Water regime	3 Category	4 Recreation		5 Conservation rating	6 Other uses
					Uses	Rating		
G1	Mullinger Swamp	25 (8 in S.A.)	P	open fresh water	P,(D)	2	1	G
G2	Leah Swamp	163	5(3--4)	deep fresh-water marsh	D,(F)	2	2	G
G3	Jaie Jaie	39	5(3--4)	shallow fresh-water marsh	(D)	3	4	G
G4	Newlands Lake	138		open fresh water	F,S,(D)	1	1	
G5A	Lake Bringalbert	95	P	open fresh water	F,B, (C,W)	1	4	B
G5B	Dumbopperty Swamp	80(25)	10(8--9)	open fresh water (water milfoil)	D,NH	2	1	
G6	Lake Charlegrark	50	P	open fresh water	F,C,B, W	1	4	DWS
G7	Winter Lake	120	A(10)	shallow fresh-water marsh (cane grass)	D	3	3	G
G8	Nowhere Else Swamp	Approx. 150	A(9),P	open fresh water	D,Y,(F)	2	1	
G9	School Swamp	30	8(6--7)	shallow fresh-water marsh (water milfoil)	D	1	2	G

G10		87	P('67)	open fresh water (eel grass)	D	1	1	
G11	Lake Yampitcha	69	P('67)	open fresh water (water-milfoil)	D (B,F)	1	2	G DWS
G12	Sheepwash	10(15)	P	open fresh water (eel grass)	D(F)	1	1	
G13	Lake Morea	90(5)	P('67)	open fresh water	(D)	3	2	G
G14	Lake Carpolac	20	P	open fresh water	F,B,(W, D,P)	1	3	G,I
G15	Broughton's Waterhole	25	P	open fresh water	B,(F,D)	2	2	G
G16		13	P	brackish wetland	(D)	3	2	
G17	Colins Lake	23(7)	P	open fresh water	F(D,B)	1	4	G,DWS
G18	Alakilu Swamp	75	A(3-4)	shallow fresh-water marsh (cane grass)		3	4	G
G19	Lake Yallakar	275	P('67)	open fresh water	(F,D, B,W)	2	2	G
G20	Lake Cocumbul	47	4(2-3)	shallow fresh-water marsh	(D)		4	G
G21A	Lake Ratzcastle	28	P	open fresh water	D,F,P, (SW)	1	2	DWS,G
G21B	Kangawall Lagoon	14	5(4)	deep fresh-water marsh	D,P	1	2	G
G22	Maryvale (plus a narrow portion of Lake Charam)	70 10(28)	P	open fresh water	B,F,D,Y	1	3	G,I

G23		75	A(9-12)	shallow fresh-water marsh (cane grass)	D,Y	1	3	G
G24		18		deep fresh-water marsh (water-milfoil)	D,Y,(F)	1	1	G
G25		16	P('67)	open fresh water	D,Y	1	3	G
G26	Brig Brig Swamp	37(18)	P	deep fresh-water marsh (spike-rush)	(F,D)	2	1	G,WS
G27A		8	I	fresh-water meadow		3	4	
G27B		13	A(4-5)	shallow fresh-water marsh	(D)	3	3	
G29	Booroopki Swamp	455	P('67)	open fresh water	C,F,B,(D)	1	3	G
N1	Macfarlanes Marsh	87(30)	A(6-8)	shallow fresh-water marsh	D	2	3	G
N2	Lake Koynock	60	A(6-8)	shallow fresh-water marsh (cane grass)	Y,D	1	1	G
N3	Lake Karnak	163	A(6-8)	deep fresh-water marsh (cane grass)	Y,D,(T)	1	1	G
N4	Murranbool Swamp	85	8(6-7)	shallow fresh-water marsh	D,Y,(P)	1	2	G
N5A	Donkey Woman	7	P('67, '68)	deep fresh-water marsh	D,Y	2	3	G
N5B		15	A(6)	shallow fresh-water marsh (cane grass)	(D)	3	3	G
N6		50	6(4-5)	deep fresh-water marsh (cane grass)	D	2	3	G

N7	Bates Lake	45	6(4--5)	open fresh water	D,Y(C)	1	3	
N8	White Lake	25	A(5--6)	saline wetland		3	3	G
N9		28	P('67)	open fresh water	D,B,(F,W)	1	3	G,B
N10		29	P('67)	open fresh water	(C,F,S, Y)	2	3	
N11		23(22)	A(6)	shallow fresh-water marsh (cane grass)	(D)	3	3	
N12	Lake Miga	130	P	open fresh water	(D)	3	3	
N13		34	A(9)	shallow fresh-water marsh (cane grass)	(D)	3	3	G
N14	Jilpanger Springs	10	P	open fresh water (50%); deep fresh-water marsh (spike-rush)	D,F,C	1	1	
N15	Mewett Swamp	13	A(5--6)	saline wetland		3	3	B
N16A		17	A(9--12)	shallow fresh-water marsh	(D)	3	3	G
N16B		2	A(2--3)	shallow-fresh-water marsh	(D)	3	4	G
N17	St. Marys Lake	94	P('67)	open fresh water	Sc,P,C, B,F,W(D)	1	1	WS G
N18		100	6(4--5)	saline wetland	(D)	3	3	S
N19		38	A(8--10)	saline wetland	(D)	3	4	R
N20A	Jaka Lake	16(30)	P('67)	saline wetland	NH,Sc, (D)	1	1	G

N20 B,C,D		45	A(9--12)	saline wetland	D	1	1	G
N21	Heard Lake	135	A(9--12)	saline wetland	(D)	2	3	
N22	Lake Carchap	89	P	brackish wetland		3	2	G,C
N23	Bow Lake	170	A(9--10)	saline wetland		3	4	S,B
N24	Mobla Lake	170	A(3--4)	saline wetland	C	2	3	B
N25A	Green's Swamp	7	6(4--5)	deep fresh-water marsh (spike-rush)	D	2	1	G
N25B	Lake Copper Colour	160	A(5)	saline wetland		3	4	
N26	Lake Clarke	105	P('67, '68)	saline wetland	D	2	2	G
N27	Boundary Swamp	125	A(6--8)	shallow fresh-water marsh	(D)	3	3	G
N28	Clear Lake	150	P	open fresh water	Y,B,P,Sc	1	3	G,P
N29		25	A(2--5)	shallow fresh-water marsh (cane grass)	(D)	3	3	G
N30	Red Gum Swamp	195	P('68)	open fresh water	Y,D	1	3	G
N31	Toolondo Reservoir	1,240	P	open fresh water	F,S,B,W, D,C,P	1	2	WS
N32	Jallumba Marsh	77	A(2--3)	shallow fresh-water marsh (cane-grass)	(NH)	3	4	G
N33		9	A(2--3)	brackish wetland		3	4	
H1	Connangorach Swamp	170	8(6--7)	shallow fresh-water marsh	(D)	3	3	G

H2		30(15)	5(2--3)	deep fresh-water marsh	(D)	3	3	G
H3		18	2(6--9)	shallow fresh-water marsh (cane grass)	(D)	3	4	G
H4	Donald Swamp	50	A(6--8)	shallow fresh-water marsh (cane grass)	(D)	3	3	G
H5	Kingcourt Swamp	24	A(3--6)	shallow fresh-water marsh (cane grass)	(D)	3	4	G
H6	Dock Lake	214	P	open fresh water	F,(D)	2	1	WS
H7	Green Lake	174	P	open fresh water	B,F,W, SW,P	1	4	WS
H8	Pine Lake	728	P	open fresh water	F,D,SW	1	4	WS
H9	Taylor Lake	670	P	open fresh water	F,D, (SW)	2	4	WS
E1		35	R(D)	shallow fresh-water marsh		3	4	
E2		88	5(4)	shallow fresh-water marsh (cane grass)	(D)	3	3	G
E3A		10	P('67)	shallow fresh-water marsh (twig-rush)		3	2	G
E3B		10	P('67)	fresh-water meadow		3	4	
E4	Dip Swamp	17(9)	A(9--12)	shallow fresh-water marsh	(D)	3	3	
E5		20	P('67)	deep fresh-water marsh (water-milfoil)	P,D	2	2	

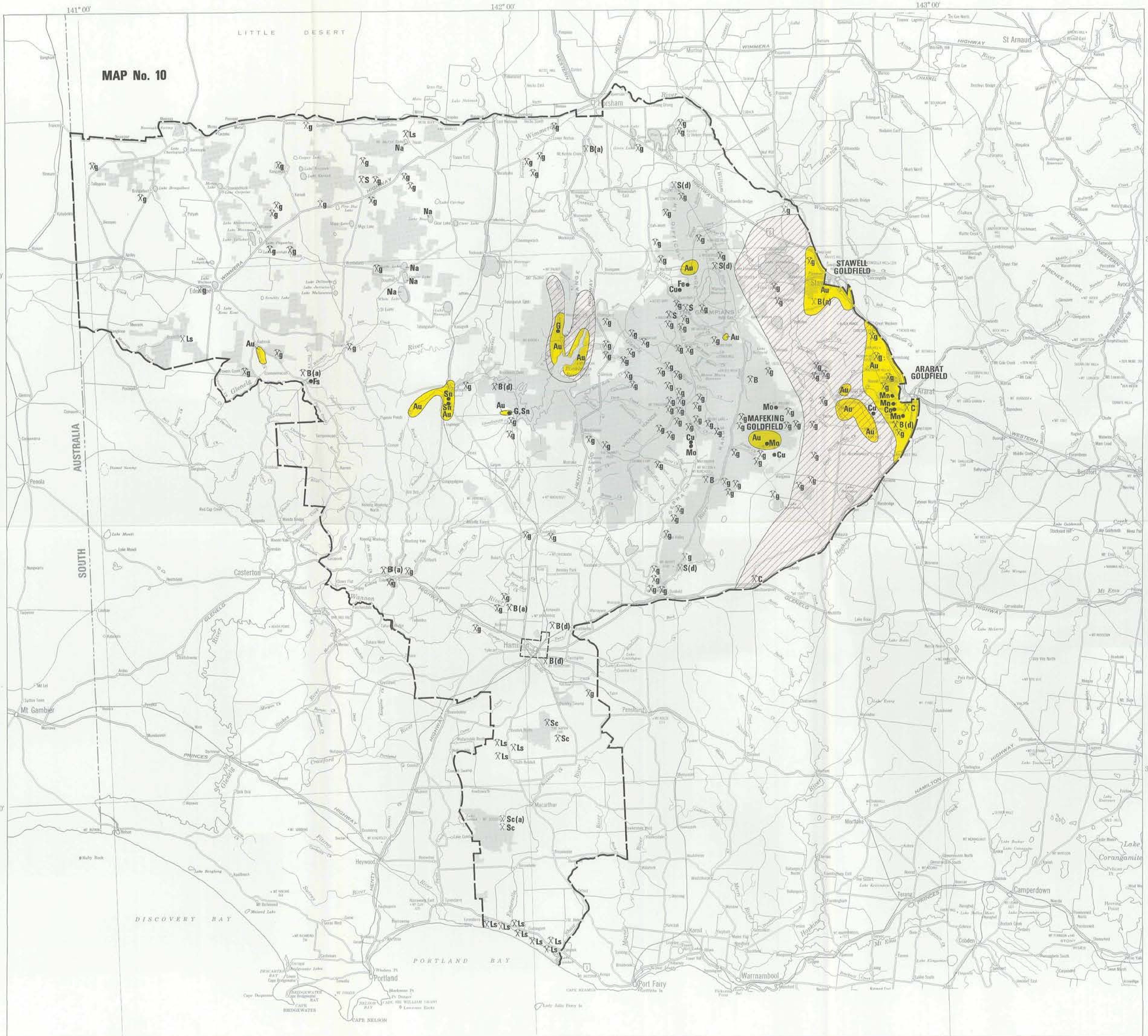
E6	Lake Wallace	194	P	open fresh water	F,B,W, SW,NH, P,C,Sc	1	1	WS
E7		25	7(6)	brackish wetland (water-milfoil)	(D)	3	1	G
E8	Kurrayah Camping & Water Reserve	40	10(9)	deep fresh-water marsh (water-ribbons)	D	2	1	G
E9	Lake Kemi Kemi	70	P	saline wetland	(D)	3	2	G
E10	Hurley's Bank	21	P	deep fresh-water marsh (water-milfoil)	Sc,(D)	2	2	G
E11	Scrubby Lake	32	P	deep fresh-water marsh	NH,(P)	2	4	
E12A		20	A(6--8)	shallow fresh-water marsh		3	3	B
E12B		15	A(9--11)	shallow fresh-water marsh (twig-rush)		3	3	B
E12C	Bunyip	10	P	deep fresh-water marsh (spike-rush)	D	2	2	B
E12F	Duckholes	15	P	shallow fresh-water marsh (spike-rush)	D(NH,Sc)	1	1	B
E13	Pot Brook	62	P	open fresh water	D	1	1	G
B1	Lake Dewabbin	25	P	open fresh water (water-milfoil)	(D)	3	2	G
B2	Lime Kiln Lake	14	P('67)	deep fresh-water marsh (submerged aquatic growth)	(F,Sc, SW,W)	2	2	G
B3	Lake Dollanoke	50	P	open fresh water	D,W,B,Y, (SW,F)	1	3	G

B4	Lake Jarracteer	40	P('67)	open fresh water	SW,D,W, B,(F),Y, P	1	1	G
B5	Lake Mullancoree	50	P('67)	saline wetland	(D)	3	1	G
B6	Lake Coppa Culla	90	A(9--12)	deep fresh-water marsh (spike-rush)	(D)	2	2	
B7	The Stony	25	A(6)	shallow fresh-water marsh (marshflower)	Sc,T,(D)	2	3	
B8	Swanee Lake	22	P('68)	open fresh water	D,(W,SW)	2	2	
B9		18	A(4--5)	saline wetland	(D)	3	3	
B10		25	A(6--7)	saline wetland	(D)	3	3	
B11	North Lake	225	A(9--10)	saline wetland		3	3	S,G,B
B12	Centre Lake	240	A(8--9)	saline wetland	NH	3	1	S,G
B13	White Lake	600	5(4)	saline wetland	NH,(D)	2	1	
B14		13	A(6--7)	saline wetland		3	3	S,G
B15		45	P('67)	saline wetland		3	3	
B16		19	P('67)	brackish wetland	(D)	3	1	
B17		15	P('67)	brackish wetland	(D)	3	1	G
B18A		10	A(6)	shallow fresh-water marsh	(D)	3	4	G,B
B18B		9	A(6)	shallow fresh-water marsh	(D)	3	4	G,B
B19	Lake Kanagulk	430	P	deep fresh-water marsh	D,Y	1	1	

B20	Black Swamp	130	5(4)	shallow fresh-water marsh (rush)	(D)	3	1	G
B21	Konong Wootong Reservoir	116	P	open fresh water	F,B,P	1	3	WS
B22	Rocklands Reservoir	6,600	P	open fresh water	B,F,P,C, D,Sc	1	3	WS
W1	The Green Swamp	81(20)	P('67)	shallow fresh-water marsh (water-milfoil)	(D,Sc)	2	1	G
W2		9	A(6--9)	saline wetland		3	4	G
Gr1		3	A(3)	fresh-water meadow		3	4	
Gr2	Victoria Lagoon	55	A(10--11)	shallow fresh-water marsh (twig-rush)	(D),Sc, P	2	2	
Gr3	Ming Ming Swamp	130	A(9--11)	shallow fresh-water marsh (twig-rush)	(Sc)	3	3	G,C
Gr4		103	A(9--11)	shallow fresh-water marsh (sword-sedge)		3	3	G,C
Gr5	Moora Moora Reservoir	486	P	deep fresh-water marsh (water-milfoil)	(Sc), NH, F,P	1	2	B,WS
Gr6	Wartook Reservoir	1030	P	open fresh water	F,B,P, Sc	1	4	WS
A1	Lake Bellfield	476	P	open fresh water	Sc,F,P,B	1	5	WS
A2	Lake Fyans	526	P	open fresh water	F,C,B,S, (D,Sc)	1	3	WS
A3	Lake Lonsdale	2620	1	open fresh water	F,C,B,SW P,D	1	4	WS

A4	Lake Muirhead	330 (280)	P('67)	brackish wetland	D,NH, (Sc)	1	1	G
A5	Mount William Swamp	630 (490)	A(5--7)	shallow fresh-water marsh (cane grass)	(D)	3	4	G
A6	Lake Buninjon	230	P	brackish wetland	F,B,C, P,(D)	1	2	G
Ha1	Bryan Swamp	640	A(6--7)	shallow fresh-water marsh	NH,D	1	1	C
Ha2A		52	A(6--8)	saline wetland		3	5	G
Ha2B	Freshwater Lake	30	P('67)	open fresh water (water-milfoil)	P,C,NH, F,D,Sc	1	1	DWS
Ha3	Brady Swamp	240 (200)	A(6--9)	shallow fresh-water marsh	D	3	2	G
Ha4	Walker Swamp	20(20)	1	shallow fresh-water marsh	(D)	3	3	PO
P1	Lake Surprise	8	P	open fresh water	Sc,F,NH	1	3	C
Wa1	Yambuk Lake	70	P	brackish wetland	F,B,SW, C,P	1	2	

F. D. Atkinson, Government Printer, Melbourne



MINING AND QUARRYING

LAND CONSERVATION COUNCIL

VICTORIA

SOUTH WESTERN STUDY AREA DISTRICT 2

LEGEND

METALLIC MINERALS

- Au — Gold-field
- • Cu — Copper
- • Mo — Molybdenum
- • Mn — Manganese
- • Co — Cobalt
- • Fe — Iron
- • Sn — Tin

NON-METALLIC MINERALS

- Na — Salt
- • G — Gemstones
- • Fs — Feldspar, mica
- Region with potential for further discoveries of minerals

EXTRACTIVE INDUSTRIES

- B — Hardrock quarry (basalt, trachyte, rhyodacite, granite, sandstone)
- S — Sandstone quarry (building stone)
- Sc — Scoria quarry
- Ls — Limestone quarry or pit (see geol. map for occurrences of limestone)
- C — Clay quarry
- g — Gravel, sand pit (shallow excavations)
- (a) — Crushing plant producing aggregate
- (d) — Quarry disused

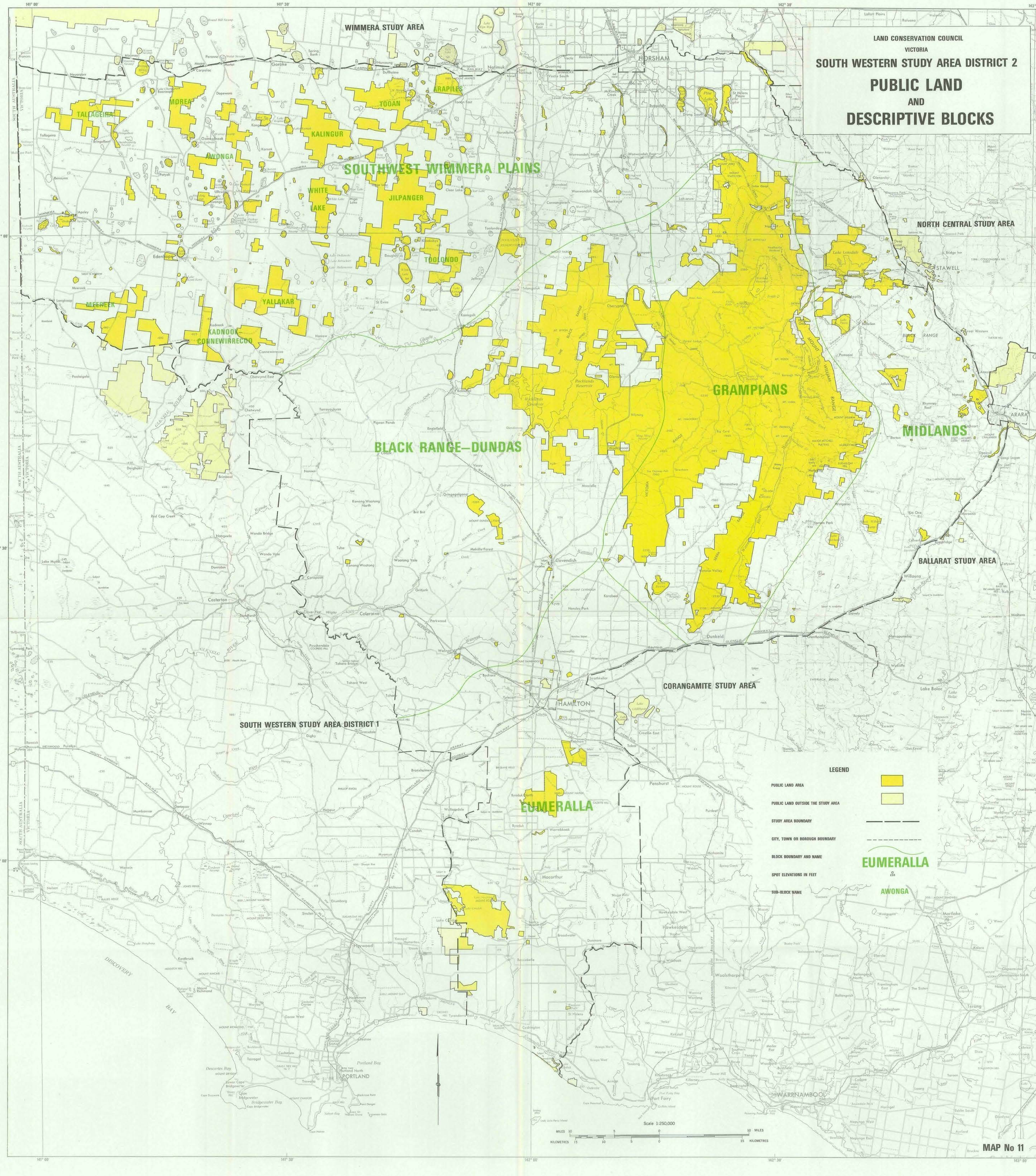
Public land (Note; many small areas of public land are not shown)

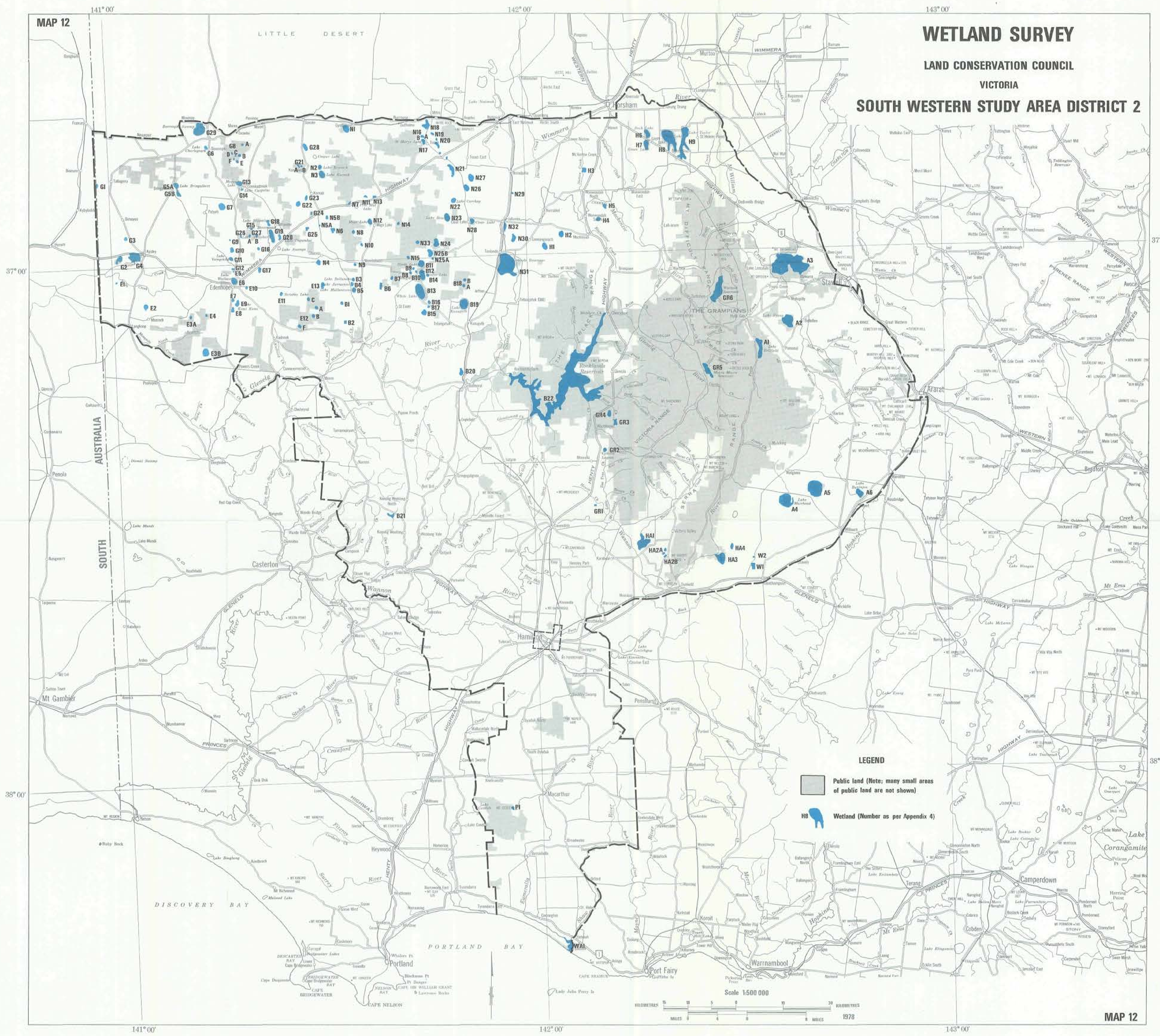
Scale 1:500 000

KILOMETRES 15 10 5 0 10 20 KILOMETRES

MILES 8 4 0 8 MILES

MAP No. 10

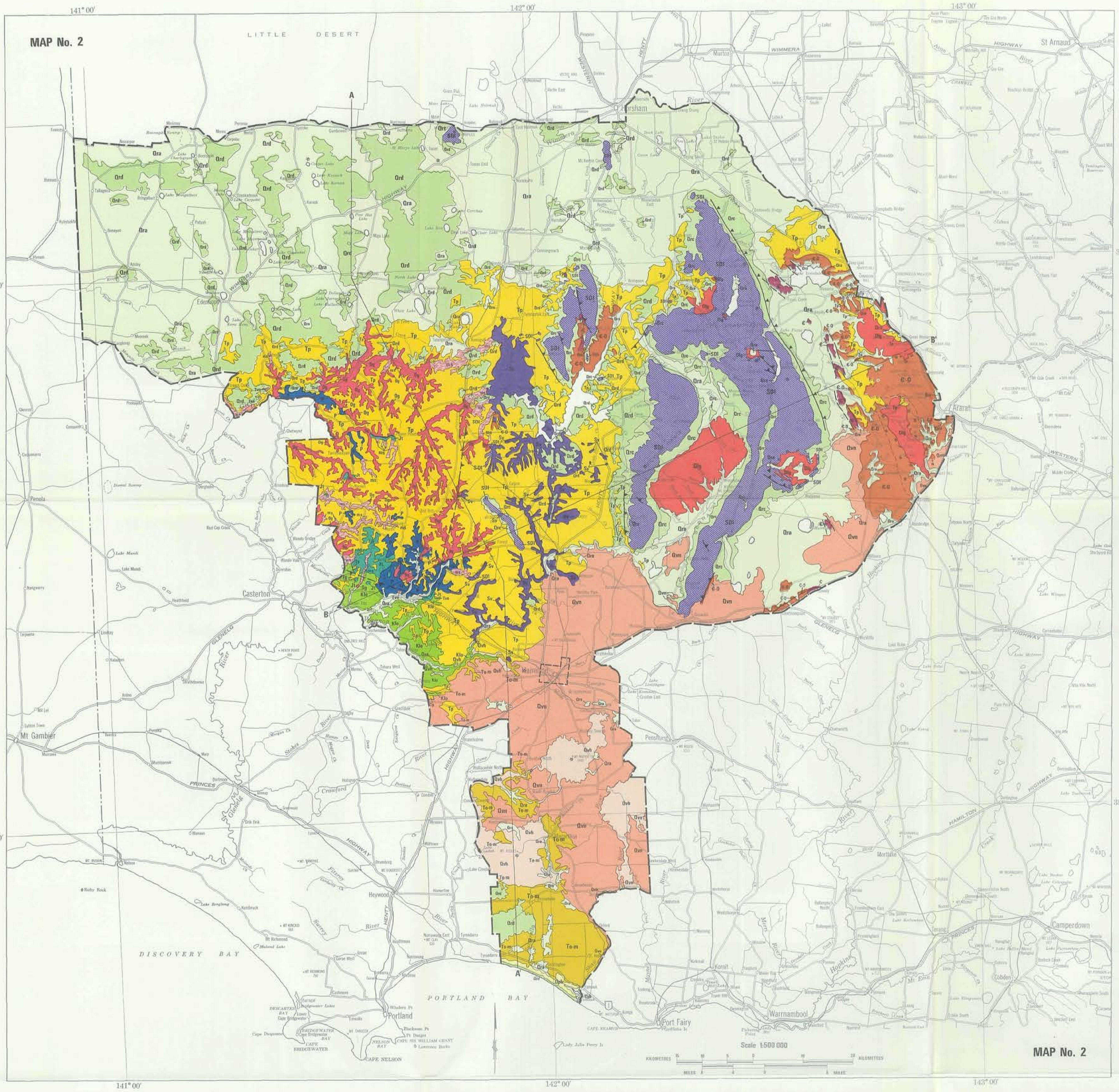

LAND CONSERVATION COUNCIL
VICTORIA
SOUTH WESTERN STUDY AREA DISTRICT 2
PUBLIC LAND
AND
DESCRIPTIVE BLOCKS
WIMMERA STUDY AREA
NORTH CENTRAL STUDY AREA
BALLARAT STUDY AREA
CORANGAMITE STUDY AREA
SOUTH WESTERN STUDY AREA DISTRICT 1
SOUTHWEST WIMMERA PLAINS
TALLAGEIRA
MOREA
AWONGA
KALINGUR
TOOAN
ARAPILES
WHITE LAKE
JILPANGER
TOOLONDO
YALLAKAR
MEEREEK
KADNOOK-CONNEWIRRECOO
GRAMPIANS
BLACK RANGE–DUNDAS
MIDLANDS
EUMERALLA
HORSHAM
STAWELL
ARARAT
HAMILTON
PORTLAND
WARRNAMBOOL
DISCOVERY BAY
LEGEND
PUBLIC LAND AREA
PUBLIC LAND OUTSIDE THE STUDY AREA
STUDY AREA BOUNDARY
CITY, TOWN OR BOROUGH BOUNDARY
BLOCK BOUNDARY AND NAME
EUMERALLA
SPOT ELEVATIONS IN FEET
SUB-BLOCK NAME
AWONGA
Scale 1:250,000
MILES
KILOMETRES
MAP No 11

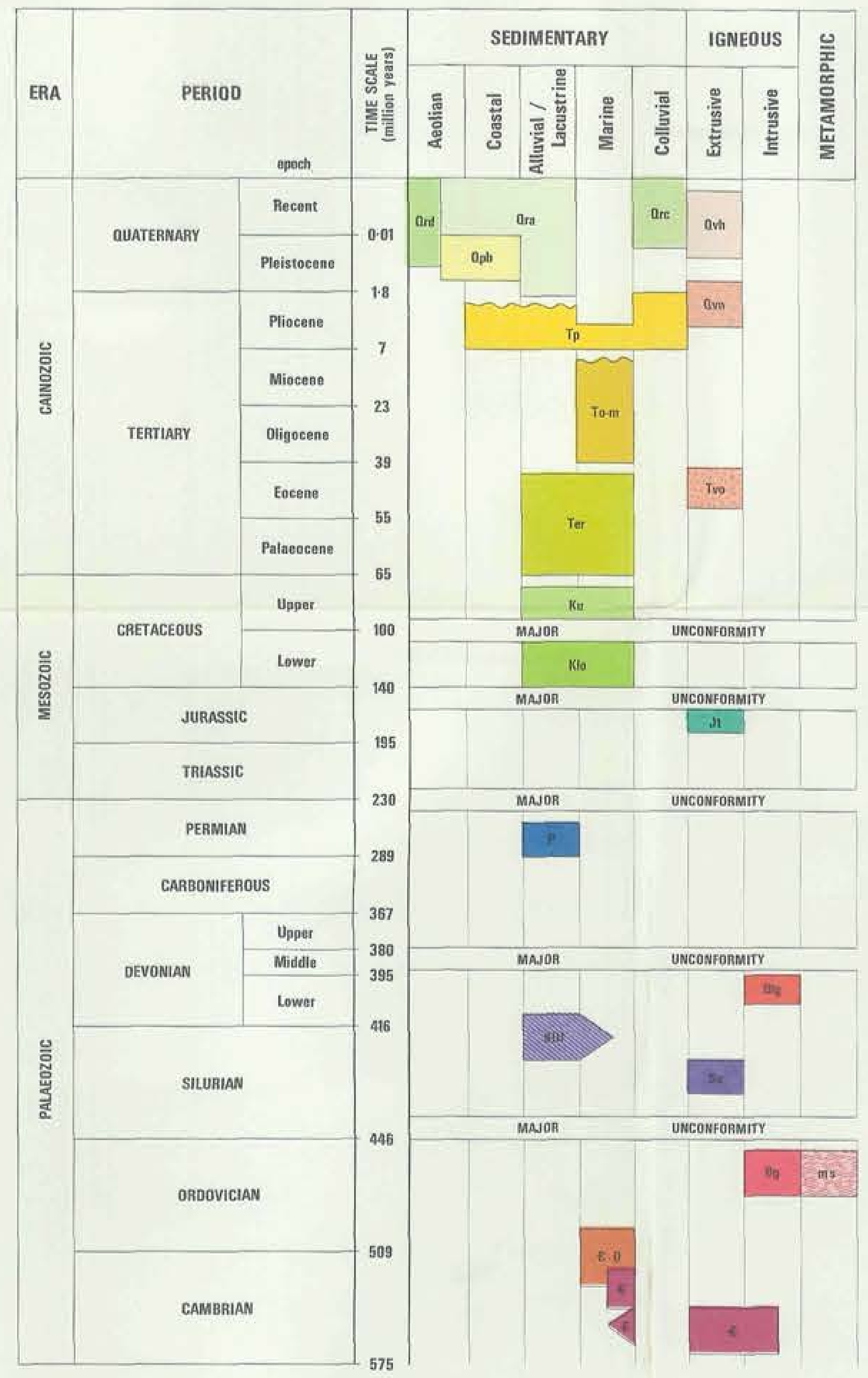

MAP 12
WETLAND SURVEY
LAND CONSERVATION COUNCIL
VICTORIA
SOUTH WESTERN STUDY AREA DISTRICT 2
LEGEND
Public land (Note; many small areas of public land are not shown)
H8 Wetland (Number as per Appendix 4)
Scale 1:500 000
KILOMETRES
MILES
1978
MAP 12
141° 00'
142° 00'
143° 00'
37° 00'
38° 00'
LITTLE DESERT
SOUTH AUSTRALIA
DISCOVERY BAY
PORTLAND BAY
THE GRAMPIANS
Rocklands Reservoir
Horsham
Stawell
Ararat
Casterton
Hamilton
Edenhope
Penshurst
Macarthur
Heywood
Portland
Port Fairy
Warrnambool
Camperdown
Mt Gambier
Nelson
Koroit
Penola
CAPE NELSON
CAPE BRIDGEWATER
Lake Corangamite

GEOLOGY

LAND CONSERVATION COUNCIL
VICTORIA

SOUTH WESTERN STUDY AREA DISTRICT 2





Sources: "The Otway Basin area of South Eastern Australia" (Geological Surveys of South Australia and Victoria Special Bulletin, 1971), and the Geological Survey of Victoria

	Qra	*River, lake and swamp deposits; sand, gravel, silt, clay, gypseous clay*
	Qrc	*Colluvium, scree, outwash deposits*
	Qrd	*Sand sheets and dunes of* Lowan Sand *and* Molangenee Sand *Lunettes of sand, silt, gypseous. Calcareous dune*
Newer Volcanics	Qvh	*Basalt, lava dome, stony rise and valley flow; tuff, scoria and ash*
	Qvn	*Basalt, lava, tuff, scoria*
Bridgewater Formation	Qpb	*Dune limestone, minor quartz sand, fossil soils*
	Tp	*Shallow marine and continental sandstone, siltstone. Includes* Parilla Sand *and* Dorodong Sand. *Laterite on various parent rocks*
Heytesbury Group, Murray Group	To-m	*Calcareous sand, limestone, marl, clay*
Older Volcanics	Tvo	*Basaltic lava, plugs*
Wangerrip Group, Renmark Group	Ter	*Subsurface units; sand, siltstone, shale, mudstone, dolomitic mudstone. Depositional environments range through marine, estuarine, swamp and alluvial*
Sherbrook Group	Ku	*Subsurface unit; siltstone, sandstone, thin coal*
Otway Group	Klo	*Feldspathic sandstone, mudstone, coal*
	Jt	*Trachyte*
Coleraine Glacials	P	*Tillite, fluvio-glacial sand, sandstone, varved clay*
	Dlg	*Granite, granodiorite, quartz porphyry*
Grampians Group	SDl	*Marine and non-marine quartz sandstone, siltstone, mudstone*
Rocklands Rhyolite	Sv	*Acid volcanics; porphyritic and banded rhyolite, rhyodacite, agglomerate, tuff*
	Og	*Granite, granodiorite*
	ms	*Schist, gneiss*
	Є-O	*Sandstone, mudstone (unfossiliferous). Contact metamorphosed around Ararat granite into aureole schist, gneiss and hornfels*
	Є	*Submarine basic lavas and intruded dykes (greenstones), with shale and chert*

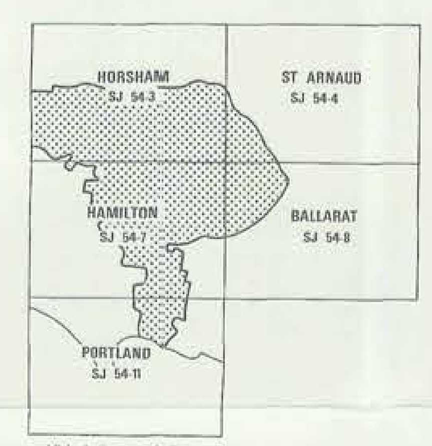
Fault

Reverse fault

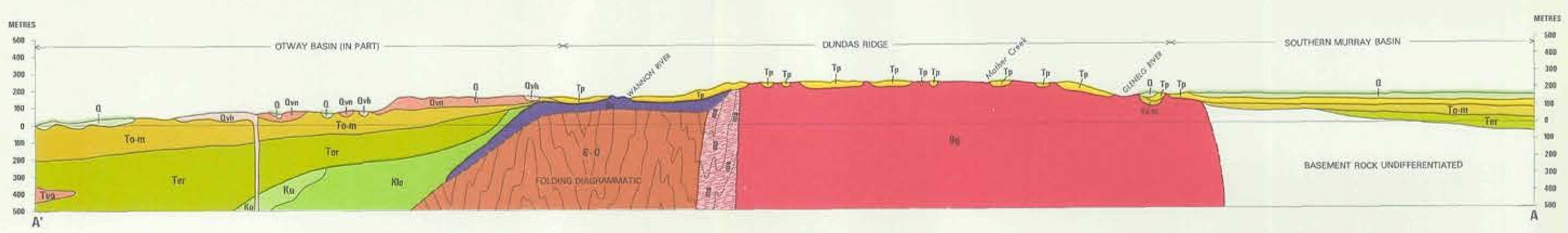
Fault inferred

m m m *Contact metamorphism*

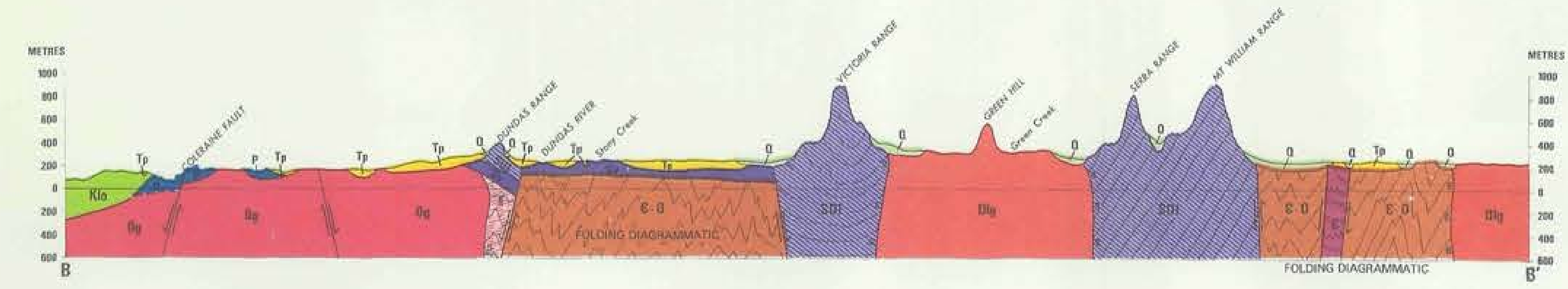
Geological feature



Key to published Geological Survey of Victoria 1:250 000 geological maps



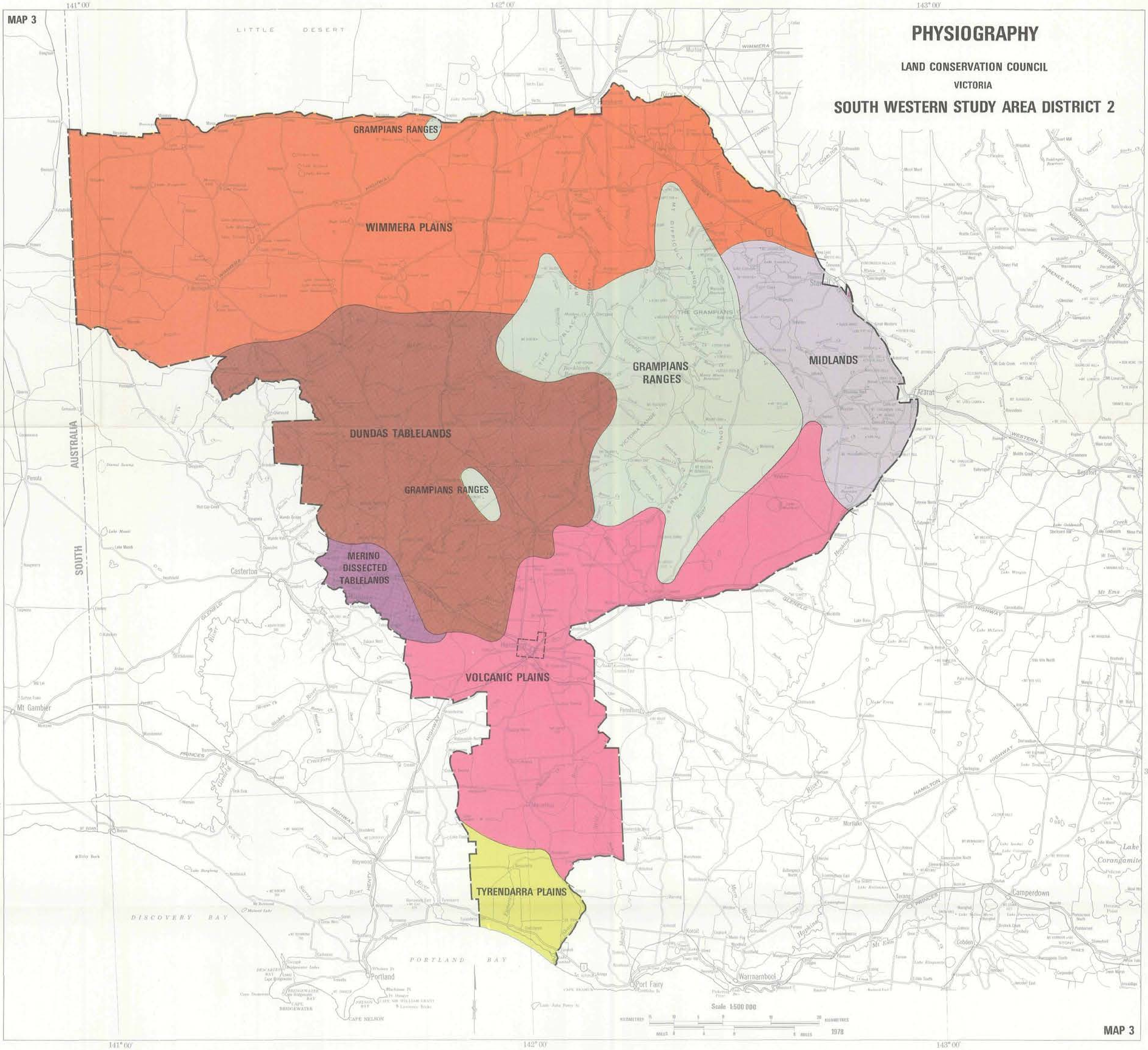
SECTION A'–A
HORIZONTAL SCALE 1:500,000
VERTICAL SCALE 1:25,000
VERTICAL EXAGGERATION 1:20

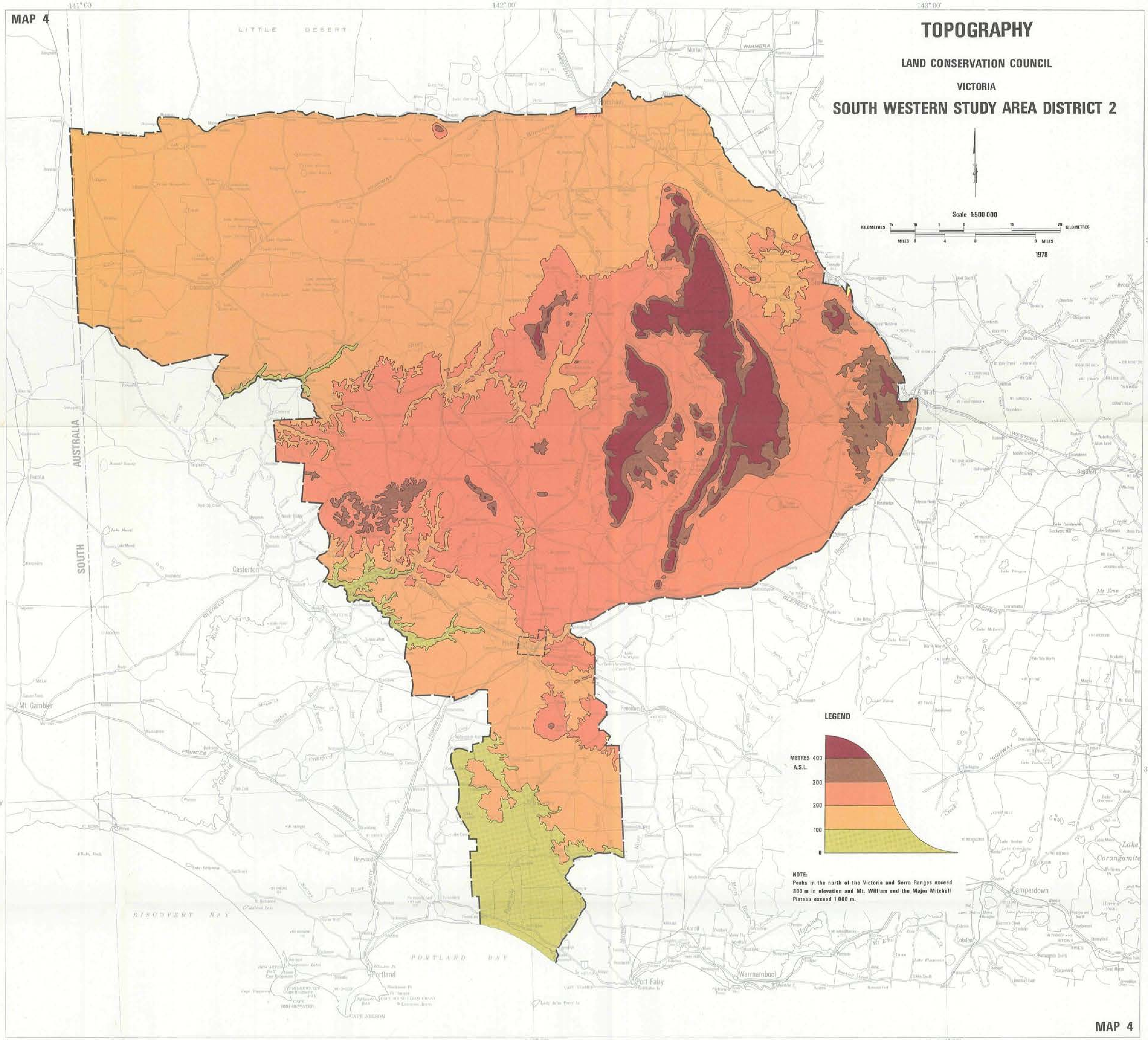


SECTION B–B'
HORIZONTAL SCALE 1:500,000
VERTICAL SCALE 1:50,000
VERTICAL EXAGGERATION 1:10

DIAGRAMMATIC SECTIONS

NOTE; *All Quaternary units (except volcanics) shown as Q on sections*


MAP 3
PHYSIOGRAPHY
LAND CONSERVATION COUNCIL
VICTORIA
SOUTH WESTERN STUDY AREA DISTRICT 2
WIMMERA PLAINS
GRAMPIANS RANGES
DUNDAS TABLELANDS
GRAMPIANS RANGES
MIDLANDS
GRAMPIANS RANGES
MERINO DISSECTED TABLELANDS
VOLCANIC PLAINS
TYRENDARRA PLAINS
LITTLE DESERT
DISCOVERY BAY
PORTLAND BAY
SOUTH AUSTRALIA
Mt Gambier
Casterton
Portland
Port Fairy
Warrnambool
Camperdown
Ararat
Lake Corangamite
Scale 1:500 000
1978
MAP 3

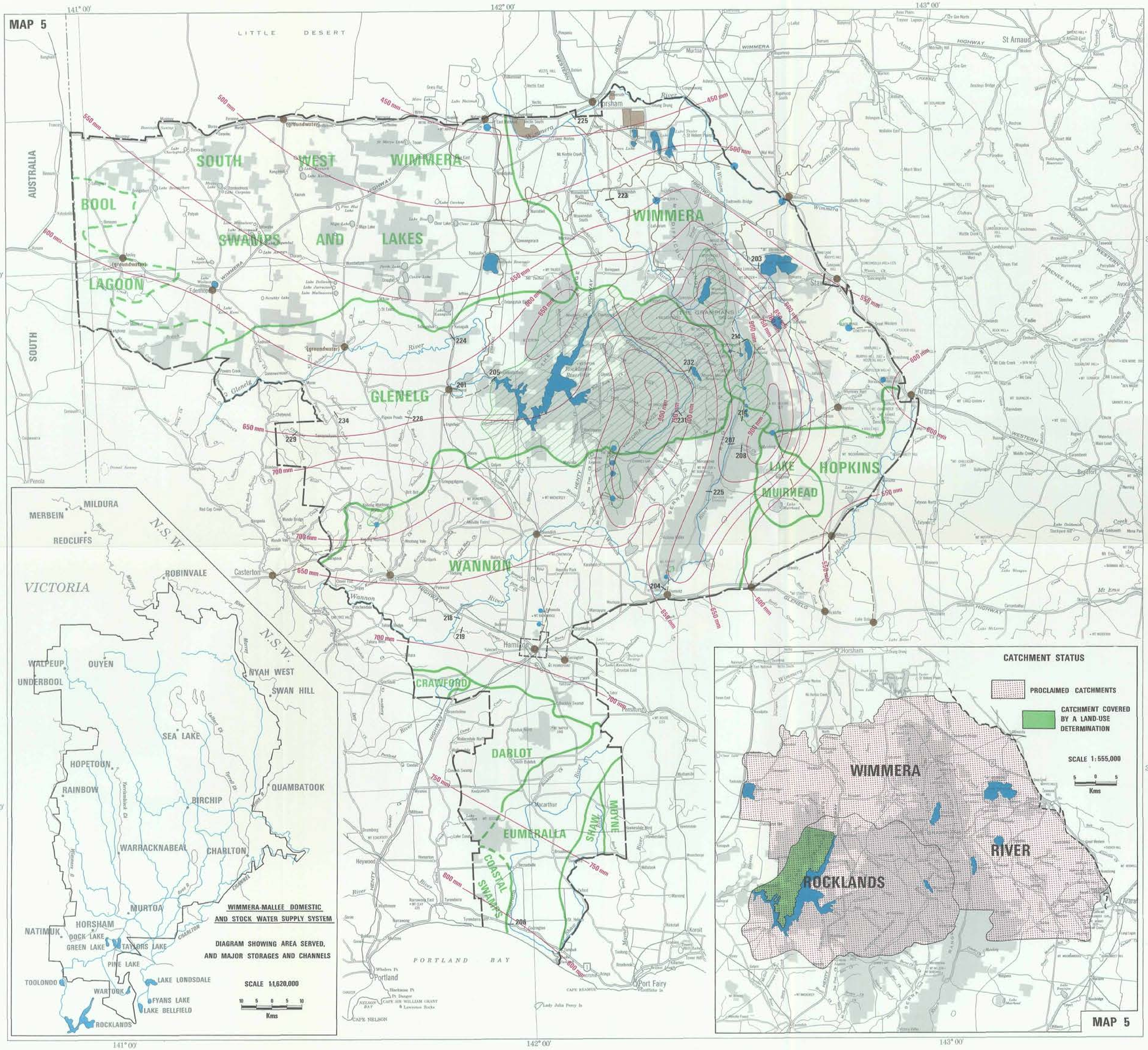

MAP 4
TOPOGRAPHY
LAND CONSERVATION COUNCIL
VICTORIA
SOUTH WESTERN STUDY AREA DISTRICT 2
Scale 1:500 000
KILOMETRES 15 10 5 0 10 20 KILOMETRES
MILES 8 4 0 8 MILES
1978
LEGEND
METRES A.S.L.
400
300
200
100
0
NOTE:
Peaks in the north of the Victoria and Serra Ranges exceed 800 m in elevation and Mt. William and the Major Mitchell Plateau exceed 1 000 m.
LITTLE DESERT
SOUTH AUSTRALIA
Horsham
Ararat
Casterton
Mt Gambier
Camperdown
Portland
Port Fairy
Warrnambool
DISCOVERY BAY
PORTLAND BAY
141° 00'
142° 00'
143° 00'
37° 00'
38° 00'
MAP 4

WATER RESOURCES AND UTILIZATION

LAND CONSERVATION COUNCIL

VICTORIA

SOUTH WESTERN STUDY AREA DISTRICT 2



Scale 1:500 000

KILOMETRES 15 10 5 0 10 20 KILOMETRES

MILES 8 4 0 8 MILES

LEGEND

RESOURCES

750 mm — Average annual isohyets (mm)

SHAW — River basins *

Major streams

226 — Stream gauging and salinity stations and numbers

UTILIZATION

Storages, offtakes, weirs, and diversions

Main channels **

Pipelines

Towns with reticulated water supply

Irrigation areas

CATCHMENTS

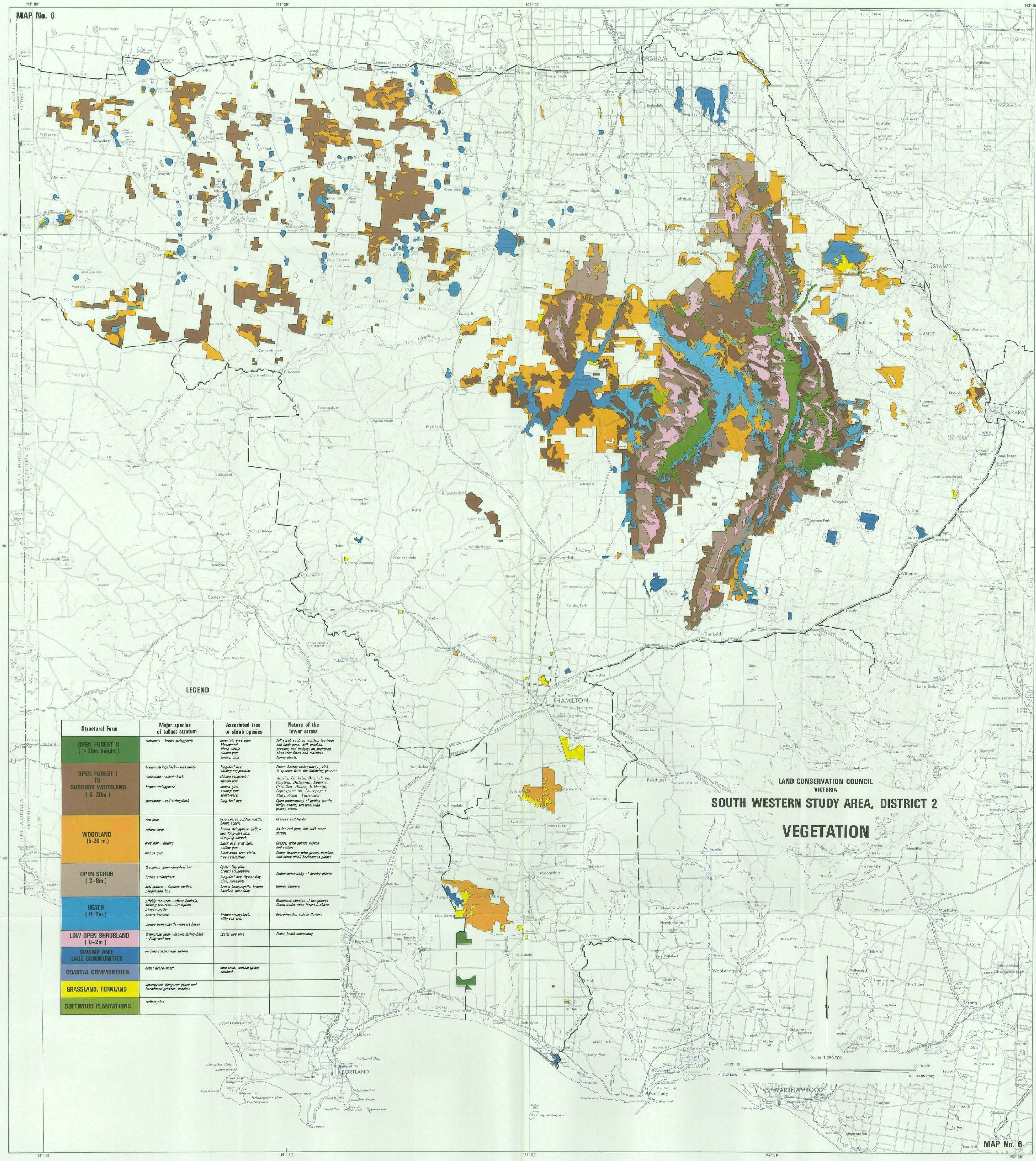
Major catchments of the Wimmera-Mallee Domestic and Stock System, and urban supply catchments

Public land (Note: Many small areas of Public Land not shown.)

* Broken line indicates that boundary is indefinite

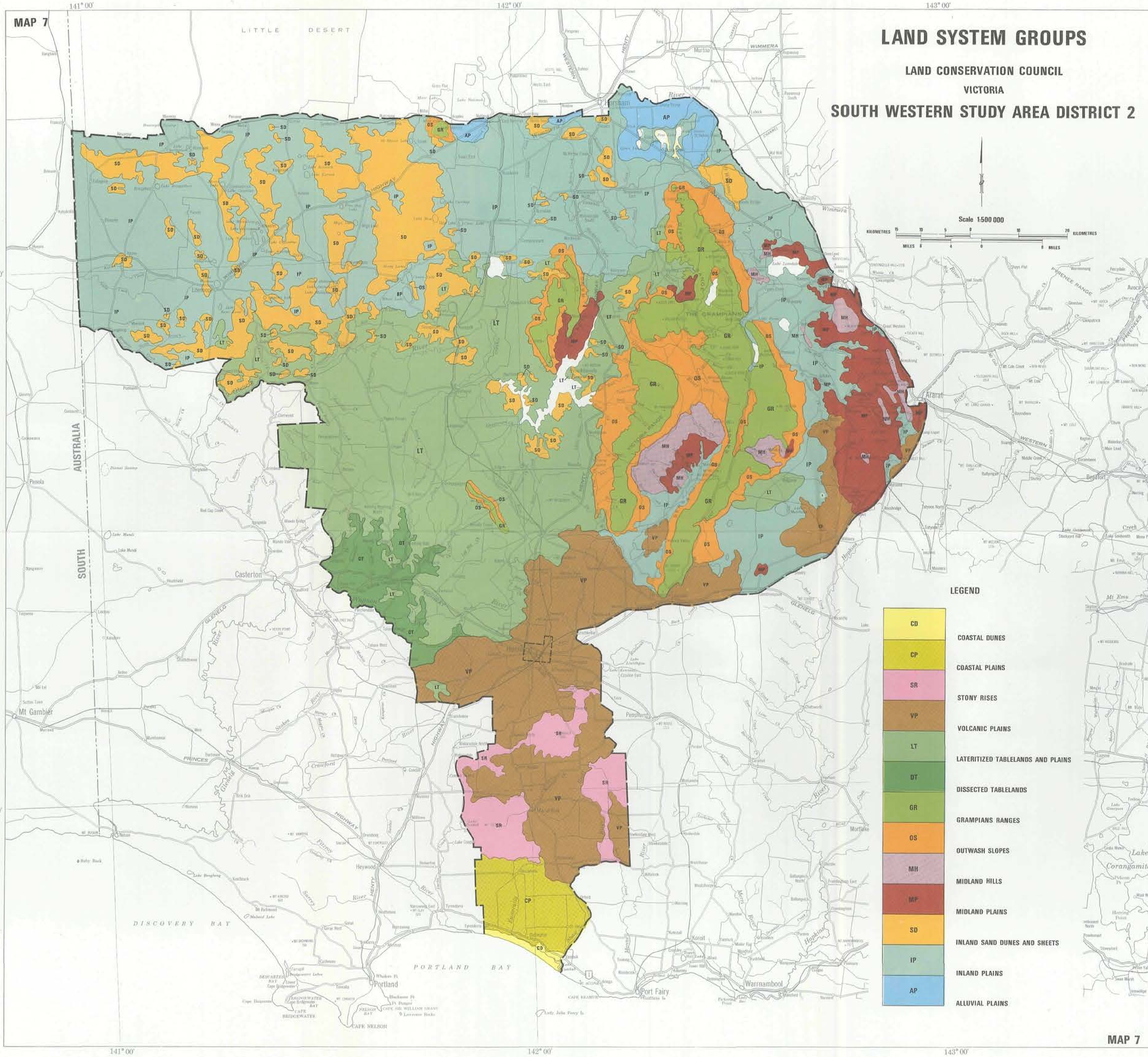
** Note that some streams are also used as channels

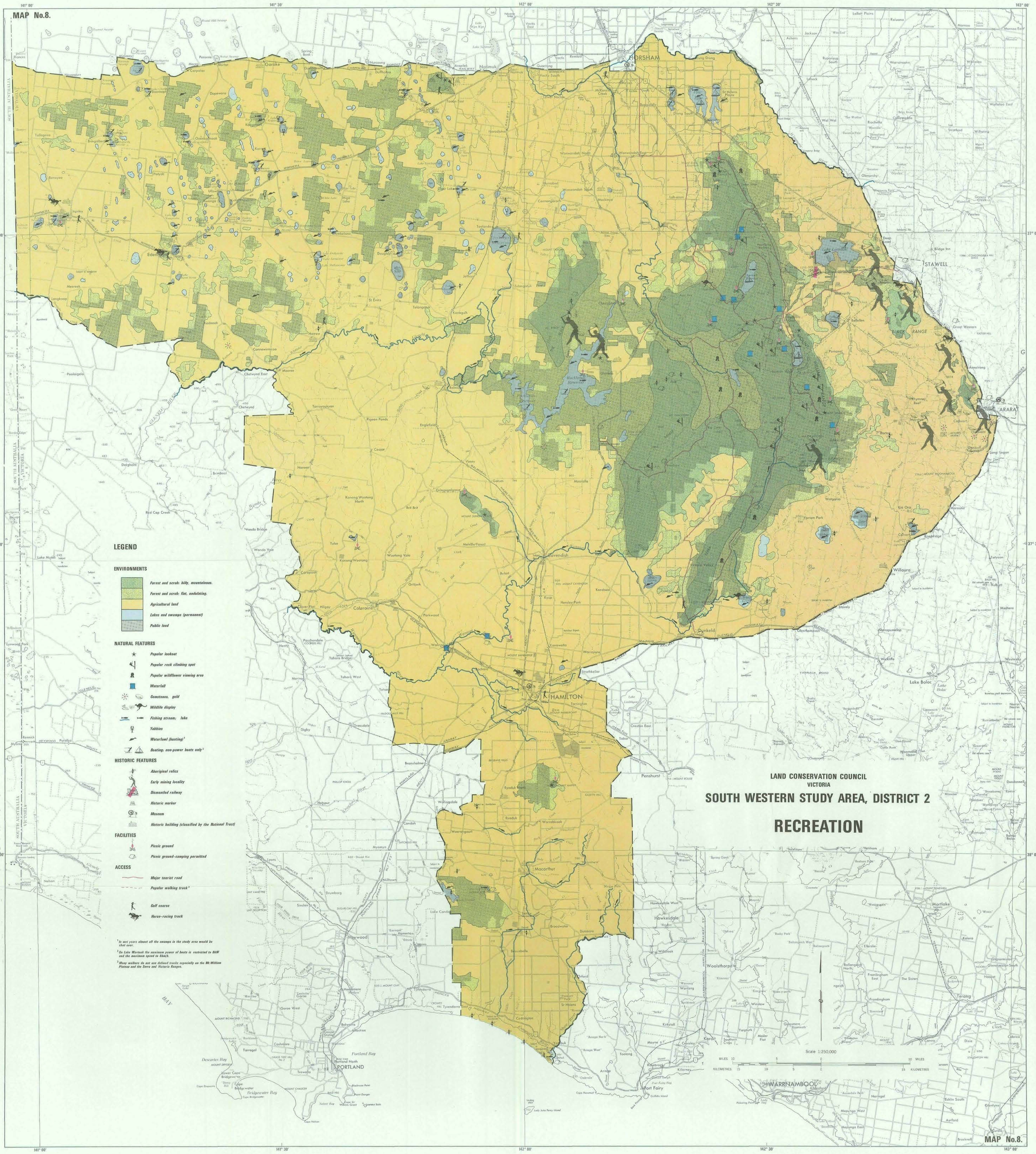
(Details of groundwater resources and use are not shown on this map)



LEGEND

Structural Form	Major species of tallest stratum	Associated tree or shrub species	Nature of the lower strata
OPEN FOREST II (>20m height)	*messmate - - brown stringybark*	*mountain grey gum, blackwood, black wattle, manna gum, swamp gum*	*Tall scrub such as wattles, tea-trees and bush peas, with bracken, grasses, and sedges; on sheltered sites tree ferns and moisture loving plants.*
OPEN FOREST 1 TO SHRUBBY WOODLAND (5–20m)	*brown stringybark - - messmate*	*long-leaf box, shining peppermint*	*Dense heathy understorey, rich in species from the following genera:*
	messmate - - scent-bark	*shining peppermint, swamp gum*	*Acacia, Banksia, Brachyloma, Calytrix, Dillwynia, Epacris, Grevillea, Hakea, Hibbertia, Leptospermum, Leucopogon, Platylobium, Pultenaea*
	brown stringybark	*manna gum, swamp gum, scent-bark*	
	messmate - - red stringybark	*long-leaf box*	*Open understorey of golden wattle, hedge acacia, tea-tree, with grassy areas.*
WOODLAND (5-20 m.)	*red gum*	*very sparse golden wattle, hedge acacia*	*Grasses and herbs*
	yellow gum	*brown stringybark, yellow box, long-leaf box, drooping sheoak*	*As for red gum, but with more shrubs*
	grey box - - buloke	*black box, grey box, yellow gum*	*Grassy, with sparse rushes and sedges*
	manna gum	*blackwood, tree violet, tree everlasting*	*Dense bracken with grassy patches, and many small herbaceous plants*
OPEN SCRUB (2–8m)	*Grampians gum - - long-leaf box*	*Oyster Bay pine, brown stringybark*	*Dense community of heathy plants*
	brown stringybark	*long-leaf box, Oyster Bay pine, messmate*	
	bull mallee - - dumosa mallee, peppermint box	*broom honeymyrtle, broom baeckea, quandong*	*Guinea flowers*
HEATH (0–2m)	*prickly tea-tree - - silver banksia, shining tea-tree - - Grampians fringe-myrtle*		*Numerous species of the genera listed under open-forest I, above*
	desert banksia	*brown stringybark, silky tea-tree*	*Beard-heaths, guinea flowers*
	mallee honeymyrtle - - desert hakea		
LOW OPEN SHRUBLAND (0–2m)	*Grampians gum - - brown stringybark - - long-leaf box*	*Oyster Bay pine*	*Dense heath community*
SWAMP AND LAKE COMMUNITIES	*various rushes and sedges*		
COASTAL COMMUNITIES	*coast beard-heath*	*club rush, marram grass, saltbush*	
GRASSLAND, FERNLAND	*speargrass, kangaroo grass and introduced grasses, bracken*		
SOFTWOOD PLANTATIONS	*radiata pine*		


MAP 7
LAND SYSTEM GROUPS
LAND CONSERVATION COUNCIL
VICTORIA
SOUTH WESTERN STUDY AREA DISTRICT 2
Scale 1:500 000
KILOMETRES
MILES
LEGEND
CD COASTAL DUNES
CP COASTAL PLAINS
SR STONY RISES
VP VOLCANIC PLAINS
LT LATERITIZED TABLELANDS AND PLAINS
DT DISSECTED TABLELANDS
GR GRAMPIANS RANGES
OS OUTWASH SLOPES
MH MIDLAND HILLS
MP MIDLAND PLAINS
SD INLAND SAND DUNES AND SHEETS
IP INLAND PLAINS
AP ALLUVIAL PLAINS
LITTLE DESERT
SOUTH AUSTRALIA
DISCOVERY BAY
PORTLAND BAY
THE GRAMPIANS
Casterton
Mt Gambier
Penola
Portland
Port Fairy
Warrnambool
Ararat
Horsham
Heywood
Hamilton
MAP 7

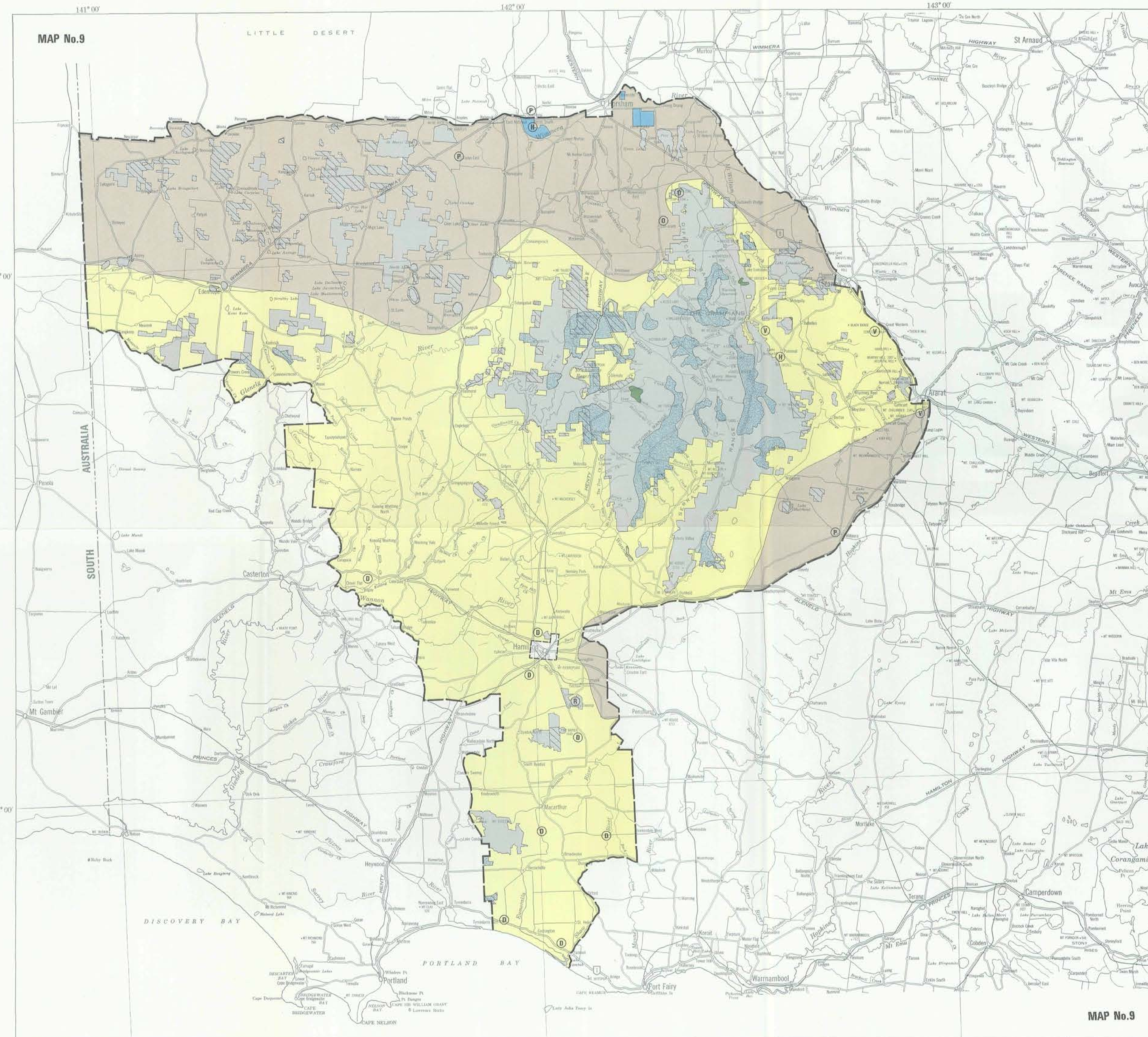

MAP No.8.
LAND CONSERVATION COUNCIL
VICTORIA
SOUTH WESTERN STUDY AREA, DISTRICT 2
RECREATION
LEGEND
ENVIRONMENTS
Forest and scrub: hilly, mountainous.
Forest and scrub: flat, undulating.
Agricultural land
Lakes and swamps (permanent)
Public land
NATURAL FEATURES
Popular lookout
Popular rock climbing spot
Popular wildflower viewing area
Waterfall
Gemstones, gold
Wildlife display
Fishing stream; lake
Yabbies
Waterfowl (hunting)[1]
Boating; non-power boats only[2]
HISTORIC FEATURES
Aboriginal relics
Early mining locality
Dismantled railway
Historic marker
Museum
Historic building (classified by the National Trust)
FACILITIES
Picnic ground
Picnic ground–camping permitted
ACCESS
Major tourist road
Popular walking track[3]
Golf course
Horse–racing track
[1] In wet years almost all the swamps in the study area would be shot over.
[2] On Lake Wartook the maximum power of boats is restricted to 8kW and the maximum speed to 8km/h.
[3] Many walkers do not use defined tracks especially on the Mt. William Plateau and the Serra and Victoria Ranges.
Scale 1:250,000
MILES
KILOMETRES
HORSHAM
STAWELL
ARARAT
HAMILTON
PORTLAND
WARRNAMBOOL
MAP No.8.

PRIMARY PRODUCTION

LAND CONSERVATION COUNCIL

VICTORIA

SOUTH WESTERN STUDY AREA DISTRICT 2



Scale 1:500 000

KILOMETRES 15 10 5 0 10 20 KILOMETRES

MILES 8 4 0 8 MILES

LEGEND

1. Generalized use of agricultural land by main farming enterprises

Cropping, sheep (wool, mutton), some beef cattle

Sheep (wool, lambs, mutton), beef cattle, some cropping

Irrigation - mixed farming

(D) Dairying

(V) Vineyards

(P) Poultry

(H) Horticulture (fruit and vegetables)

(O) Olives

Note: Pig farming enterprises are scattered throughout the area.

2. Use of public land for primary production.

Public land - used for recreation, nature conservation, timber production, grazing, honey production, catchment protection, water storage and mineral and stone extraction

Hardwood timber production (only the most productive areas are shown - many other areas are used for low intensity timber production)

Softwood timber production

Areas covered by current grazing licences or agistment rights (mainly sheep grazing)

(R) Pastoral Research Institute

Note: Most of the public land is used for honey production when conditions are suitable. The major exceptions are the steep and rocky parts of the Grampians and the stony rises country in the south of the study area.