Land Conservation Council Victoria

Gippsland Lakes Hinterland Area

Price $7.00

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GOVERNMENT OF VICTORIA

LAND CONSERVATION COUNCIL

464 ST. KILDA ROAD, MELBOURNE VICTORIA 3004

REPORT

GIPPSLAND LAKES

HINTERLAND AREA

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

All such submissions must reach the Secretary no later than Friday 25 June, 1982.

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

I. KUNARATNAM
Secretary
Land Conservation Council

REPORT

on the

GIPPSLAND LAKES HINTERLAND AREA

Land Conservation Council, Victoria

Melbourne: April 1982

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

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

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

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

Land Conservation Council
464 St. Kilda Road
MELBOURNE 3004

S.G.McL. DIMMICK
Chairman

LAND CONSERVATION ACT 1970

EXTRACT

Public land

Section 2.

(1) "Public land" means -

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

(i) unalienated land of the Crown including land permanently or temporarily reserved under section 4 of the *Crown Land (Reserves) Act* 1978, State forest and parks within the meaning of the *National Parks Act* 1975;

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

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

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

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

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

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

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

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

Functions of the Council

Section 5.

(1) The Council shall -

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

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

(c) advise the Soil Conservation Authority concerning policy on the use of land (whether public 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 recommendation to -

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

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

(c) any person or body who made a submission under section 9 -

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

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

Government departments and authorities to give effect to recommendations.

(3) Where the Council has made a recommendation to the Minister under paragraph (a) of sub-section (1) of section 5 the Minister may, after he has given not less than fourteen days notice of his intention so to do to the Minister administering a government department or responsible for a public authority recommend to the Governor in Council that notice of the recommendation or that part of the recommendation that affects the government department or public authority be given to the government department 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 compilation would not have been possible without the generous assistance and co-operation of a great many individuals and organizations.

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

Many other bodies and individuals also readily supplied information, checked drafts, or contributed valuable discussion and advice. They include other Victorian and Australian government bodies, local apiarists, members of field naturalists clubs, outdoor recreation and sporting societies, historical societies, speleological groups, and many individuals with expert knowledge in fields such as botany or zoology. Their assistance is gratefully acknowledged.

This Council is indebted to the many government Departments mentioned above that made photographs available for the report, and to the following organizations and individuals for the use of their photographs:

The Latrobe library, Victorian Eastern Development Association, and Messrs. K. Watson, E. Hamilton-Smith, R. Frank, and N. Vincent.

PART I

INTRODUCTION

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 and its history.

Part II describes the main features of the environment for the whole study area. Climate, geology, geomorphology, soils, vegetation, fauna, water resources, and land systems are described. Maps showing the geology, geomorphology, 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, mining and quarrying, 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 eight 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.

CONSERVATION PRINCIPLES

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

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

Natural Resources

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

Non-renewable resources

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

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

Renewable resources

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

Conservation of renewable resources requires a thorough understanding of ecological principles and development of sound management techniques based on those principles. An ecosystem typically contains many interrelated components. A change in any one of these will have effects elsewhere in the system. In general, an ecosystem with a diverse range of species will be better able to adapt and absorb the impact of sudden change - such as that caused by fire, disease, or Man's activities - than a simple ecosystem with few species.

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

Relations Between Resource Uses

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

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

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

The Principles of Land Use

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

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

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

These needs should be clearly stated as aims.

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

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

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

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

THE STUDY AREA

The Gippsland Lakes hinterland study area comprises approximately 8,850 sq. km (3.9% of the area of Victoria) in the Gippsland region, including portions of the Shires of Avon, Bairnsdale, Maffra, Omeo, and Tambo. It excludes the City of Sale and the town of Bairnsdale.

In terms of environment, settlement patterns, land use, and land tenure, it can be broadly divided into two sections: the foothills to the Eastern Highlands in the north, and the coastal plains in the south. The sparsely populated foothills section - predominantly steep, heavily timbered public land - is cooler and receives more rain than the relatively flat coastal plains, which, in comparison, are much more densely settled and in the main consist of freehold land cleared for agriculture.

Public land

Public land occupies approximately 5,100 sq. km (58% of the study area) and is concentrated in the mountainous section and in and around the Gippsland Lakes. Most of it is either unreserved Crown land or reserved forest - in about equal proportions. The remainder comprises State game reserves, the Glenaladale National Park, land owned by the State Rivers and Water Supply Commission for its Glenmaggie reservoir and proposed Mitchell River dam, and land owned by the Gas and Fuel Corporation on the shores of Lake Victoria.

Population

At the time of the 1976 census, the Gippsland Lakes hinterland had a population of 45,210, representing 2.5% of Victoria's total population. This figure includes the main urban centres of Sale and Bairnsdale, which technically are not part of the study area (see Table 1).

Settlement is concentrated overwhelmingly on the coastal plains: more than 90% of the population live at or below an east--west line drawn through Lindenow. The mountainous topography north of this latitude has inhibited settlement, with the result that this portion of the study area contains only two towns - Bruthen and Buchan - with populations of more than 200.

Demographic trends in the 1960s and 1970s have further concentrated population here. While the area as a whole has

LAND CONSERVATION COUNCIL
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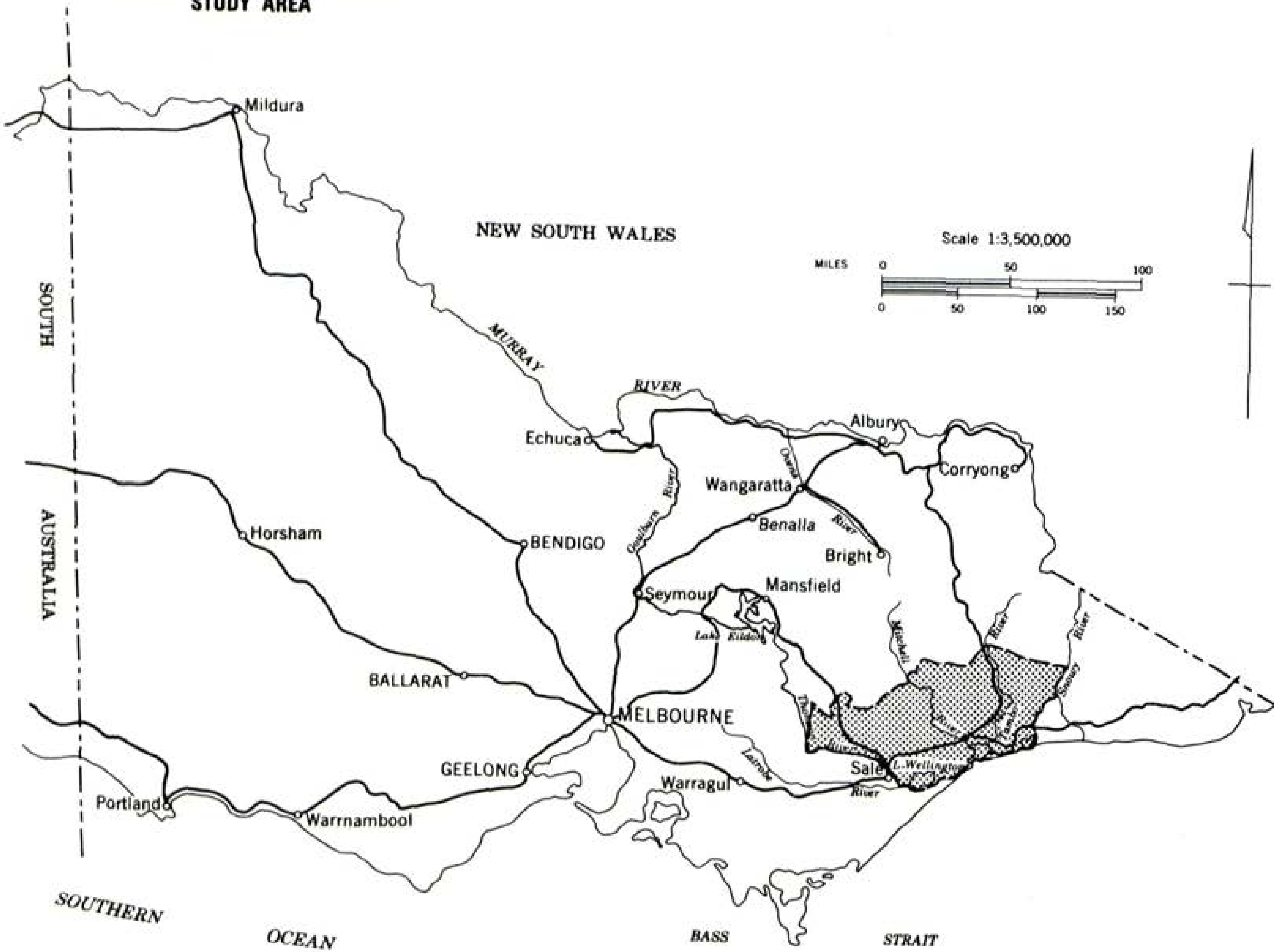
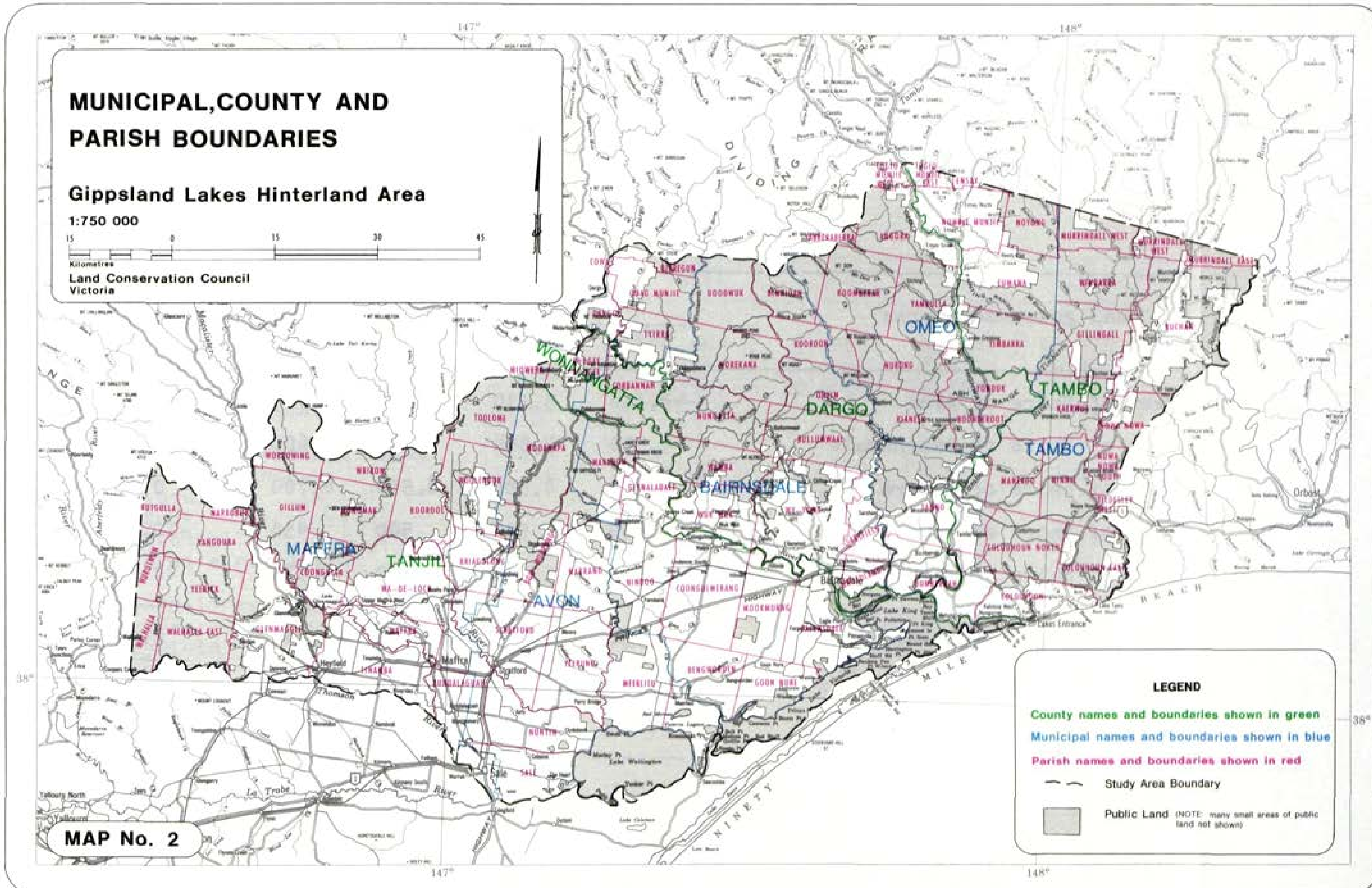
GIPPSLAND LAKES HINTERLAND STUDY AREA

LOCALITY PLAN



MAP No.1



MUNICIPAL, COUNTY AND PARISH BOUNDARIES
Gippsland Lakes Hinterland Area
1:750 000
15
0
15
30
45
Kilometres
Land Conservation Council Victoria
147°
148°
38°
LEGEND
County names and boundaries shown in green
Municipal names and boundaries shown in blue
Parish names and boundaries shown in red
Study Area Boundary
Public Land (NOTE: many small areas of public land not shown)
MAP No. 2
OMEO
TAMBO
DARGO
WONNANGATTA
BAIRNSDALE
MAFFRA
TANJIL
AVON
Orbost
Lakes Entrance
Bairnsdale
Maffra
Heyfield
Stratford
Sale
Lake Wellington
Lake King
NINETY MILE BEACH
DIVIDING
La Trobe
River

maintained a positive rate of population growth since 1961, in contrast to the situation in some other non-metropolitan regions, many of the rural areas and small towns have suffered declines. Growth has been concentrated on Sale and Bairnsdale and around the Gippsland Lakes (particularly the towns there).

Table 1

DEMOGRAPHY

Local government area	Population 1961	1966	1971	1976	Pop. growth 1961--1976 %
Part of Shire of Avon	3,210	3,130	3,080	3,080	- 4.0
Part of Shire of Bairnsdale	3,550	3,600	3,740	4,600	29.6
Part of Shire of Maffra	8,750	8,500	8,550	8,700	- 0.6
Part of Shire of Omeo	500	500	500	450	-10.0
Part of Shire of Tambo	5,420	5,540	5,850	6,510	20.1
Total (actual study area)	21,430	21,270	21,720	23,340	8.9
Town of Bairnsdale	7,647	7,960	8,560	9,400	22.9
City of Sale	7,964	8,708	10,540	12,470	56.6
	15,611	16,668	19,100	21,870	40.1
Total (including main urban areas)	37,041	37,938	40,820	45,210	22.1

The proportion of the population living in Sale, Bairnsdale, Lakes Entrance, Paynesville, and Metung has increased from 48.6% in 1961 to 58.5% in 1976. Correspondingly, in the same period, the proportion living in rural areas and towns of less than 200 has declined from 37.0% to 29.3% (see Table 2).

Table 2

URBAN AND RURAL POPULATION, 1961--1976

		1961	1966	1971	1976
A.	Major urban areas				
	Sale	7,964	8,708	10,540	12,470
	Bairnsdale	7,647	7,960	8,560	9,400
	Sub-total	15,611	16,668	19,100	21,870
	% area's population	42.1	43.9	46.8	48.4
B.	Towns on Gippsland Lakes				
	Lakes Entrance	1,602	1,837	2,591	3,023
	Paynesville	564	611	958	1,242
	Metung	226	179	172	279
	Sub-total	2,392	2,627	3,721	4,544
	% area's population	6.5	6.9	9.1	10.1
C.	Other large towns				
	Maffra	3,404	3,569	3,666	3,836
	Heyfield	1,917	1,893	1,830	1,699
	Sub-total	5,321	5,462	5,496	5,535
	% area's population	14.4	14.4	13.5	12.2
D.	Other towns (200--1,000 population)				
	Sub-total	2,461	2,005	1,980	2,096
	% area's population	6.6	5.3	4.9	4.6
E.	Rural				
	Sub-total	11,256	11,176	10,523	11,165
	% area's population	30.4	29.5	25.7	24.7

Table 3

EMPLOYMENT BY INDUSTRY IN THE GIPPSLAND LAKES HINTERLAND
AT JUNE 30, 1966, 1971 & 1976

Industry	1966 Total	1966 % of total	1971 Total	1971 % of total	1976 Total	1976 % of total
Agriculture, fishing, & hunting	3,330	23.5	2,995	19.0	2,903	15.4
Forestry	298	2.1	233	1.5	250	1.3
Mining	40	0.3	192	1.2	444	2.4
Manufacturing	1,286	9.1	1,833	11.6	1,412	7.5
Sawmilling	638	4.5	343	2.2	328	1.7
Electricity, gas, & water	176	1.2	288	1.4	205	1.1
Construction	1,425	10.1	1,355	8.6	1,680	8.9
Wholesale & retail trade	2,410	17.0	3,062	19.4	3,227	17.1
Transport & storage	615	4.3	514	3.3	537	2.9
Communication	367	2.6	355	2.2	319	1.7
Finance, insurance, real estate, & business services	392	2.8	543	3.4	809	4.3
Public administration & defence	884	6.0	1,153	7.3	1,206	6.4
Community services	1,356	9.6	1,552	9.8	3,020	16.0
Entertainment, recreation & personal services	890	6.3	864	5.5	995	5.4
Others	80	0.6	580	3.6	1,485	7.9
Total	14,147	100.0	15,802	100.0	18,820	100.0

Source: Australian Bureau of Statistics censuses; compiled from Collector District data.

Note: Data from the 1966 census have been reclassified to conform with the industry classifications used in the 1971 and 1976 censuses.

Economic activity

Since settlement, the major form of economic activity in the area has been the raising of sheep and beef cattle. Vegetable-growing and dairying (on the alluvial flats of the Mitchell and Tambo Rivers and in the Macalister Irrigation District) and fishing (at Lakes Entrance and Paynesville) have also been important.

The rapid expansion of forestry in the East Gippsland region (which includes the Gippsland Lakes hinterland and areas to its north and east) from the 1940s constituted the first of a series of major resource-based developments that have had a marked effect on the region's economy in the last 30 years. Over this period the region has developed into Victoria's most important supplier of sawn hardwood timber. However, the consistently high output of timber products has not been matched by employment opportunities, as the process of structural adjustment and capital intensification has reduced labour demands within the industry.

The waters offshore from the Ninety Mile Beach are now responsible for nearly 90% of Australia's oil production and half of its natural gas, as a result of the development of nine commercial oil and gas fields from the early 1960s.

The 1960s also saw an upsurge in tourist and recreational activity in the study area - so much so that it now has one of the highest numbers of guest rooms and caravan sites of any region in Victoria.

In common with trends elsewhere in the State, however, the most significant source of employment growth in the last decade has been in the tertiary sector. Much of this growth has stemmed from the expansion of the resource-based tourist and oil and gas industries and from the upgrading of community services and the progressive decentralization of Commonwealth and State administrative functions.

The development of these new industries has been critical in preserving employment growth in the Gippsland Lakes hinterland at a time when, as shown in Table 3, employment in the industries that comprised its traditional economic base has been declining.

HISTORY

Aborigines

Prior to European settlement of what is now Gippsland, Aborigines had inhabited the area for between 10,000 and 30,000 years. In stark contrast to the 140 years that have followed the white man's 'discovery' of Gippsland, this long period of Aboriginal occupation had very little impact on the land.

The study area included the territory of four of the five clans of the Kurnai tribe, as shown in Figure 1. These clans mainly occupied land around the lakes and river systems, where food was most plentiful. Concentration of Aboriginal relics such as middens, scarred trees, and grinding rocks around these water bodies and on the adjoining plains provides evidence of this pattern of habitation. Unfortunately these lowlands were also the areas most prized by the white pastoralists, a fact that brought the two groups into open and often violent conflict in the early days of European settlement.

The Kurnai met the early settlers with open hostility, which at times involved the killing of stock and occasionally attacks on the settlers themselves. Fear of the Aborigines was one reason given in the 1840s for the difficulty of obtaining labour for Gippsland areas. These attempts by the blacks to resist the invaders of their land brought savage reprisals, including a number of appalling massacres. In 1846 the intensity of these reprisals was such as to move one Henry Meyrick to write of the Aborigines: 'No wild beast of the forest was ever hunted down with such unsparing perseverence as they are.'

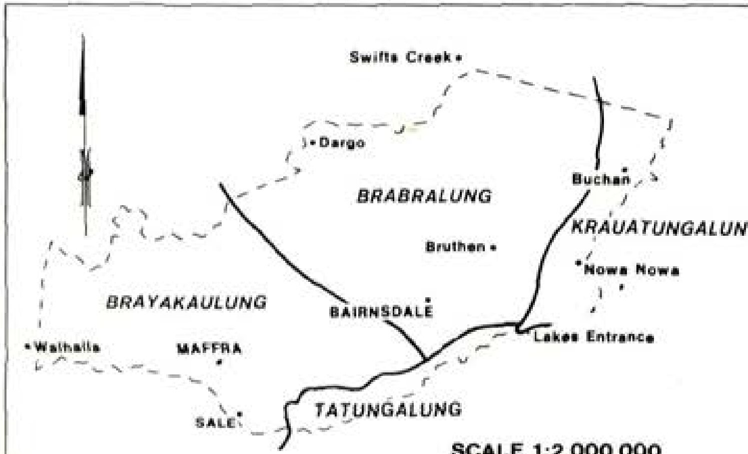


Fig. 1 CLANS OF THE KURNAI TRIBE

The combination of murder, disease, changed diet, and social disorganization led to the Aboriginal population dropping from an estimated pre-settlement figure of 2,000 to about 150 by 1877. The demoralized remnants of the Kurnai were by this time dependent on white charity for survival.

It is a tragic irony that the early exploration, which led to the 'opening up' of Gippsland and the subsequent devastation of the Aboriginal population, relied heavily on Aboriginal assistance. Indeed, the two most influential exploratory journeys - by McMillan and Strzelecki - depended for their success on Aboriginal guides. Omeo Aborigines guided McMillan along the old Aboriginal track from the Maneroo into Gippsland, and Strzelecki and his party would have perished in southern Gippsland had it not been for the resourcefulness of their Aboriginal guide, Charlie Tarra.

In 1858 Victoria's Legislative Council appointed a Select Committee to inquire into the conditions of the Aboriginal people. The Committee's subsequent report highlighted the disastrous effects that white settlement had had on the Aboriginal population, and recommended that 'a vigorous effort should be made to repair the great wrongs done to the Aborigines in the past'.

As a result of the findings of the Select Committee and recommendations it received from William Thomas, the Guardian of Aborigines, the government in 1860 created a 'Central Board to watch over the interests of the Aborigines in the Colony of Victoria'. By 1861 this Board had initiated plans for the establishment of Aboriginal reserves and had encouraged churches to start mission stations on Crown land channelled to them through the Board. Thus were founded the Ramahyuck and Lake Tyers Mission Stations.

Founded by the Rev. F.A. Hagenauer, the Ramahyuck Station was established in 1863 on a 940-ha reserve on the Avon River near Lake Wellington. It operated until its official closure in 1908, by which time its few remaining Aboriginal occupants had been transferred to Lake Tyers.

The reserve was subsequently made available for selection and all that remains of the Station today are three headstones in the old cemetery.

The Lake Tyers Station was also established in 1863, with an initial reservation of 800 ha. A further 800 ha was allocated in 1889. Under the direction of Mr. John Bulmer, the Lake Tyers Station accepted survivors of the vanishing tribes from all parts of Victoria. Bulmer and his wife remained with the Station and its people for 50 years, until his death in 1913.

The Church of England ran the Station until 1908, at which time the Victorian government assumed the responsibility. Government control continued until 1971. when the 91 Aborigines of the Lake Tyers Aboriginal Trust were granted freehold title to the 1,600-ha property.

Exploration

Exploratory trips into this part of Gippsland came initially from Maneroo - the present-day Monaro district in

Lake Tyers Station, 1886

southern New South Wales. A severe drought in 1837--38 forced squatters in Maneroo to consider searching for the well-watered pastures that were rumoured to exist beyond Macfarlane's station at Omeo.

The first incursions into this previously unpenetrated southern section of the Great Dividing Range came in 1839. In that year Edward Bayliss discovered pasture lands at Buchan. This area around the Snowy River remained an outlier of grazing land, and as such had little influence on the region's development.

The most important move from Maneroo into Gippsland, in terms of consequent settlement, came with Angus McMillan, who left Macfarlane's station in May 1839 on the first of four expeditions that effectively opened Gippsland for settlement. In his capacity as overseer for a wealthy squatter, Lachlan Macalister, McMillan formed a station at Numblamunjie (the present-day Ensay) in September 1839. Four months later he pushed down the Tambo River to the plains, discovering and naming Lake Victoria (now Lake King) and the Nicholson, Mitchell, Avon, and Macalister Rivers.

With a view to taking possession of the 'fine, open plains intersected by occasional narrow belts of open forest ... and with grass up to our stirrup-irons', McMillan started to clear a stock route through the mountains. But Macalister instructed him to form no more stations until he found his way to Corner Inlet so that a shipping port for stock could be established.

After several attempts were thwarted by swollen rivers and dense scrub, McMillan finally reached the coast at the site of what was to become Old Port (just west of present-day Port Albert) in February 1841. Within a few months he had established a dray track from the port to Numblamunjie, more than 200 km away.

While the initial occupation of Gippsland was from Maneroo, its development was to depend heavily on its contacts with Port Phillip. Ironically, it was an explorer from the Maneroo side, Count Paul Strzelecki, who indirectly opened a way into Gippsland for those from Port Phillip. In March 1840 Strzelecki left Numblamunjie and followed McMillan's path to the Latrobe River, from where he travelled due west through completely unexplored country. After having been given up for lost, Strzelecki's party finally arrived, starved and exhausted, at the small settlement of Westernport on May 12.

Great publicity was given to the news of the expedition's arrival and to Strzelecki's accounts of the country he had traversed. Strzelecki claimed himself as the discoverer of Gippsland, and indeed suggested the area be named in honour of Sir George Gipps, at that time the Governor of New South Wales. In

Angus McMillan

fact, it was not so much the discoveries made as the wide publicity it received that gave Strzelecki's expedition its importance.

This publicity - coupled with the favourable reports by Captain Lewis, captain of the coastal steamer 'Clonmel' that ran aground near Corner Inlet in January 1841 - stimulated the interest of squatters and prompted the formation of the Gippsland Company. The company chartered the 300-ton barge, 'Singapore', and with horses and supplies set sail from Hobson's Bay, arriving at the mouth of the Albert River in early March 1841. The site selected for settlement, on the east side of the river entrance, was precisely the one visited by Angus McMillan only a few weeks earlier.

Settlement

The opening of a shipping port enabled movement on two fronts: from the Maneroo --Yass--Goulburn area of New South Wales via Omeo, and from Port Phillip or Van Dieman's Land by sea via Port Albert.

New runs were selected by settlers 'leap-frogging' from the established runs, around Omeo and Port Albert, to the Gippsland plains. In this process a pattern of clustering became evident, whereby newcomers were content to trust the judgement and experience of the initial settler and attach their runs to his. With infilling and expansion, these clusters eventually merged into one another. In this way most of the open grazing country of the Gippsland plains was occupied by 1844.

The area around Buchan remained an isolated sub-district of Maneroo, with most of the squatters obtaining licences from Cooma.

With the exception of the upper reaches of the Mitchell River valley, where in 1845--47 four runs between Dargo and Tabberabbera were taken up, the mountainous country north and north-west of the plains remained largely unexplored until the gold rush era.

While population increased after 1844, the area already occupied then remained the basic area of settlement.

Agriculture was stimulated greatly by the increased population that had to be fed during the gold rushes. Then, as alluvial mining tapered off, many diggers sought to become farmers and wanted access to land. However, by this time almost all the arable land had been taken up by the squatters. The cry 'open the land to small farmers' was to be increasingly heard from the early 1850s, when the prospective farmers wanted to break the squatters' monopoly.

When pastoral licences ceased to be issued in 1870, the system of land tenure changed dramatically from squatting to settlement by purchase from the State. Following the 1869 *Land Act*, squatters who already held land often selected areas of it, particularly the choicest tracts. Large areas east of Sale were selected and granted to former pastoral licensees. Pastoral interests also took control along the Avon River plains, Angus McMillan gaining the majority of allotments in this area.

By 1874 the river flats of the Mitchell, Avon, Thomson, and Macalister Rivers had been alienated from the Crown. Other settlers also moved into the region, with the result that selectors had taken up many of the early runs by the turn of the century.

Development of towns

As population densities increased in the Gippsland plains and mountains, the need arose for local servicing and supply centres. The most important of these centres to emerge during the 1850s was Sale. The township was surveyed in 1848, but the first land sale did not occur until 1850. The area's other major centre, Bairnsdale, on the Mitchell River, had its first post office and store in 1856. Only 4 years later the township was laid out.

Early growth in both centres was slow, with expansion being due to the townships' importance as ports for the pastoralists and gold-miners. The discovery of gold in Gippsland, as in other parts of Victoria, caused large increases in the region's population. For example, Sale's population increased five-fold between 1854 and 1861.

Like Sale and Bairnsdale, many of the area's smaller centres have developed on the sites of the original river crossings. Stratford and Maffra, for instance, developed where the stock routes crossed the Avon and Macalister Rivers respectively.

Heyfield developed on the cattle run of the same name and was a stopping-over point for carriers who took supplies from Port Albert to the Jordan gold-fields. Bruthen was also a convenient stopping-over point for merchants carrying supplies to the mining centres in the north, as well as being a trading centre for the surrounding districts.

Transport and communication

Bush tracks formed the first line of communication in the region, and bullock drays and horseback the main means of transport. The first inland route, the track cut by McMillan, was soon superseded as the Port Albert--Maneroo route by one that Townsend surveyed in 1842. Although impassable for wheeled traffic, this formed the main axis for new settlers arriving with stock from New South Wales. For a long period Port Albert was Gippsland's only port, with all goods and stock passing through it.

Sale, 1887

In the early 1850s, the state of transport in Gippsland was primitive. Many of the early tracks were extremely rough and nearly impassable during the winter, and the overland link to Port Phillip was particularly hazardous. But as a consequence of the gold rushes, the increased population felt the need for a more efficient transport system. This need was met in various ways - such as the establishment of Road Boards charged with the construction and maintenance of colonial roads, the introduction of coaches, navigation of the Gippsland Lakes, and the commencement of agitation for rail links between Melbourne and Gippsland.

During the 1860s the first coach services were introduced into Gippsland. Cobb & Co. extended their lines into the region, and coaching remained the prin-

Horse-drawn coach at Tambo Crossing

cipal means of passenger and mail transport until the advent of the railway. A coach road between Sale and Melbourne was completed in 1865, but even into the 1870s this route involved an arduous 24-hour journey.

The first real step in opening the lakes to navigation from the sea was taken in 1858, when the schooner 'Georgina Smith' entered the lakes through the natural entrance at Red Bluff. For many years following this, shipping played an important role in communications and transport between townships on the lakes and the feeder rivers. In 1864 the Gippsland Lakes Navigation Company instituted a direct weekly service from Melbourne. The Company's light-draught schooners were able to enter the lakes and navigate the river systems to Bruthen on the Tambo, Sarsfield on the Nicholson, Bairnsdale on the Mitchell, and Sale on the Thomson.

Uncertainty concerning the navigability of the natural entrance to the lakes was the major factor limiting water transport development. In 1869, work commenced on construction of an artificial entrance some distance west of the natural channel through the outer barrier. Lack of money and other problems caused considerable delays in this project, and the new entrance was not opened until 1889.

Meanwhile, the railway line linking Sale with Melbourne had been opened in 1879, and that between Sale and Bairnsdale in 1888. The extension of this line to Orbost was completed in 1916.

The opening of the railway to Sale and Bairnsdale marked the beginning of the decline in shipping as a means of transport both to and within the region. Steamers were used on the lakes as late as the 1930s, with the last remaining vessel, the 'Tambar', being withdrawn from service in 1938. By this time competition from motor transport and the railways had put an end to shipping activities in the region.

Gold

Until the discovery of gold, Gippsland belonged to the pioneer pastoralists. In Gippsland, the main effect of gold was to consolidate the patterns that had already developed; the rate, but not the nature, of this development was changed. Population increased in the gold-fields and generated an increase in imports through Port Albert, while pastoral and agricultural production continued to develop on the basis of growing market demands in Melbourne, on the central Victorian gold-fields, and in the northern Gippsland gold-fields.

Gold finds within the study area were never spectacular. The first occurred on the Nicholson River in 1854. In the 1850s the diggers concentrated on the alluvial fields along the Nicholson, Mitchell, Wentworth, and Dargo Rivers

Steamboat wharf on the Mitchell River at Bairnsdale (c. 1889)

and the Boggy and Iguana Creeks. Reef mining began along the Mitchell River and its tributaries in the 1860s. Towns such as Merrijig, Tabberabbera, Bullumwaal, Deptford, and Dargo grew up and then declined as the gold was worked out. From time to time new areas caused excitement - such as Clifton Creek and Freestone Creek in 1868.

The search for gold led to an influx of people and an increase in trading activity. Most of the mining activity took place in the mountains, away from the occupied plains. A network of rough tracks serviced these isolated mining areas, none of which survived as significant permanent settlements once the supply of gold was exhausted. Thus the direct effects of the gold discoveries were short-lived, but many ex-miners remained to select land for agriculture, and become permanent settlers in the region.

Agriculture

As early as 1844, the economic base of the district had been set: it was a pastoral economy based on sheep for wool and cattle for the meat trade. The early squatters preferred cattle to sheep, as being more suited to the rough nature of the country, particularly in the mountain areas. Properties on the plains, however, especially in the south-west, carried a higher proportion of sheep. As new areas were settled, sheep and cattle gradually spread

Harvesting hops

throughout the region, but problems were encountered in securing suitable markets. The difficulties resulting from isolation and lack of suitable outlets for production characterized this early period of expansion.

In the initial settlement period, the cultivation of crops was geared solely to subsistence production for the local population. However, by the 1880s the area was producing a wide range of agricultural products. Land around Bruthen and Lindenow supported tobacco-growing between the 1860s and 1880s. Maize was being grown extensively along the river valleys in the Bairnsdale--Buchan--Bruthen area, together with small areas of wheat, barley, oats, and potatoes. By 1884 more than 300 ha in the Mitchell valley carried hops. Land near Stratford on the Avon and Perry Rivers also carried hops, and wheat and potatoes were grown in the vicinity of Maffra.

The extension of the railway line to Sale and Bairnsdale stimulated dairy production and the intensive cropping of maize and vegetables. Construction of Glenmaggie reservoir led to the establishment in 1920 of a large irrigation area in the Maffra--Sale district, which in turn led to the further development of dairying and the establishment of two large processing factories at Maffra. Prior to this, Maffra had been a cattle-trading centre, and it is estimated that, as far back as the 1880s, 100,000 head passed through the saleyards annually.

A sugar-beet factory built at Maffra in 1897 drew its supplies from plantings around Maffra and Lindenow. At the peak of production, more than 1,600 ha carried sugar beet. Production was suspended during the World War II, however, and later efforts to re-establish the industry failed.

During that war, government action promoted the introduction into the area of several crops grown specifically for the war effort. Apart from vegetable production, which was increased to supply dehydrating factories at Bairnsdale and Maffra, flax and navy beans were the two most important crops. The production of both declined as demand slackened after the war.

Many other crops have been tried in Gippsland at one time or another. Some failed; others prospered for a short time. Those that achieved some measure of success include sunflower, chicory, broom millet, pyrethrum, opium poppy, linseed, and mustard.

Pastoral expansion continued until the early 1920s, when first the European currency collapse and later the depression caused prices for agricultural products to plummet. During this period stock numbers decreased due to the worsening economic conditions, which made it difficult to maintain much of the less-fertile country that had been cleared using low-cost labour. The gradual loss of much of this light grazing country was offset by the advent of topdressing and sown pastures in the 1930s. Production of prime lambs became more common.

Since World War II, development has been concentrated on increasing the productivity and numbers of stock rather than expansion into new areas.

In 1890, the first water supply scheme in the study area was inaugurated in the Bairnsdale region. However, the construction of a weir on the Mitchell River was plagued by floods and problems with the foundations and, although completed in 1893, the scheme never operated because of repeated flood damage.

Subdivision of land into small holdings in the rain-shadow area between the Macalister and Avon Rivers brought demands for reliable water supplies, which resulted in the construction, in 1926, of a dam on the Macalister River (Lake Glenmaggie). Irrigation works were then extended throughout the area between the Thomson and Avon Rivers. After World War II, they were further extended to service the Nambrock--Denison Soldier Settlement Scheme - south of the Thomson River.

From its beginnings - supplying building and fencing timbers to the infant pastoral industry - the timber industry expanded rapidly in the late 1800s, with the demand for mining timbers, fuelwood, and construction timbers created by the gold-mining boom, the expansion of the railway system, and the resultant ready access to the Melbourne market.

Sawmilling increased to meet the demands for timber during World War II and reached a peak during the post-war building boom, which continued into the 1960s. Subsequently, timber output declined to the current, more stable level of output.

PART II

NATURE OF THE LAND

GEOLOGY AND GEOMORPHOLOGY

This chapter first deals with the geological history of the area and the geomorphic evolution of the landscape as we see it today. Secondly, it describes the geomorphology or land form of the study area; the third section, stratigraphy, describes the rocks outcropping in the area - from oldest to youngest.

Reference to the stratigraphy table (Table 4), the simplified geological history (Figure 2), and Maps 3 and 5 (Geomorphology and Geology) will assist the reader to understand the geology of the study area. In addition, a glossary at the end of this chapter defines many of the technical terms used here.

A simplified picture of the study area's geological setting emerges from consideration of the region in two sections. The northern section, which forms part of the Eastern Highlands, consists of an uplifted and deeply dissected mass of Palaeozoic rocks and igneous intrusions; to the south, the Palaeozoic formations pass beneath a deep sedimentary basin that contains Cretaceous, Tertiary, and Quaternary deposits folded and faulted along mainly east--west alignments.

Geological History and Geomorphic Evolution

About 500 million years ago, during the Ordovician period, an extensive marine trough known as the Tasman Geosyncline occupied most of Victoria. The oldest rocks in the study area - consisting of a thick sequence of late Ordovician marine sediments - were deposited in this trough.

At the beginning of the Silurian period, large-scale earth movements associated with the Benambran Orogeny destroyed much of this trough in the study area, resulting in the deformation (or folding and faulting) and alteration of the Ordovician sequence, in part to high-grade metamorphic rocks. Where intruded by granitic magma, heat and pressure altered the surrounding rocks to low-grade contact metamorphic rocks.

This Benambran deformation established the NNW--SSE to NNE--SSW fold and fault trends that are preserved in the outcropping Ordovician rocks. The earth movements elevated these rocks to a position well above sea level, where they

(continued on page 28)

ERA	PERIOD	EPOCH	Age	WEST	CENTRAL & EAST	EVENT
CAINOZOIC	QUATERNARY	RECENT &	0.1	Alluvial and coastal deposition	Alluvial and coastal deposition	*Alluvial sedimentation, erosion, terraces, dunes. Coastal barriers, lakes, and caves (Buchan) initiated*
		PLEISTOCENE	1.8			
	TERTIARY	PLIOCENE	5	Haunted Hill Gravel; Coongulmerang Formation; Boisdale Beds (Sale Gp)	Haunted Hill Gravel; Coongulmerang Formation; Boisdale Beds (Sale Gp)	*Non marine deposition*; *Uplift, retreat of sea*
		MIOCENE	23		Seaspray Group; Jemmy's Point Fm; Tambo River Fm; Gippsland Limestone; Lakes Entrance Fm	*Incursion of sea over plains*
		OLIGOCENE	37			
		EOCENE				
		PALAEOCENE	65	Latrobe Valley Group	Latrobe Valley Group	*Earth movements and volcanism, land subsides in south. Highlands and Gippsland Basin outlined*
MESOZOIC	CRETACEOUS	UPPER & MIDDLE				*Uplift and erosion*
		LOWER	136		Strzelecki Group	*Large scale earth movements cause subsidence in south and sedimentation*
	JURASSIC & TRIASSIC		225		Sediment	*Minor sedimentation in south*
PALAEOZOIC	PERMIAN		289		Erosion	
	CARBONIFEROUS		367			*Mild deformation*
	DEVONIAN	UPPER		Avon River Group		*Non - marine basins subside in west. Acid and basic lavas extruded*
				Intrusion of granite	Intrusion of granite	*Folding and faulting. Last major orogeny (Tabberrabberan) to effect area. Palaeozoic marine sedimentation ends*
		MIDDLE			Buchan and Wentworth Groups	*Incursion of clear, shallow warm seas. Much limestone deposited*
		LOWER	416	Marine sedimentation in Melbourne Trough	Snowy River Volcanics	*Massive outpourings of acid lavas and hot ash flows*
					Intrusion of granite	*Folding and faulting (Bowning Orogeny)*
	SILURIAN		446		Marine sedimentation	*Small deep basins develop in east*
					Erosion	*Many km of rock worn away*
					Period of folding and metamorphism, intrusion of granite	*Orogeny destroys much of trough except in far west (Benambran Orogeny)*
	ORDOVICIAN	UPPER	470+	Sediment deposited in marine trough	Sediment deposited in marine trough	*Major geosynclinal trough occupies study area*

TABLE 4 STRATIGRAPHY

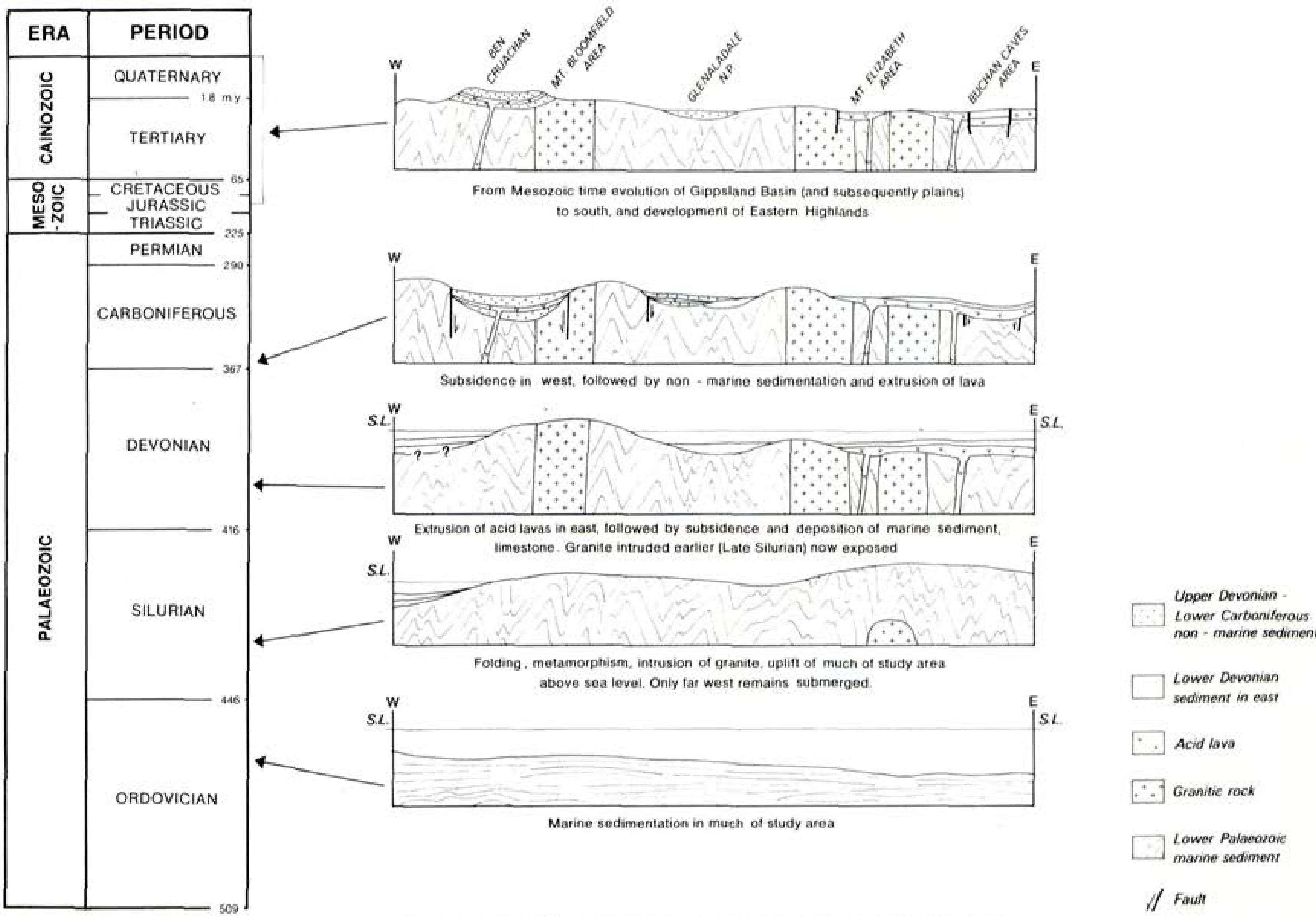


FIG 2 SIMPLIFIED GEOLOGICAL HISTORY GIPPSLAND LAKES HINTERLAND AREA.

were subjected to prolonged erosion until early Devonian times (a period of 30 million years).

Rocks from this era form much of the present landscape in the northern part of the study area. The deeply dissected Eastern Highlands are composed mainly of folded Ordovician sediments. Erosion has exposed granitic and metamorphic rocks that were emplaced or developed deep in the earth's crust.

Apart from the small intermontane basin at Buchan, all the basins are associated with granitic rocks that, in this area, are less resistant to weathering and erosion than the surrounding sedimentary rocks. As a result, undulating to hilly moderately dissected country develops on the granitic rocks, while the Ordovician sedimentary rocks are characterized by deeply dissected, mountainous terrain. The metamorphic rocks bordering the granitic intrusions often form a rim of rugged terrain, because of their resistance to erosion.

The early Silurian Benambran Orogeny did not destroy all marine sedimentation, which continued to the early Devonian in the far west of the study area. Much of the sediment laid down there came from eroding land uplifted by the Orogeny in the central and eastern parts.

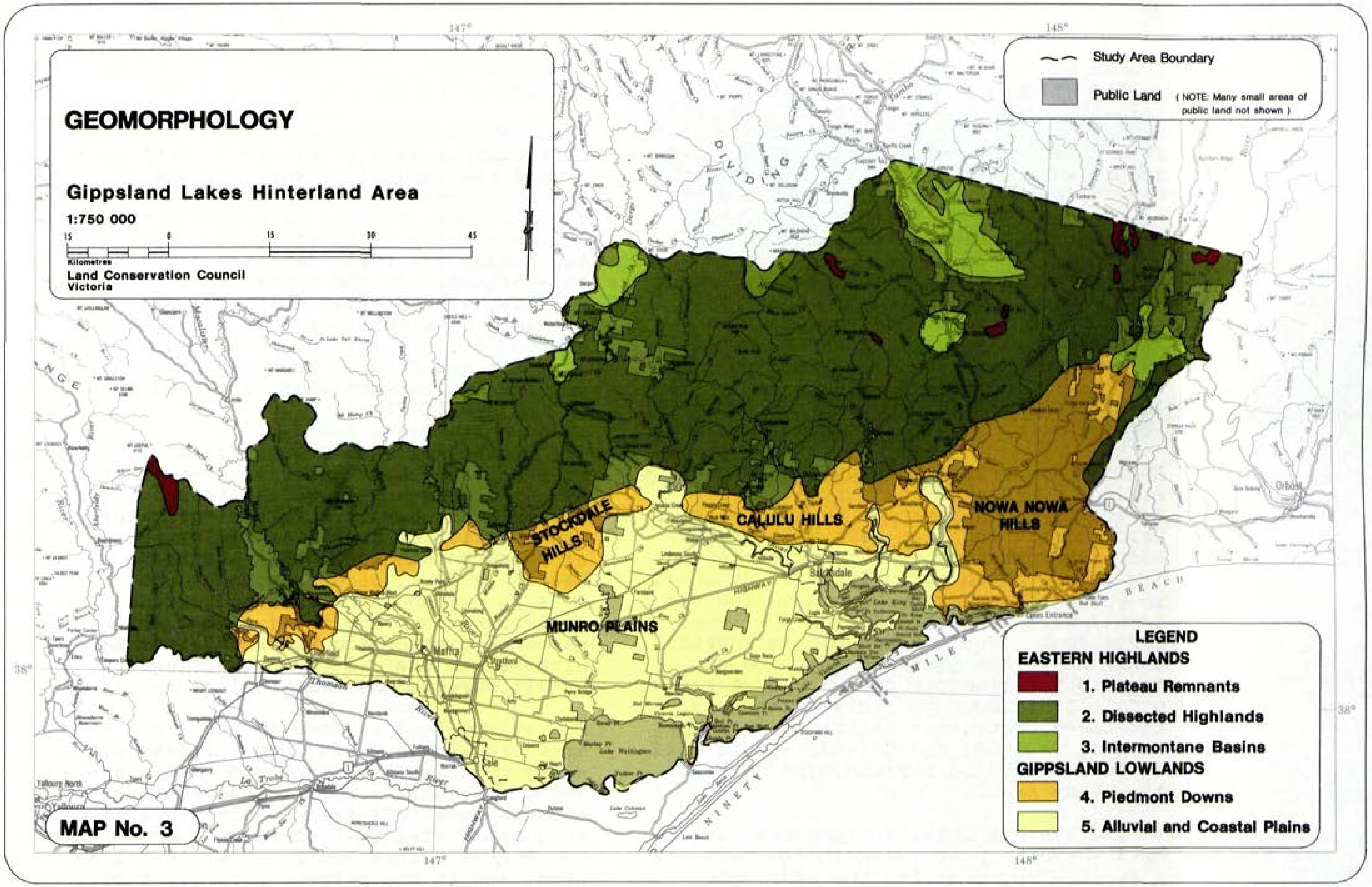
In the east - during the late Silurian - small but deep sedimentary basins developed, receiving a thick marine and non-marine sequence. These rocks (occurring only below the surface here) were deformed and folded in early Devonian times.

Also in the early Devonian, widespread volcanic activity resulted in massive outpourings of viscous acid lavas and associated hot ash flows (Snowy River volcanics) in the east of the study area. Periods of volcanic activity alternated with the deposition of marine and non-marine sediments. These rocks outcrop north of Nowa Nowa.

Marine sedimentation, including limestone deposition, returned to much of eastern Victoria towards the close of the early Devonian. These sediments now outcrop at Tabberabbera and in the Mitchell River Gorge at Glenaladale National Park (Wentworth Group) and in the Buchan--Murrindal area (Buchan Group).

All the rocks in the study area were folded, faulted, and intruded by granite during the middle Devonian Tabberabberan Orogeny. Folding was along north--south trends and included the Snowy River volcanics and the Buchan Group, which were tightly folded.

Although the Tabberabberan deformation was the climax of the structural evolution of the Tasman Geosyncline, gentle movements continued after the middle Devonian, causing down-warping in the west of the study area forming the north--south trending Howitt Trough. The



GEOMORPHOLOGY
Gippsland Lakes Hinterland Area
1:750 000
15 0 15 30 45
Kilometres
Land Conservation Council
Victoria
Study Area Boundary
Public Land (NOTE: Many small areas of public land not shown)
STOCKDALE HILLS
CALULU HILLS
NOWA NOWA HILLS
MUNRO PLAINS
LEGEND
EASTERN HIGHLANDS
1. Plateau Remnants
2. Dissected Highlands
3. Intermontane Basins
GIPPSLAND LOWLANDS
4. Piedmont Downs
5. Alluvial and Coastal Plains
MAP No. 3
147°
148°
38°
NINETY MILE BEACH
DIVIDING

trough received a thick sequence of non-marine sediment interbedded with some volcanic rocks (Avon River Group), laid down on a previously eroded surface of folded sediment and granite. These sediments were mildly deformed in the early Carboniferous and they outcrop along the southern margin of the Highlands from Bairnsdale to Lake Glenmaggie.

Apart from some minor deposition during the Permian, the period of about 230 million years from late Palaeozoic to late Mesozoic appears to have been one of stability and prolonged erosion, which resulted in a landscape of low relief extending over most of the study area.

During the Jurassic period, about 150 million years ago, the separation of Australia and Antarctica began. Large east--west troughs or rift valleys developed across southern Victoria, including the southern part of the study area, in which thick layers of non-marine sediments were deposited during the Lower Cretaceous. Their trend was in marked contrast to the north-south trend of the older Palaeozoic trough. During the middle Cretaceous to early Palaeocene, the Lower Cretaceous sediments were upwarped, faulted, and tilted, then eroded to form a subdued terrain over much of the study area.

In the south a shallow depression developed - probably as a result (in part) of a fault - representing the embryonic Gippsland Basin, which was to receive sediment through much of the Cainozoic.

Fault and monoclinal movements occurred particularly during the early Tertiary around the margins of what are now the Eastern Highlands and it was then that the outlines of these Highlands first became clearly delineated, although the topography was still gentle and drainage ill-defined. In the Buchan area basaltic lava of the older volcanics was extruded onto this surface, infilling some of the valleys, displacing the streams, and forcing them to incise new valleys in less-resistant rocks marginal to the basalt flows.

The Buchan and Timbarra Rivers at Dinner Hill Gap are twin lateral streams that have isolated a narrow flat-topped ridge of resistant basalt. This ridge marks the position of the river valley that extended to Buchan South. Another basalt residual occurs at Mount Useful, just to the north of the study area. It is thought that the Snowy River, which was once part of the Buchan system, was diverted to the east by outpourings of basalt during this same period.

The oldest land surface in the study area probably derived from this subdued early Tertiary landscape and the associated volcanics. Uplift and subsequent erosion have left remnant plateau surfaces associated with the basalts running north from Buchan South, at Mount Elizabeth, and in the extreme north-west of the study area. Other remnants probably occur at Mount Dow and Mount Sugarloaf. Hence, by the early Tertiary, the broad topographic outline of the study area was established - with the highlands to the north and the Gippsland Basin to the south. At this time the present drainage pattern began to develop, influenced in part (in the east) by volcanism. Periodic regional uplift throughout the Cainozoic caused the rejuvenation of streams draining the north of the study area and, as a consequence, accelerated erosion and dissection of the newly formed highlands took place.

Erosion in the highland areas was matched by deposition in the Gippsland Basin, where a series of broad shallow depressions, gradually subsiding, received a variety of non-marine sediments, including thick layers of organic matter that have since compacted to form the brown coals of the Latrobe Valley. These deposits are Eocene to Pliocene in age.

In middle to late Tertiary times the sea invaded the Gippsland Basin - resulting in deposition of marine sediments that extended to the southern margin of the highlands. At the end of the Tertiary it retreated, partly in response to earth movements; this event was marked by an increase in the deposition of coarse-grained material of fresh-water origin. Extensive alluvial fans of sand and gravel (Haunted Hills Gravels) developed along the southern margin of the highlands and deposits extended up the

Limestone cliffs of middle Tertiary age on the Tambo River

valleys of the major streams. The sediments were derived from the highlands, which were undergoing deep dissection following uplift and subsequent stream rejuvenation. Earth movements continued during this period and the Tertiary deposits were uplifted, warped, and dissected by streams. Continued erosion of these deposits has exposed underlying Palaeozoic rocks along the highland margin. Elsewhere a thin cover of Tertiary material remains, although the thickness increases towards the south. The Piedmont Downs correspond to the distribution of these Tertiary rocks. Evidence of river capture in the highlands during

Good exposures of Buchan Caves limestone in cliffs at the Pyramids this period occurs to the north-west of Nowa Nowa and at Clifton Creek, where wide belts of Tertiary alluvial sediments mark former stream courses.

The occurrence of the Tertiary rocks has a marked influence on the form of the major stream valleys in the study area. As the streams encounter the Tertiary outcrops across the Piedmont Downs their valleys widen and broad alluvial flats develop. Lateral erosion and vertical downcutting by the rivers are unimpeded by the relatively unconsolidated sediments of Upper Tertiary age. In contrast, the middle Tertiary 'Bairnsdale Limestones' that outcrop further downstream are much more resistant to erosion. As the rivers encounter the resistant limestone their valleys constrict, and gorges develop as the streams' ability to erode laterally falls. These features occur in the Tambo, Mitchell, and Nicholson River valleys.

In the Buchan--Murrindal area, Devonian limestones of the Buchan Group have been preserved by down-faulting. Limestone is partly soluble in water, and circulating groundwater (and rain water percolating from the surface) during the late Pleistocene and Recent periods have led to cave formation and the development of small areas of karst topography. The only area that can be said to have pronounced karst features is limited to the immediate vicinity of the Pyramids, where the Murrindal River flows underground. Enlargement of the surface openings or subsidence over undermined ground has produced sink holes, which may open up into a cave system or be clogged by sediments, rock, and soil. The largest group of sink holes in the Buchan district occurs on both sides of the Gelantipy Road, 4 km south of the Murrindal State School.

During late Tertiary to Recent times, landscape evolution has been dominated by two processes: earth movements and

Limestone sinkhole south of Murrindal

fluctuating sea levels. Earth movements uplifted and subsequent erosion defined the various land forms in the highlands as we see them today. In the south, earth movements and alternating high and low sea levels throughout the Pleistocene were responsible for the land forms of the Gippsland plains. Phases of high sea level are marked by coastal terraces (bordered by distinct breaks of slope, representing the positions of former shorelines). The terraces can be traced for considerable distances across the study area and they merge into the river terraces along the major stream valleys - for example, on the Tambo, Mitchell, Avon, and Latrobe Rivers.

Dune fields consisting of both sand ridges and sand sheets are widely distributed across the coastal plain. Sandy material, perhaps derived from sediments deposited during high-sea-level phases, or deflated from stream beds during more arid climatic periods, have been redistributed by wind action over a wide area, particularly on the 'Munro Plain' lying between Stratford and Bairnsdale. From the distribution of the dune fields in this area, Providence Ponds Creek and the Perry River were probably important sources of sandy material.

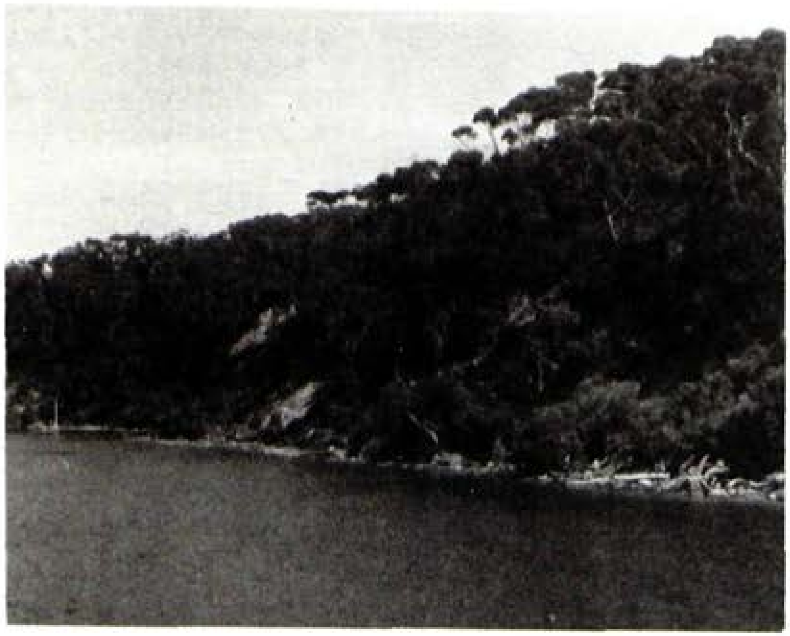
During periods of high sea level, the major river valleys were infilled with a variety of sediments, but as sea level fell and the streams were rejuvenated, the valleys were deepened and remnants of the former flood-plains were preserved as river terraces. On some of the higher terraces, abandoned flood-plain features such as levee banks, prior stream courses, and backswamp depressions remain apparent today. The low terrace to the east of Sale displays many of these features.

During low-level phases, the major streams flowed out onto the emerged floor of Bass Strait, but as sea level rose, and the southern part of the Gippsland lowlands was inundated and progressively enclosed by sandy barriers to form the Gippsland Lakes, the rivers no longer reached the sea but drained into the lake system.

The oldest barrier occurs only as a series of isolated remnants because of stream dissection during intervening phases of lower sea level. Remnants of this barrier occur at Raymond Island, Banksia Peninsula, and along the northern shores of Lake Wellington and Lake Victoria. A younger barrier of late Pleistocene age forms the Boole Poole Peninsula and the southern shore of Lake Victoria, included in the Lakes National Park. The youngest barrier, enclosing the whole lake system and bordered by the Ninety Mile Beach, extends from Lake Tyers to Corner Inlet, north of Wilsons Promontory; it is considered to be of Recent age.

The barriers consist of masses of unconsolidated sand in the form of beaches and dunes. The two youngest barriers

*Lakes Entrance,
looking west to
the main
Gippsland Lakes*



Former sea cliff between Lakes Entrance and Metung

are outside the study area, but they are important in the geomorphic evolution of the Gippsland Lakes region.

The Gippsland Lakes occupy former estuaries, bays, and inlets, substantially cut off from the direct influence of the sea by the outer barrier. Following this isolation, the outlines of the lakes have been modified by sedimentary processes typical of a relatively sheltered lagoon and lake environment. Sediment reaches the lakes from streams, from erosion of lake shores and adjacent cliffs, and from the sea via the artificial opening in the outer barrier at Lakes Entrance. It is deposited in sheltered areas, protected from the dominant south-westerly and westerly winds - for example, on the southern and western shores of Lake Wellington, where sedimentation assisted by the encroachment of swamp vegetation is reclaiming part of the lake. The sheltered lake environment favours the development of elongated river deltas, which are really extensions of the levee banks bordering the river channel. These features, termed 'silt jetties', occur on the Latrobe, Avon, and Tambo Rivers, but are best developed at the mouth of the Mitchell River, south of Bairnsdale.

On the more exposed lake shores, sand and gravel beaches are common, particularly where sediment has been derived from local sources such as cliffs. Sand and gravel spits also receive sediment from longshore drift. Good examples occur on Banksia Peninsula, Butlers Point near Paynesville, and Shaving Point at Metung. Cliffs, found where the coastal terraces intersect the lake shores, are important sources of sediment. Those between Metung and Lakes Entrance on the northern shore of Lake King formed part of the sea cliff that was active prior to the emplacement of the outer barrier. The cliff line can be traced along the northern side of the Gippsland Lakes as far east as Lake Tyers, where it intersects the present coastline at Red Bluff and becomes an active marine cliff once more.

In 1901 Gregory noted that the lakes were contracting as a result of swamp-land encroachment. However, at present, many areas of lake shore that were advancing in the early nineteen-hundreds are now receding. The Avon and Latrobe deltas still have a protective cover of reed-swamp vegetation and are thus still advancing into Lake Wellington, but the Mitchell and Tambo deltas are eroding, having lost their protective reed-swamp fringe.

The disappearance of the reed swamp is thought to be related to increased salinity in the lakes, caused by cutting the artificial opening through the

Example of a braided stream - the Avon River at Stratford

outer barrier at Lakes Entrance. Formerly, an intermittent natural entrance (located near Lake Bunga at the eastern extremity of the lake system) limited the marine influence and opened only when the water level in the lakes rose sufficiently to breach the outer barrier. The artificial cut, constructed in 1889, allows a continuous exchange of water between the lakes and Bass Strait. As a result, salinity has increased - particularly in Lakes King and Victoria, and to a lesser extent in Lake Wellington. It is thought that the reed-swamp vegetation cannot tolerate the increased salinity and therefore dies, exposing the sediment previously trapped by the vegetation to erosion. As a consequence the silt jetties are breaking up into a series of islands.

Human interference in the Gippsland Lakes catchment has initiated a number of river channel modifications. The Avon River and Freestone Creek are the only streams in the study area that are conspicuously braided, although braided reaches do occur in other rivers - for example, the Tambo River at Bruthen. Historical evidence indicates that these streams were originally narrow, with steep banks, but clearing operations in the catchment during the 1860s and 1870s led to an increased supply of sediment derived from erosion of unconsolidated material, particularly adjacent to the river channels. The streams now have very wide channels, filled with enormous quantities of sediment.

Geomorphology

Five major geomorphic units have been recognized within the study area and they fall into two major geomorphic regions, the Eastern Highlands and the Gippsland Lowlands.

Eastern Highlands

The Highlands are characterized by a broad belt of uplifted and deeply dissected mountainous terrain. Periodic elevation by tectonic forces and differential erosion of various rock types have been the most important factors in the geomorphic evolution of this region.

Deeply dissected terrain in the Macalister River catchment

Three distinctive geomorphic units occur within the Eastern Highlands: plateau remnants, dissected highlands, and intermontane basins.

Plateau remnants

To the north, the highlands consist of a series of extensive plateaux. Within the study area, however, the plateaux have been reduced to isolated remnants, following intense and prolonged stream dissection, and occur as elevated ridge crests that are flat to gently undulating, although the surrounding terrain is deeply dissected. The largest of these remnants occurs in the extreme northwest and represents the continuation of a larger plateau centred on Mount Useful to the north; others occur at Mount Elizabeth, Mount Sugarloaf, and Mount Dow, and in the area around Murrindal.

Dissected highlands

Deeply dissected mountainous tracts cover most of the northern part of the study area. Relief is greatest in the north, where differences of 200 to 500 m between ridge crests and valley floors are common. The valley sides are generally steep and the ridge crests narrow and well defined. Interlocking spurs are common along the valleys of major streams. The highlands decrease in elevation toward the south, where the boundary with the Gippsland lowlands can be difficult to distinguish; although a marked change in stream patterns and slopes usually occurs. Many of the larger streams throughout the highlands - such as the Macalister River northwest of Glenmaggie, the Buchan River at Buchan, and the Mitchell River at Tabberabbera - meander across broad alluvial flats within the dissected ranges.

Intermontane basins

A number of isolated basins occur within the highlands, and their development and distribution were directly related to the process of differential erosion of the underlying rocks. The basins are characterized by gentle gradients from ridge crest to valley floor, and the many stream channels are usually lower than the deeply dissected terrain surrounding the basin. The topography within the intermontane basins is generally subdued, with broad valley floors and rounded ridge crests. In the study area the basins develop on a particular rock type (commonly granite) while the surrounding mountainous terrain overlies other rocks, usually Palaeozoic sediments. Differential erosion of these rock types is responsible for the development of the basins.

Within the study area most of the public land occurs in the highland region, primarily because the terrain is too rugged to be cleared for agriculture. The intermontane basins and sections of the alluviated valleys along the major streams within the highlands, however, have been alienated (at least partly) because of their subdued relief. The larger intermontane basins at Dargo and in the Ensay--Swifts Creek district have been completely alienated, but some of the more isolated basins remain as public land.

Gippsland Lowlands

This area, lying to the south of the uplifted Eastern Highlands, has periodically acted as a sedimentary basin since the late Mesozoic. Various sediments have accumulated here in response to earth movements and to fluctuations of sea level. Two major geomorphic units occur in this region: the Piedmont Downs and the alluvial and coastal plains.

Piedmont Downs

The Downs consist of a low, gently undulating terrace. As there is only minor relief across the terrace, stream dissection and slopes are minimal. Geologically, the unit is located on an uplifted, partially dissected plain of Tertiary sediments, draped over Palaeozoic rocks that form the southern margin of the highlands. The cover of Tertiary material is discontinuous in the north but increases in thickness towards the south. In places, residuals of Palaeozoic rock protrude above the Tertiary sediments. The terrace form typical of this unit is preserved in the Nowa Nowa and Calulu Hills, but the original surface has been almost completely destroyed in the Stockdale Hills.

Between Glenmaggie and Bruthen, the Piedmont Downs have been alienated, mainly for pasture, but in the Nowa Nowa Hills they remain as public land.

Alluvial and coastal plains

Between Heyfield and Lake Wellington, an extensive alluvial plain associated with the Thomson and Macalister Rivers forms the western part of this unit. The topography is generally flat to slightly undulating. Associated geomorphic features include present-day flood-plains, former flood-plains and abandoned levee bank deposits, and flights of river terraces.

The eastern section - from Stratford to Lakes Entrance - is a broad coastal plain characterized by a series of coastal terraces of marine origin, covered partly by sand ridges and sheets. To the south of the lakes, several phases of sand barrier formation during late Pleistocene to Recent times resulted in progressive isolation of the lake system from the sea. The sediments are of late Tertiary to Recent age, and include fluvial, marine, estuarine, lake, and lagoonal deposits. Remnants of Pleistocene barrier systems, dunes, and other coastal features occur in the area.

Most of the Gippsland lowlands have been alienated to provide land for settlement and agriculture. The alluvial plains are favoured because of subdued relief, abundant supplies of water for irrigation, and good soils; the coastal plain has been utilized for grazing activities. The Gippsland Lakes and some adjacent shoreline areas still remain as public land; isolated pockets of unalienated land occur, the largest block being located along the Perry River near Fernbank.

Stratigraphy

Ordovician

Marine sedimentary rocks laid down during the Ordovician are the oldest rocks outcropping in the study area and form much of the northern or highlands part of the area. They consist of sandstone, siltstone, and greywacke laid down under deep-sea conditions. Fossils are rare, but those present, mainly graptolites, suggest middle to late Ordovician age.

During the Benambran Orogeny (early Silurian) the sediments underwent folding and faulting, causing much of the fine-grained rocks to be metamorphosed into slate and phyllite. These rock types outcrop along the Omeo Highway between Bruthen and Walsh's Cutting. The deformation was at its most intense north from Ensay, where moderate pressure and locally high temperatures caused complete recrystallization of the sediments to light-coloured crystalline gneiss. Where it was less intense, the original sediments were altered to lower-grade metamorphic rocks varying from phyllites through to schists.

Subsequent to the Benambran Orogeny, the metamorphic belt and unmetamorphosed bedrock was subject to large-scale and repeated faulting. Examples include the Ensay and Kiewa faults, and the small infaulted slices of Upper Ordovician sediment north of Glenmaggie.

Silurian--middle Devonian

During the Silurian and early Devonian, the portion of the Tasman Geosyncline within the study area had constricted to three distinct areas of deposition - formed by the Tabberabbera, Buchan, and Melbourne Troughs.

Marine mudstone, sandstone with subordinate conglomerate, and limestone were laid down in the extreme west - in the Melbourne Trough. During the Tabberabberan Orogency this succession was deformed into relatively open folds with north-trending axes. The stratigraphy of these sediments, which outcrop in the Walhalla area, is still unclear.

During this period, the geological history of the eastern part of the study area was much more complex than that of the Melbourne Trough. It included several periods of deformation, extrusion of volcanics, and deposition of marine

Ordovician sediment along the Tambo

sediments. No Silurian rocks outcrop here, although they occur just below the surface at Nowa Nowa. The marine sediments were folded, intruded by granite, and partly eroded during the Bowning Orogeny. Granites, intruded during this Orogency, outcrop in the Timbarra area.

The early Devonian saw the extrusion of the Snowy River Volcanics and deposition of non-marine conglomerate rocks - which outcrop in a broad belt north of Nowa Nowa. This sequence unconformably overlies or is faulted against granite, Ordovician sediments, and metamorphics.

The basal 2,000 m of the Snowy River volcanics comprises a lower unit of conglomerate and subordinate sandstone with pebbles of Ordovician sediment, rhyodacite, and granite, and thin rhyodacite flows, overlain by a unit of siltstones, sandstone with subordinate conglomerate, and ignimbrite. The main extrusive phase of these volcanics is represented by a 2,450-m sequence of fine-grained rhyodacite with minor siltstone, sandstone, and conglomerate.

In places the rhyodacites contain inter bedded sediments, which, west of Buchan, contain fossils of marine origin. Similar fossils are found south of Buchan, where the sequence grades up into tuff and shale. Thus, although the volcanics are principally non-marine, it would appear that some were laid down in a marine environment. This association of volcanics with marine sediments provides

Conglomerate of late Devonian - early Carboniferous age a suitable environment for the formation of stratiform sulfide ores and, as a result, high values for copper, lead, zinc, and silver have been recorded in some areas.

Following the main period of extrusion of the Snowy River volcanics, block faulting and planation developed an extensive shelf. Subsidence of this planar shelf in the late Lower Devonian led to the deposition of the Buchan Group in the Buchan--Murrindal area, and the Wentworth Group at Tabberabbera. The Buchan Group is in places faulted against the Snowy River volcanics, but elsewhere conformably overlies them, and the transition from Snowy River volcanics to Buchan Group may be gradational - as evidenced by the occurrence of tuff at the base of the calcareous sediments.

Buchan Group limestones comprise three units: Buchan Caves Limestone, Taravale Formation, and Murrindal Limestone.

The Buchan Caves Limestone, a dark grey dolomitic unit, is 370 m thick at Buchan and is very rich in fossilized coral fauna, suggesting deposition in a restricted shallow marine environment. Caves at the Buchan Caves Reserve lie within this unit. An economically significant feature are the stratiform lead--zinc deposits and zinc--silver pyrite ores associated with it.

Taravale Formation conformably overlies the Buchan Caves Limestone and consists of 550 m of siltstone with thin bedded nodular limestone and occasional thicker limestone beds. It outcrops both north and south of Buchan.

Murrindal Limestone, a light grey limestone unit 300 m thick, is exposed in the caves at Murrindal. Fossil remains indicate it was deposited in a high-energy, shallow-water situation.

The Wentworth Group is restricted to a long narrow synclinal belt, which overlies Ordovician sediments with marked unconformity. It consists of the Wild Horse and Tabberabbera Formations.

Wild Horse Formation consists of between 30 and 360 m of sandstone and conglomerate derived from Ordovician sediments. The Tabberabbera Formation comprises a mixture of siltstone, sandstone, claystone, impure limestone, and conglomerates, up to 1,400 m thick. Fossils of a rich shelly fauna are mostly confined to a calcareous sandstone in the middle of the Formation.

Following the middle Devonian Tabberabberan Orogeny, and extending to early Cretaceous, the study area experienced a recognizable cycle of rock formation, precipitated by further gentle earth movements.

Upper Devonian--Lower Carboniferous

The first phase of this post-orogenic cycle was one of widespread igneous activity. The Woods Point Dyke Swarm in the western part of the study area and the Tabberabbera Dyke Swarm further east both intruded into newly folded Lower to middle Devonian sediment. A number of small scattered granitic bodies were intruded into the more stabilized Ordovician bedrock, possibly including those at Castleburn, Mount Blomford, and Dargo.

During the next phase, down-warping in the western part of the study area progressively developed a trough, which attained a maximum width of at least 40 to 50 km. A thick non-marine sequence (Avon River Group) accumulated in this trough to a maximum depth of about 4,200 m. In the study area these rocks now outcrop in two broad synclinal basins - the Avon Synclinorium and the Mitchell Syncline.

The Avon River Group is dominated by non-marine sediments with interbedded volcanics. In the study area it is divided into three formations: the Moroka Glen Formation, Wellington Rhyolite, and Snowy Plains Formation.

Moroka Glen Formation outcrops along the western margin of the Avon Synclinorium running north from Lake Glenmaggie and in the Freestone Creek area. It is characterized by conglomeratic beds with widespread basalt flows.

Wellington Rhyolite volcanics, which include minor basalt flows, are thought to represent one major phase of predominantly fissure-type eruptions. They conformably overlie the Moroka Glen Formation and outcrop around the Avon Synclinorium and on the western side of the Mitchell Syncline.

The Snowy Plains Formation is by far the thickest (2,400 m) and comprises the bulk of the Upper Devonian--Lower Carboniferous outcrops in the study area. Purple to red sandstone and mudstone are most common, with minor basalt flows also present.

Progressive down-warping during sedimentation was followed in the early Carboniferous by strong local deformation, regional tilting, and broad folding of the Avon River Group.

Permian

In the study area, Permian rocks are known only subsurface near Paynesville, where they underlie more than 1,000 m of Cretaceous and Cainozoic rocks. The Permian section consists of just under 200 m of shale, siltstone, and muddy sandstone lying directly on Ordovician bedrock.

Cretaceous

A new depositional setting developed with the separation of Australia and Antarctica in the Jurassic--Cretaceous period. A series of rapidly subsiding basins stretched across southern Victoria, in which accumulated non-marine and, later, marine sediments. Within the study area, rocks of this period (Strzelecki Group) are confined to subsurface occurrences south and west of Bairnsdale.

Exploratory drilling has shown that the Group thickens rapidly from north to south - being only 249 m thick in the Duck Bay well; but, even after drilling through the sediments (including 100 m of basalt) for 2,634 m, the base was not reached in the Wellington Park well.

Lower--middle Tertiary

As a result of tectonic movements during this period, most of the southern part of the study area was subjected to the incursion and subsequent retreat of the sea. Volcanic activity, probably associated with the earth movements, resulted in local extrusion of basaltic lava in the highlands. Small areas of basalt from these older volcanics occur northwest of Buchan. The sedimentary sequence that developed to the south over this time is divided into three groups. Oldest to youngest, they are the Latrobe Valley Group, the Seaspray Group, and the Sale Group.

Sediments of the Latrobe Valley Group, within the study area, lie well below the surface. They are the result of non-marine sedimentation, including the accumulation of thick layers of organic matter. In the Latrobe Valley, where they are close to the surface, they contain major coal seams and important aquifer systems.

Victoria's major oil and gas reserves are trapped in Latrobe Valley Group sediments. They are generally considered to be derived from plant matter deposited with the Group, and to have migrated through permeable quartz sandstones and along fault planes to traps, where they are sealed by impermeable shales of the overlying Lakes Entrance Formation (Seaspray Group). Gas tends to occur in shallow fields near the margin of the basin, while the oil is found at deeper levels further offshore. Traces of oil that were recovered from bores near Lakes Entrance suggest that accumulations of oil once existed onshore, but have been flushed out by percolating rain and flood-waters.

Seaspray Group marine sandstones, limestones, and marls were laid down following the subsidence of the southern part of the study area. They conformably overlie the Latrobe Valley Group. Within this Group the following sequence is recognized.

* The basal Lakes Entrance Formation of sands and gravels rests on a planed-off Palaezoic basement. It represents the initial transgression of the sea in the Oligocene.

* The overlying and more extensive Gippsland Limestone Formation of

Cliffs in Tertiary sediment at Eagle Point bluff

limestone and marls was deposited when the marine incursion was at its maximum during the early Miocene. This formation is exposed in the bluffs that border the Mitchell Valley above Bairnsdale.

* The Tambo River Formation, consisting of limestones and marls, and the sands, silts, and clays of the Jemmy's Point Formation were deposited as the sea level fell during the Upper Miocene and early Pliocene. The latter formation outcrops at Jemmy's point, Red Bluff, and Eagle Point.

Sale Group consists of non-marine sediments that were deposited in two phases as, and after, the sea receded. The first phase is represented by the Boisdale Formation, which in the study area is partly contemporaneous and partly younger than the Jemmy's Point Formation. This mixture of sands, clays, and silts includes the major aquifer system in south-east Gippsland. It is bext exposed along the Avon River and Freestone

Creek near Bushy Park. It is separated in time from the younger Coongulmerang Formation and the extensive Haunted Hill Gravels by periods of erosion, recorded as ironstones. These two units of clayey, fine quartz gravels - with lesser sands, silts, and clays - form a veneer over a large part of the lowlands. They were deposited following rejuvenation of highland streams by renewed uplift (the Kosciosko Uplift) in the late Pliocene and/or early Pleistocene. Remnants of these deposits occur on low dissected hills at the foot of the highlands.

Upper Tertiary--Recent

Terrace deposits formed during this period as the Gippsland Plain was intermittently uplifted, resulting in alternating periods of erosion and deposition. Seven well-defined sets of stepped terraces are recognizable in the lower tracts of the main streams draining the Eastern Highlands and smaller streams flowing across the Nowa Nowa Hills.

Inland dunes - the late Pleistocene dune-fields of the Munro Plain - are probably of inland origin, with sand supplied by deflation from various stream beds such as Providence Ponds Creek and Perry River. Most consist of loose grey sand with cores of soft clay-cemented sand, while others have only a thin sand cap overlying gravelly sand.

The coastal dunes formation consists of unconsolidated well-sorted sand and includes the barrier systems of the Gippsland Lakes. Within the study area it is represented by a narrow discontinuous belt of dunes along the lakes' northern shores. The lakes and associated land forms were discussed more fully in the section on geological and geomorphic history.

Alluvial and colluvial deposits include 'hillwash', fan, and scree deposits, as well as all modern flood-plain deposits, the most extensive of which are along the lower reaches of the main streams.

Both types of deposit comprise mixtures of gravel, sand, and silt, with the flood-plain deposits being distinguished from the others by their lower gradients and more complete sorting and rounding.

Swamps of three types occur in the study area: fresh-water swamps of the Eastern Highlands, fresh-water interdune swamps of the Munro Plain, and lagoons along the present-day shoreline.

The highland swamps are silty or clayey peat bogs, which fill shallow depressions in granite, gneiss, or older volcanics. They may be quite old, perhaps of Pleistocene or Pliocene origin.

Interdune swamps are very common on the Munro Plain, where they form small internal drainage basins within or adjacent to dune-fields. They contain black clay, silt, and sandy silt and are probably of late Pleistocene to Recent age.

Lagoonal sediments are restricted to the coastal belt, where they form behind the coastal barrier and dune systems. They include salt, brackish, and fresh-water swamp and lake deposits, which grade imperceptibly into flood-plain sediments along the major streams. The sediments include consolidated and loose dark mud and clay, fine sand, and some medium sand along channel ways.

Glossary

Aquifer	-	water-bearing layer of rock or soil
Braided stream	-	a stream consisting of interwoven channels constantly shifting through islands of alluvium and sandbanks
Calcareous	-	of or containing calcium
Geosyncline	-	elongated basin that becomes filled with great thicknesses of sediment
Intermontane	-	between mountain ranges
Karst features	-	cavities and sinkholes caused by the dissolution of underlying limestone
Lateral streams	-	streams that subsequently develop course along the edges of basalt flows; streams that develop on either side of a flow are known as 'twin laterals'
Magma	-	molten stratum from which igneous rock is formed
Monocline	-	fold in the stratum
Orogeny	-	process of mountain formation
Stratigraphy	-	study of the order and relative position of strata
Tectonic	-	relating to deformation of the earth's crust or to structural changes caused thereby

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CLIMATE

The climate of the area varies quite considerably from north to south in response to orographic variations (the system of mountains and valleys). Elevations range from a maximum of 1,400 m down through the foothills to plains and coastal areas. Generally the transition from the warmer and drier lowlands to the cooler and wetter highlands is gradual, although local orographic variation can give rise to sharp gradations in climate.

Rainfall

The most common rainfall-producing circumstance for most of southern Victoria is the passage of a low-pressure system to the south of Tasmania, while cold fronts cross Victoria. However, much of the Gippsland Lakes hinterland area may receive little or no rain from such an occurrence, most of the rain being deposited on mountains to the west.

Rainfall in Gippsland is much more likely to result from a low-pressure system centred off the eastern coast of Australia. Such depressions commonly develop off the New South Wales coast and then move southwards. Alternatively, a low may pass through Bass Strait and intensify in the Gabo Island area. A depression in this location produces a vigorous southerly air flow over the Gippsland region. This air flow is both warm and moist, having its origins in the Tasman Sea, and can deposit heavy rainfall over most of Gippsland.

At most localities in the area, rainfall is fairly evenly distributed throughout the year. For example, the maximum and minimum monthly rainfall averages for Briagolong are 64 and 44 mm respectively. The corresponding data for Buchan are 80 and 60 mm.

Predictably, rainfall increases with elevation. In general, the mean annual rainfall totals vary quite considerably from the plains to the higher country. Recorded annual averages range from a minimum at Maffra in the south-west (572 mm), gradually increasing eastwards to Lake Tyers (856 mm), to more than 1,000 mm in the high country. Because of a paucity of rainfall stations north of the foothills, however, rainfall patterns there must often be inferred from topography.

The well-defined rain shadow over the Heyfield--Maffra--Sale area is caused by the mountains to the west intercepting rainfall. A rain-shadow effect is also evident in deep valleys such as those of the Macalister, Mitchell, and Tambo Rivers. For instance, Tabberabbera, in the Mitchell River valley, has an average annual rainfall of 659 mm, while Bullumwaal on the bordering high country receives 1,080 mm.

Snow

Snow rarely occurs on the low country, and even at Buchan and Dargo its frequency is low.

At elevations above 600 m, snow falls fairly regularly during winter; only at isolated locations in the study area, however, does it lie on the ground for any length of time.

Temperature

Variations in altitude across the area exert a considerable influence on temperatures, with a temperature gradient generally rising from the cooler northern mountain country to the warmer plains and coastal land. Within this general trend, local topographic changes and proximity to the sea can markedly affect the temperatures.

The warmest district is around Sale and Maffra, with 45.6°C at Sale being the highest temperature ever recorded in the area. This district is mainly less than 30 m in elevation, but summer day temperatures are not significantly tempered by sea breezes.

Mild winter weather over the plains and coastal areas is a feature of the climate of Gippsland. Northerly winds in the east of the State, particularly those bringing rain to the north-eastern highlands, become quite warm when descending from the mountains. This is known as the Föhn effect and, under its influence, it is not uncommon for the area to record the highest temperatures in the State for that period.

The valleys and gorges in the mountainous terrain to the north influence night temperatures, complicating the study of minimum temperatures. Minima are normally lower at stations subject to such influences than at well-exposed stations at the same altitude, even though they have approximately the same maximum temperatures.

Minimum temperatures along the seaboard are higher than those at inland stations because moist air has a blanketing effect on out-going radiation. With the exception of minor deviations, therefore, minimum temperatures increase steadily from north to south.

Frosts

The occurrence of frost depends not only on the temperature and the humidity of the air, wind speed, and cloud, but also on characteristics of the ground surface

Table 5

CLIMATIC DATA FOR SELECTED LOCATIONS

Station		J	F	M	A	M	J	J	A	S	O	N	D	Annual
MELBOURNE	A	48	50	53	59	57	50	49	49	59	67	59	58	658
	C	26.5	25.9	24.0	20.9	16.5	14.5	13.5	14.9	17.1	19.7	21.8	24.0	19.9
	D	14.9	15.3	13.5	11.2	8.7	7.0	6.2	6.8	8.1	10.0	11.4	13.3	10.5
BAIRNSDALE	A	61	52	64	51	55	57	50	51	57	69	66	69	702
	B	58	55	64	71	75	83	84	85	92	86	66	68	
	C	25.1	25.4	23.6	21.1	16.9	15.5	14.3	15.4	17.2	19.6	21.6	22.9	19.9
	D	13.0	13.2	12.0	8.9	6.6	5.0	4.3	4.8	6.2	8.4	9.9	11.8	8.7
BRIAGOLONG (43)	A	56	55	47	44	47	61	46	46	65	64	50	60	640
BRUTHEN (91)	A	65	58	60	64	62	66	54	54	61	77	68	76	763
	B	59	51	62	76	76	82	89	90	93	89	69	67	
BUCHAN (90)	A	66	61	60	64	67	78	63	60	69	80	71	75	815
	B	62	63	63	75	89	89	94	95	98	92	76	71	
BULLUMWAAL (7)	A	110	77	69	92	103	84	52	109	69	74	133	108	1080
BUTCHERS RIDGE * (77)	A	79	70	73	75	79	90	84	72	86	89	81	89	967
DARGO (34)	A	54	59	58	52	61	57	46	59	60	79	77	82	752
	B	55	63	65	70	88	91	93	95	93	92	69	70	

A Mean monthly and annual rainfall (mm)

B Probability of receiving at least the effective rainfall (%)

C Mean monthly and annual maximum temperature (^{o}C)

D Mean monthly and annual minimum temperature (^{o}C)

Station		J	F	M	A	M	J	J	A	S	O	N	D	Annual
ENSAY (63)	A	65	57	56	48	55	55	52	48	57	69	73	77	715
	B	64	61	60	73	73	83	89	91	86	78	61	68	
GLENMAGGIE WEIR (35)	A	65	54	61	49	60	43	33	47	49	64	70	65	657
	B	48	53	58	61	60	86	88	88	83	85	64	52	
HEYFIELD (44)	A	49	47	52	59	42	51	36	46	46	61	58	56	619
	B	48	37	52	63	54	86	87	78	79	84	64	52	
LAKES ENTRANCE (88)	A	63	49	65	61	60	62	53	49	59	73	65	69	734
	B	63	55	74	83	84	91	96	88	98	90	70	70	
	C	23.8	23.8	21.6	20.3	16.4	14.5	14.4	15.0	16.7	18.9	19.5	21.4	18.8
	D	14.2	14.9	13.0	10.9	8.2	6.1	5.3	5.8	7.1	9.1	10.4	12.2	9.8
MAFFRA (72)	A	51	43	55	43	47	45	36	40	48	61	55	59	572
	B	45	44	56	55	63	77	82	80	87	85	54	50	
	C	25.8	26.9	24.1	21.7	17.4	14.7	14.7	15.1	17.3	20.3	21.7	24.0	20.3
	D	12.8	13.5	11.1	8.3	5.9	3.5	2.7	3.9	5.1	7.3	8.9	10.9	7.8
OMEO (94) *	A	51	54	54	46	54	57	52	55	62	71	62	62	676
	B	49	56	63	72	86	92	97	93	95	89	66	59	
	C	25.8	25.3	22.9	18.9	13.9	11.3	10.2	11.8	14.8	18.0	20.9	23.1	18.1
	D	9.5	9.8	7.7	4.4	1.9	0.3	0.4	0.4	2.3	4.6	6.2	8.0	4.6
EAST SALE (30)	A	47	46	57	46	59	46	38	53	51	66	64	59	633
	B	41	45	62	65	70	90	91	93	93	87	68	55	
	C	25.4	25.3	23.4	20.6	16.3	14.3	13.5	14.6	16.6	19.0	21.1	23.0	19.4
	D	12.9	13.3	11.5	8.5	6.1	4.1	3.3	4.3	5.6	7.8	9.4	11.4	8.2

Notes:

1. Figures for Melbourne have been included for comparative purposes
2. Stations located just outside study area indicated thus *
3. Number of years of records included in parenthesis

- the slope (and slopes of nearby surfaces), vegetative cover, and water content. Local topography can significantly influence its distribution. Hollows are particularly frost-prone, due to pooling of dense cold air, while slopes (where the flow of air is unimpeded) are much less subject to frost.

For the settled area, at low elevations, frosts can be expected primarily in the period May to September, The higher minimum temperatures close to the sea reduce the incidence in comparison with stations inland. Lakes Entrance, for instance, experiences an average of only nine frosts per year, while East Sale has 34.

The elevated valleys, for which no data are available, would almost certainly have a longer frost season and higher frost incidence. Omeo, just outside this area, experiences frosts on an average of 115 days a year, with at least one each month between March and December.

Evaporation

The amount of evaporation is determined by measuring the loss of water from an open-topped standardized tank. This measurement (strictly, the potential for evaporation) depends on temperature, humidity, and wind speed.

Evaporation measurements at stations at Bairnsdale and East Sale indicate average figures of approximately 1,360 mm (compared with rainfall of 600-700 mm). During the summer, evaporation exceeds rainfall by a factor of 3 or 4. During winter, however, rainfall totals approach or exceed those of evaporation.

Wind

The Great Dividing Range prevents almost entirely any strong northerly wind reaching the coast and plains region; here the prevailing wind blows from the north-west to south-west quarter. This is most marked in the winter, when the wind blows from this quarter for almost two-thirds of the time. In summer the influence of the east to south-east sea breeze is quite marked, being felt on about two-thirds of the afternoons.

Strong winds (mean speed more than 40 km per hr) are infrequent away from the coast, and occur on only 15 to 20 days a year, generally in late winter and spring. About 90% of these strong winds blow from a generally westerly direction.

Sunshine

The area's only sunshine-recording station is at East Sale, and data from here cannot necessarily be considered representative of the whole area. Records from this station indicate that January has the most sunshine per day (average 8.2 hrs), while June has the least (4.3 hrs). The average for the same months at Melbourne are 8.5 and 4.4 hours respectively.

In general, sites at higher altitudes will experience less sunshine because of cloud formation by orographic lifting.

Growing season

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

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

Estimates of effective rainfall are useful for agricultural planning, but they do not necessarily indicate the effects of dry spells on deep-rooted perennial plants, and the reseeding ability of annual plants.

Section B of Table 5 shows the frequency of occurrence, month by month, of rainfall equal to or exceeding the effective amount.

As this table indicates, the normal growing season may be considered as extending from March--April to November--December even in the drier districts. However, the long-term average presents a different picture from the actual annual growth pattern, as wide variations have occurred within years. Over the last 100 years the area has experienced some 22 drought periods, and with this frequency the area could be considered to be unreliable compared with some parts of the State.

In some localities, low temperatures rather than lack of moisture can limit plant growth. This is particularly relevant to the higher country in the north of the area.

WATER RESOURCES

Surface Water

Major streams

Although no significant river system lies completely within it, the study area is traversed by a number of major streams that together carry one-sixth of the State's total stream flow. These streams, which generally flow in a south or south-easterly direction, all rise outside the area in the upper reaches of the Eastern Highlands. With the exception of the Snowy River, which discharges into Bass Strait at Marlo, they all drain into the Gippsland Lakes.

Table 6 lists the average annual flows of the major rivers.

Catchment yields

Yields from catchments are related firstly to precipitation rates and secondly to the percentage of this precipitation that is lost as evaporation, transpiration, deep seepage, and impoundment. In highland catchments, the highest elevations yield the most water per unit area as precipitation is higher and evapotranspiration is lower. Also, a high proportion of precipitation is ultimately available as run-off as it mainly falls as snow, and the water stored in this way is released by snow melt while evapotranspiration remains relatively low.

It is estimated that surface run-off within the study area contributes only about 3% of Victoria's annual average stream flow, compared with approximately 14% produced by catchments of the major rivers that extend beyond the study area into the highlands. Thus, although it is well endowed with surface water, the study area itself does not contribute significantly to this resource.

Furthermore, of the estimated total volume of rainfall received each year over the land surface of the Gippsland Lakes hinterland (5,363,550 ML), only about 9% (or 486,900 ML) is discharged to the river systems. The remainder is lost or retained within the study area.

Stream-flow distribution

Typical of eastern Victorian rivers, about three-quarters of the average annual flow occurs in winter and spring (see Figure 3). This distribution closely follows the pattern of greater

Table 6

DRAINAGE BASIN CHARACTERISTICS

Drainage basin	*Stream gauge* location & number	*Catchment area* above gauge (km^2)	*Annual discharge* ('000 ML) Max.	Min.	Mean	*Mean annual* discharge rate (ML/km^2)	*Reliability* (% of annual discharge) 6mths Dec-May	3mths Jan-Mar.	*Salinity* (mg/L) Max.	Min.	Mean
Thomson	Thomson R. at Cowwarr Weir (225206)	1088	653	157	409	376	31.7	11.2	126	11	41*
	Macalister R. at Glenmaggie Reservoir (225204)	1891	1620	52	539	309	27.0	6.8	178	10	44
	Avon R. at Valencia Ck. bridge (225205)	862	758	13	143	166	40.1	14.5	-	-	-
	Freestone Ck. at Briagolong (225218)	311	154	8.9	74	239	59.0	10.9	176	31	65
Mitchell	Mitchell R. at Glenaladale (224203)	3900	2312	257	936	240	24.6	7.9	123	12	51
	Mitchell R. at Bairnsdale (224200)	4584	1620	102	847	185	20.1	8.6	-	-	-
Tambo	Nicholson R. at Deptford (223204)	293	92	12	44	151	50.7	17.2	180	15	69
	Tambo R. at Bruthen (223200)	2727	680	29	216	79	41.3	24.2	-	-	-
Snowy	Buchan R. at Buchan (222206)	850	514	48	189	223	31.6	11.8	225	15	62

* Derived from samples taken just upstream from gauging station 225206

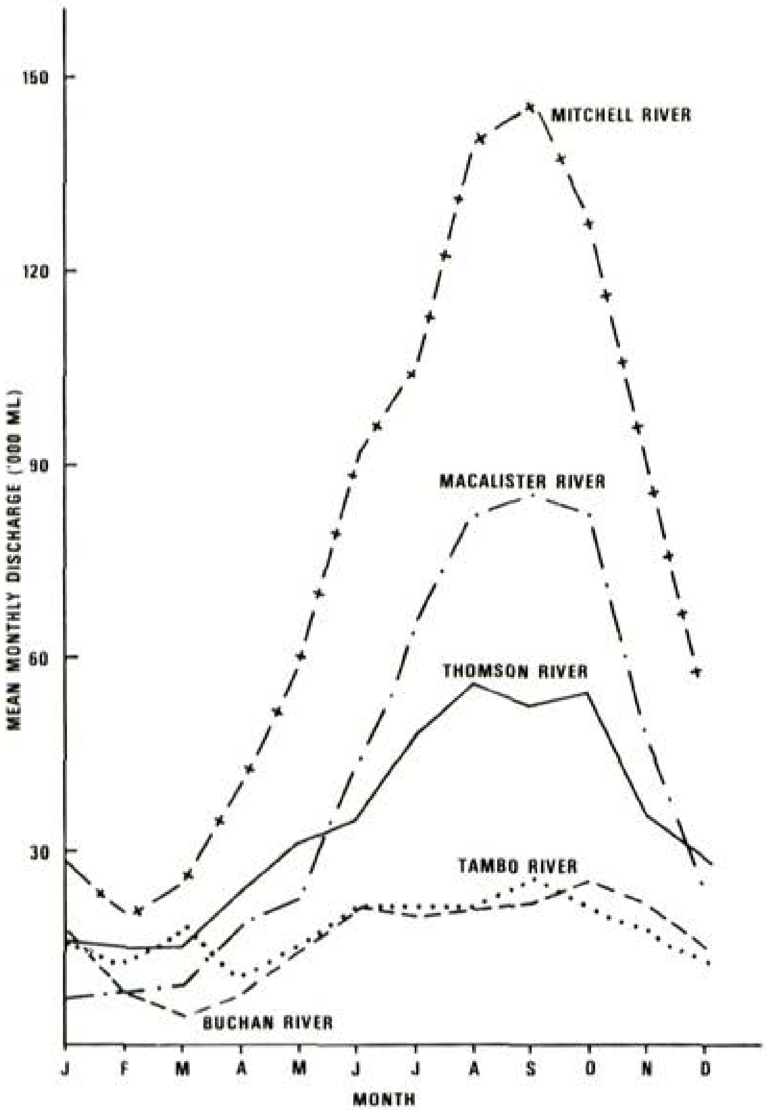


Fig. 3 MEAN MONTHLY DISCHARGE

winter precipitation in the highlands and the melting of snow in the spring.

Although a seasonal variation in stream flow is evident in all major streams, it is less pronounced here than in most other Victorian streams. A significant factor in this regard is the contribution of the highland catchments, which not only produce the greatest quantities of water, but also release this over a long period. These headwater catchments are largely responsible for maintaining reliable stream flows well into the summer months.

Short-term flow characteristics are also important, particularly with respect to flooding. Stream flow is closely related to rainfall intensity and duration, and to the characteristics and soil-moisture condition of the catchment. Heavy rains are apt to produce short-duration high-peak flows, whereas extended light rains can result in a slower, more prolonged yield.

High-intensity rains at any time of year can cause high stream flows in the study area and floods in the lower reaches of most major rivers. The chance of flooding is compounded in late winter and spring, when soils may already be saturated and stream flows high.

Water quality

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

The suitability of water for domestic, stock, irrigation, and industrial uses is affected by such factors as hardness, turbidity, colour, organic content, and concentration of total dissolved solids (T.D.S.). The T.D.S. content, or salinity, is the most convenient single parameter of water quality for practical purposes.

Water is considered suitable for human consumption below 750 mg T.D.S. per litre. Table 6 indicates that, even though maximum and minimum T.D.S. contents may vary enormously at the gauging stations on all major streams, the water never falls below potability.

Other water uses have varying quality requirements, all being less stringent than those for drinking water. The major streams are therefore also of suitable quality for these other uses.

It should be noted that the gauging stations are all in or close to the margin of forested public land, where human activity would have had little effect on water quality. In the lower reaches of the rivers, however, where they flow through the more densely populated and developed Gippsland plains, water quality would be subjected to the influences of agricultural, residential, and industrial land uses. As a result, a substantial deterioration in water quality could be expected as the major streams approach the Gippsland Lakes.

Salinity conditions in the Gippsland Lakes are largely determined by the meeting and mixing of fresh water - from rain and rivers - with salt water flowing in from the sea. There is a salinity gradient from fresh water at the river mouths to sea water at the artificial entrance.

Regular sampling at selected points across the Gippsland Lakes has demonstrated a seasonal salinity regime. In summer and autumn, when evaporation is high and fresh-water input from rain and rivers reduced, sea water invades the lakes and salinity increases. At the end of summer, Lake Wellington is brackish and the eastern part of Lake King becomes virtually an arm of the sea. In winter, when evaporation is low, rainfall augmented by increasing river flow freshens the lakes, diluting and displacing the salt water, and so in spring the water is relatively fresh.

Analysis of salinity measurements in the lakes, recorded by the State Rivers and Water Supply Commission over the period 1957 to 1976, shows marked fluctuations from year to year. Exceptionally high levels were attained during the 1967/68 drought, and exceptionally low levels followed periods of wet weather and river flooding (notably in February to April, 1971) as a sequel to the late January floods.

Mitchell River upstream from Billy Goat Bend

The sediment load of streams and lakes is another important parameter of water quality. The catchments of the Macalister and Latrobe Rivers contain a large proportion of the region's agricultural, industrial, and urban areas (the eastern streams drain predominantly forested catchments). As a result these two rivers discharge comparatively high loads of suspended material into Lake Wellington. Thus, at any given time, water quality with regard to suspended material is poorer in Lake Wellington than in the eastern lakes.

Besides being an important factor in the plant and animal ecology of the lakes, salinity also determines the mode of sedimentation. It is often observed that fine-grained sediment will remain in cloudy suspension in fresh water where brackish water is clear and green; salt in the water causes the sediment to precipitate. The boundary between clear and cloudy water is often visible on Lake Wellington, in McLennan Strait, or in the western part of Lake Victoria.

Salinity level exhibits a positive gradient from west to east across the lakes; as a result, most other measures of water quality display a reverse gradient. Hence, at any given time, the sediment load is higher in Lake Wellington, although salinity is lower, than in the eastern lakes.

Increasing fresh-water diversions from the input streams will reduce flushing of the lakes and so increase the concentration of pollutants entering the lakes.

Because it receives flow from the rivers most affected by increased utilization, Lake Wellington at present shows greater water-quality degradation than the other lakes in the system and, considering the type and scale of developments in the Latrobe Valley, is likely to experience declining standards in the future.

Drainage basins

The study area comprises parts of four major drainage basins:

* Thomson River - including the Thomson, Latrobe, Macalister, Avon, and Perry Rivers and Valencia and Freestone Creeks

* Mitchell River - including the Mitchell, Wonnangatta, Wongungurra, Dargo, and Wentworth Rivers

* Tambo River - including the Nicholson, Tambo, and Timbarra Rivers

* Snowy River - including the Buchan, Snowy, and Murrindal Rivers

Table 6 facilitates comparisons between these drainage basins, while individual river catchments that are gauged within the study area are discussed below.

Thomson River drainage basin

Just under one-half of the Thomson River basin lies within the study area; only 46% of this is gauged. However, the part remaining ungauged - the plains and coastal fringe - contributes little to the yield, which is derived mainly from the highlands.

The Thomson River has its headwaters in the vicinity of Mount Whitelaw, some 80--90 km north-west of where it forms part of the study area's southern boundary. After flowing almost due east for approximately 60 km, the Thomson joins the Latrobe River south of Sale, eventually to discharge into Lake Wellington. Mid-way between Maffra and Sale, the Thomson is joined by its major tributary, the Macalister River. Serious flooding can occur at the junction of these two rivers when peak flows in each coincide.

At Cowwarr, the Thomson River provides a relatively reliable flow of good-quality water, 11% of its mean annual discharge being in the summer months of January--March. The catchment above the gauging station is highly productive, yielding a run-off rate of 375 ML per km^2.

The catchment to the Macalister River extends approximately 60 km north of the study area to Mount Howitt on the Great

Avon River at Avon Track crossing

Dividing Range. From there the river flows in a generally southerly direction to join the Thomson River.

Although the Macalister at Glenmaggie Reservoir has a higher mean annual discharge, its reliability of flow during the period January--March (7%) and its catchment yield (310 ML per km^2) are both significantly lower than those of the Thomson River at Cowwarr.

Headwaters of the Avon River are located on the slopes of Mount Wellington, approximately 20 km north of the study area boundary. The north--south trending Turtons Spur divides the upper portion of the Avon River catchment into two approximately equal sub-catchments. To the west of this spur is the Avon and its main tributary, Ben Cruachan Creek; to the east are Valencia and Freestone Creeks, both of which join the Avon River at points above Boisdale.

Valencia Creek

Estimated mean annual discharge for the Avon at the Valencia Creek bridge is 143,000 ML and, although 40% of the discharge occurs in the 6 months December to May and 14% in the 3 months January to March, flows in the Avon River can vary considerably from year to year and show very little correlation with coincident annual flows in the adjoining Macalister River catchment. During the severe drought of 1967/68, the Avon and its tributaries virtually dried up.

Because of the rainshadow effect, catchment yield is of the order of 165 ML per km^2, which is lower than in most other Gippsland catchments. Water quality is excellent in the Avon River and Freestone Creek, with T.D.S. readings in the vicinity of 30 mg per L.

Mitchell River drainage basin

Approximately 39% of this basin lies within the study area, and 65% of this is gauged. The remaining ungauged area adjacent to the coast contributes little to the basin's total yield.

Headwater streams of the Mitchell River rise in the Barry Mountains between

Derelict footbridge over the Dargo River

Mounts Howitt and Hotham. In this area it is known as the Wonnangatta River - a stream that is joined by many tributaries, including the Wongungarra and Dargo Rivers, before meeting the Wentworth River above Tabberabbera. Only below this junction is it named the Mitchell River. Downstream of Tabberabbera, the river flows through a narrow gorge and emerges on the Mitchell River flats at Glenaladale. Above this point most of the catchment is forested, with only isolated pockets cleared for permanent settlement.

Below Glenaladale, the river winds along a corridor of intensively farmed fertile alluvial flats approximately 2 km wide and 20 km long, extending as far as Bairnsdale. At Bairnsdale the flats are pinched between steep low cliffs, beyond which they widen again to merge with the tidal morass bordering the eastern shore of Lake King. The final segment of the river course is between silt jetties protruding 5 km into Lake King.

With the exception of the Latrobe River (almost all of which is outside the study area), the Mitchell River carries more water than any other stream in the study area. Catchment productivity is again significantly greater in the highlands, with an estimated run-off of 24 ML per km^2 from the catchments above the gauging station at Glenaladale. The T.D.S. contents at this station indicate a high standard of water quality.

Tambo River drainage basin

The study area contains 65% of this drainage basin, 60% of which is gauged. As in the Mitchell and Thomson River drainage basins, the ungauged portion of the catchment contributes little to the total yield, which depends mainly on the high-precipitation areas in the upper catchment.

The Tambo River catchment extends some 35 km beyond the northern boundary of the study area to the Bowen Mountains in the Great Dividing Range. The river valley winds south from the mountains, joined by short tributary creeks, before turning in an easterly direction south of Mount Elizabeth. Then, after the Timbarra River joins it, the Tambo turns to flow south-sou-west until it reaches Lake King near Johnsonville.

Although it has a smaller total annual discharge than some of the larger rivers, it has a more even distribution of flow through the year. Run-off from the catchment area above the gauging station at Bruthen is of the order of 80 ML per km^2, the lowest run-off rate of all gauged catchments within the study area. This low rating is linked with the mean salinity figure of 120 mg per L, which represents the highest T.D.S. content of any of the streams involved.

The Nicholson River catchment is situated almost entirely within the study area in the western part of the Tambo River drainage basin. Its headwaters rise on the slopes of Mount Baldhead, just north of the study area boundary. Flowing due south, the river quickly emerges onto alluvial flats, winding its way to the northern shores of Lake King south of Nicholson township.

From the limited gauging information available for the Nicholson River at Deptford, it has been estimated that the mean annual flow in the river is in the vicinity of 45,000 ML, with 50% of the discharge contributed in the 6 months December to May and 17% between January and March.

Water quality is good, with a mean T.D.S. content of 69 mg per L, while catchment yield is only average at about 150 ML per km^2.

Snowy River drainage basin

Only 310 km^2 of the vast Snowy River drainage basin lies within the study area. The entire basin, which extends into New South Wales, covers 15,799 km^2.

Buchan River's catchment extends north almost to Victoria's border with New South Wales. Just downstream of Buchan township, the river flows due east and is joined by the Murrindal River prior to flowing into the Snowy River about 4 km further downstream.

Most of the catchment above the gauging station at Buchan is heavily timbered, which accounts for the high quality of the river's water. The estimated mean annual discharge in the Buchan River at Buchan is 189,000 ML, of which just over 30% is discharged in the 6 months December to May and 12% in the 3 months January to March.

Catchment productivity is again influenced by the higher precipitation in the upper catchment, where some areas receive rainfalls of about 1,500 mm per annum. For the 850 km^2 of catchment above the Buchan gauging station, estimated run-off exceeds 220 ML per km^2.

Groundwater

Most of the water in any land region occurs below the surface as groundwater. Groundwater is held in, and flows through, bodies of permeable rock known as aquifers, of which the study area contains two types: fractured rock and porous rock aquifers.

Fractured rock aquifers

These occur chiefly in the Eastern Highlands and consist of igneous rocks or consolidated sediments. The water flows along structural features, including bedding and cleavage planes and especially joints and faults. Success in drilling for water depends on intersecting these. In limestone country such as at Buchan, dissolution of the rock results in the formation of cave systems, which permit easy movement of water.

Although not widely used as a source of water supply, these aquifers are important as they supply the springs and seepages that provide a large proportion of the summer flow of the area's major rivers. The groundwater is generally of excellent quality, usually having less than 200 mg T.D.S. per litre, and this is reflected in the good quality of the summer flows of the rivers.

Porous rock aquifers

These are found in the foothills and plains and consist of unconsolidated sediments. As long as there is a considerable proportion of pore space (that is, not much clay), water can flow through the aquifer as a whole rather than along certain planar fractures. The greater the pore space, the greater is the flow: hence sands and gravels make the best aquifers.

Porous rock aquifers are the most productive in the study area and include four principal systems, recognized by their geological names: the Latrobe Valley Group; the Boisdale Formation; and two systems of Quaternary sediments.

Aquifers within the Latrobe Valley Group consist of medium to coarse gravels and sands separated by relatively impermeable brown coals and clays. The depth to the aquifer varies - from near the surface north of Bairnsdale, to more than 470 m below the surface in the Sale--Stratford--Lake Wellington area and 450 m at Lakes Entrance. In most of the south-western part of the study area it underlies the younger Boisdale Formation system. Its potential for utilization is best in the Bairnsdale and Lakes Entrance areas, where the Boisdale Formation is not present.

The quality of water within the system varies with the distance it has travelled from the recharge area (water movement within the aquifer is generally from west to east) and its depth from the surface. Thus, salinity ranges from about 500 mg per litre in the Sale region to about 1,000 mg per litre at Lakes Entrance. The water is soft and has a low pH, but the usually high soluble iron content reduces its usefulness.

Thermal groundwater occurs in this Group west of Lake Wellington and near Bairnsdale and Lakes Entrance. Water temperatures vary from 50 to 70°C.

Very few data are available on the volume of water in storage or the rate of movement of groundwater within this aquifer system.

The Boisdale Formation is the most important and most used aquifer system for water supply in south-eastern Gippsland. It underlies much of the Gippsland plains and the Gippsland Lakes (see Figure 4), extending from Rosedale and Cowwarr in the west to east of the Ninety Mile Beach and from Briagolong and Paynesville in the north to near Longford in the south.

This Formation consists of sands and clays with some ligneous and coally seams. The best aquifer sequence is the highly permeable sands, which usually occur at a depth of 20--80 m.

The water is generally under pressure and many bores flow at the surface. It is believed that recharge to this aquifer system occurs through the overlying quaternary age river sediments along the Avon, Macalister, and Thomson Rivers, close to the highlands, and that discharge occurs offshore as well as in the Gippsland Lakes.

Groundwater quality is good, varying as the water travels from west to east, from 300 mg T.D.S. per litre to 600 mg. Yields from bores tapping these aquifers are comparatively high, ranging from 10 L to 120 L per second. The total volume of water stored is estimated at 1.7×10^{10} cu.m.

Quaternary sediments occur along most of the major rivers and creeks, around the Gippsland Lakes, along the coastline, and over much of the plains.

Wherever they are thick enough, these sediments contain the water table aquifer, which is usually unconfined and assumed to be in direct hydraulic connection with surface water bodies such as streams, lakes, and the sea. Typical deposits coarse enough to form useful aquifers include old channel gravels, buried sand ridges, and old beaches.

They all tend to be variable in nature and limited in extent, and their location is extremely difficult to predict.

Because recharge occurs directly from the surface, these aquifers are liable to contamination: industrial processes, waste-disposal sites, and septic tanks are potential sources. Agricultural practices can also cause contamination, by pesticides and nutrients.

The quaternary sediments are thick enough to contain aquifers only in restricted areas, the major ones being along the Mitchell River valley and around the Gippsland Lakes.

The alluvial sediments flanking the Mitchell River between Glenaladale and Bairnsdale are extensively utilized for irrigation and stock water supplies.

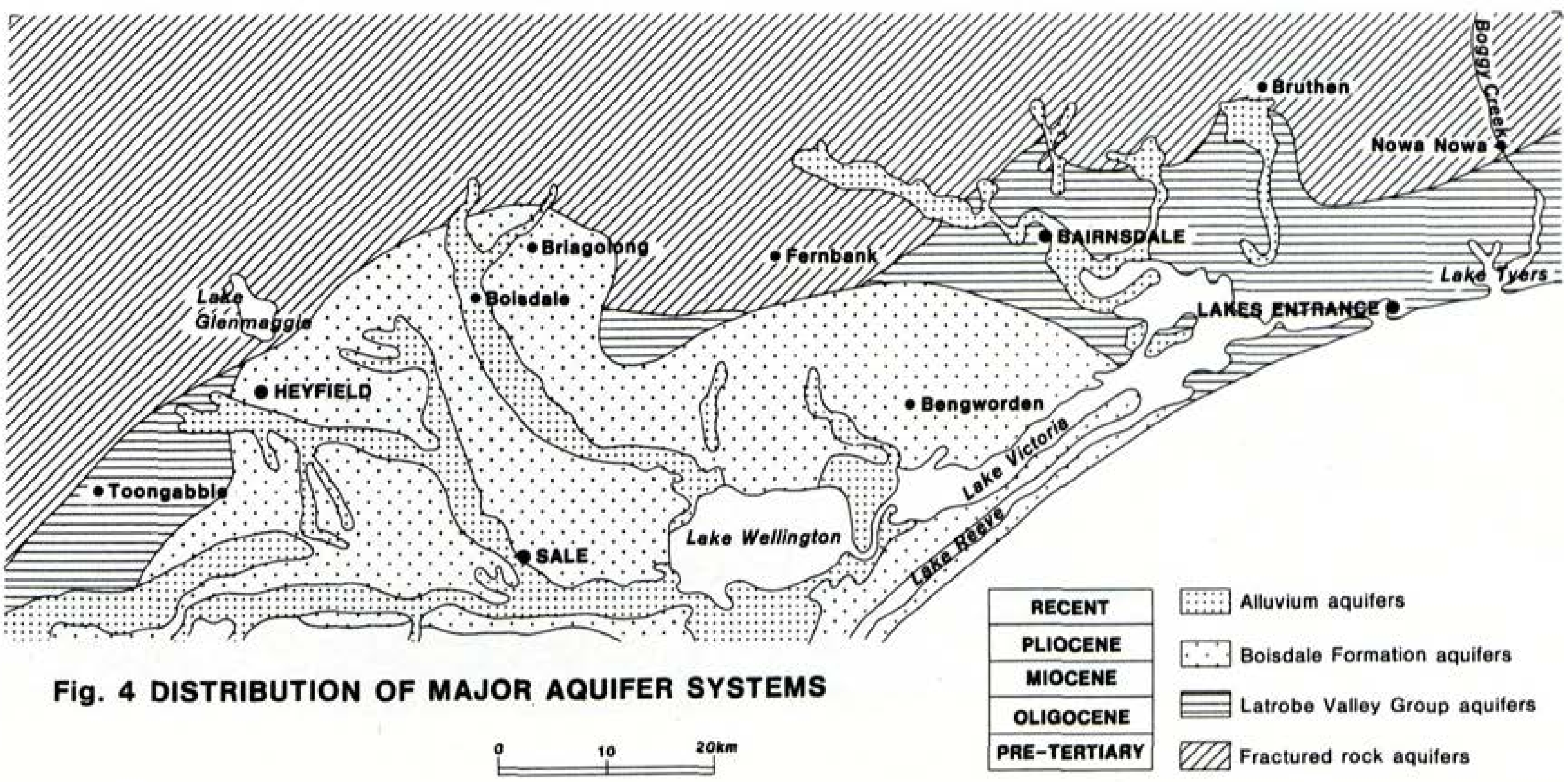
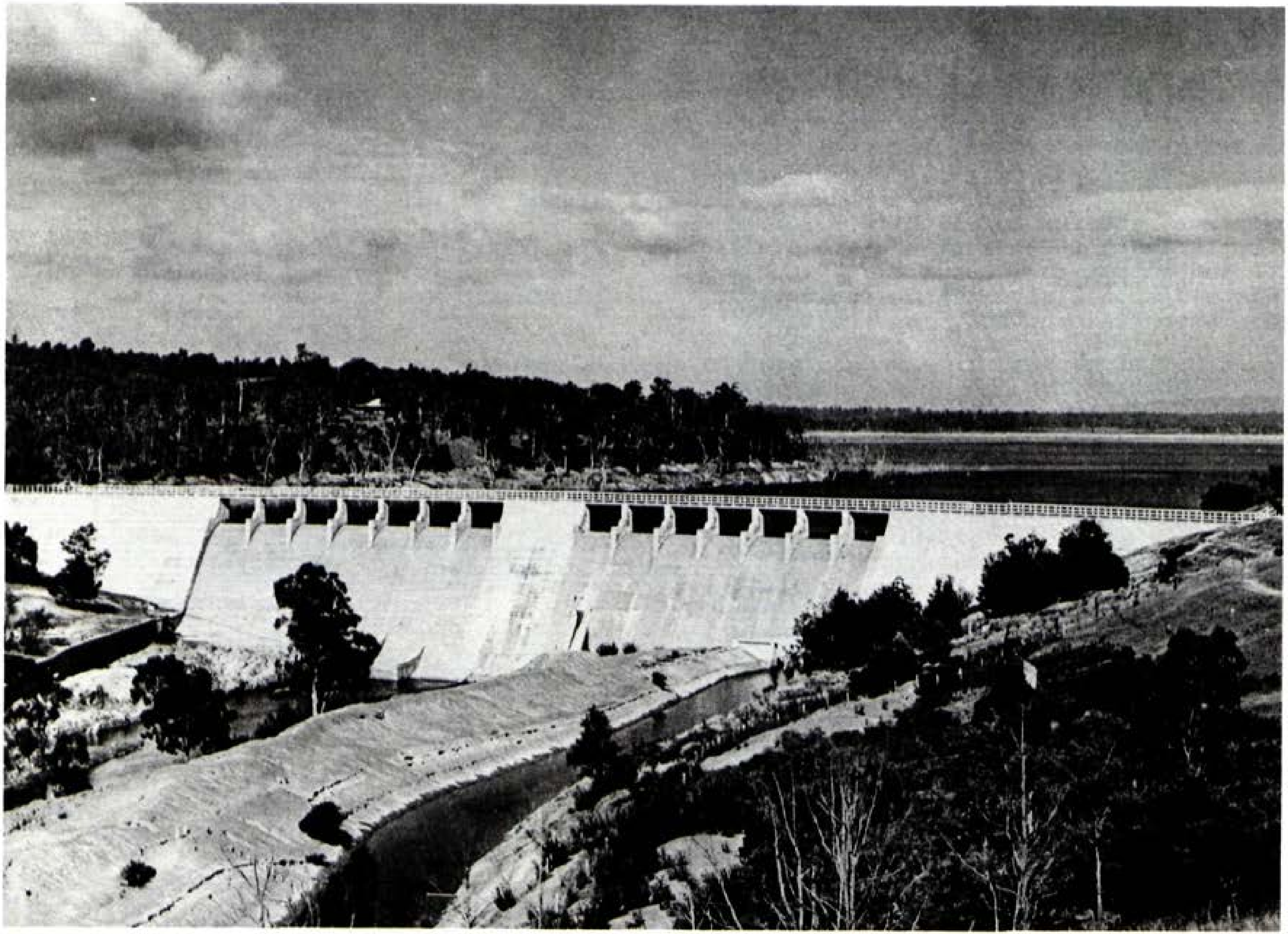


Fig. 4 DISTRIBUTION OF MAJOR AQUIFER SYSTEMS



Lake Glenmaggie Weir

They consist of sand, gravel, silt, and clay, with the main aquifer system comprising coarse gravel up to 6 m thick. It has been estimated that, when fully saturated, the gravel has a total volume of stored water of about 3.3×10^7 cu.m This is supplemented by additional water stored in the overlying finer sediments.

Quality of the groundwater varies from 200 to 600 mg T.D.S. per L, with an average of 300 mg per L, making it useful for most purposes. Yields of individual bores vary, but the better bores yield in excess of 3 L per second.

Recharge to the aquifer occurs partly by infiltration of rainfall and irrigation water; by far the most important source of recharge, however, is flooding. It has been estimated that a safe yield for the aquifer system is about 8×10^6 cu.m per year, given that floods of the Mitchell River occur on a 5-year average.

Within the study area, Quaternary deposits around the Gippsland Lakes appear to be significant as a usable source of water only west of Lake Wellington between the Avon and Latrobe Rivers, and along the northern side of Lake King. Very few bores have been sunk to tap these sediments, and the information available is therefore limited.

Artificial Water Storages

At present the study area contains only one major man-made water storage - Lake Glenmaggie, situated on the Macalister River approximately 6 km north of Heyfield.

Lake Glenmaggie has a capacity of 190,000 ML, and is the main source of supply to the Macalister Irrigation District. It is also operated to provide a measure of flood control.

Because of the high probability of Lake Glenmaggie filling each spring, storage operation is determined on a yearly basis and supplies are not restricted in any year to reserve a carry-over for the following year. During May and June each year the target storage level is 160,350 ML. From July to the actual commencement of irrigation, the reservoir level is adjusted - having regard to catchment condition, expected inflows, and expected irrigation demand. The aim of the adjustment is to provide a storage volume for flood mitigation consistent with having the reservoir full when irrigation demand matches inflows.

To provide information for flood warnings and flood routing through the reservoir, two rainfall-gauging stations and three river-height stations, all radio-interrogated from an office at the dam, have been established in the catchment. They are also used in assessing expected inflow operation from July to the commencement of irrigation.

The aim of flood regulation is to keep the outflow from the reservoir at or below the bank-full capacity of the Macalister River downstream (7,500 ML a day) for as long as possible without the reservoir being over-full. After the reservoir fills, gates are opened so that outflow matches inflow.

Another dam is currently planned on the Mitchell River, about 3 km downstream of the Mitchell--Wentworth Rivers junction. When constructed, the 15,000-ML storage would safeguard the existing irrigation development on the Mitchell River flats. The total annual supply available from the river, with the security afforded by the dam, will be 48,000 ML. Of the average annual flow at the dam site (900,000 ML), less than 2% will be impounded. Site investigation works have been undertaken and a works road constructed part of the way to the site.

Gippsland Lakes

The Gippsland Lakes cover approximately 30,000 ha and are fed by five main river systems - the Latrobe and the Avon flowing into Lake Wellington, and the Mitchell, Nicholson, and Tambo flowing into Lake King. Together these rivers drain a catchment of more than 20,000 km^2, extending to the Great Dividing Range.

It has been estimated that the annual input of fresh water to the Gippsland Lakes totals 3.6×10^6 ML. Of this, 3.37×10^6 ML is discharged to the sea. The bulk of fresh water entering the lakes is fluvial in origin, delivered at the mouths of the rivers - 60% from the Latrobe and 3% from the Avon into Lake Wellington, and 28% from the Mitchell, 1% from the Nicholson, and 7% from the Tambo into Lake King.

Of all the rain that falls within the Gippsland Lakes catchment, only some 20% ever reaches the Lakes. This water loss may be mainly attributed to:

* evapotranspiration - water lost both by direct evaporation into the atmosphere and transpiration by plants

* groundwater recharge - loss through percolation into water tables and groundwater sources

* net use.- water used for industrial, agricultural, and domestic purposes

SOILS

Soils are formed by the weathering of rock or unconsolidated material near the earth's surface. Complex interactions between climate, parent material, topography, living organisms, and the time span over which these factors have operated, all influence soil formation. Their relative importance varies from one site to another. Some indication of the pattern of distribution of soils and their relation to soil-forming factors is given in the Land Systems chapter and map.

In this chapter the soils of the study area have been classified according to the morphology of the profile and are further discussed under a set of descriptive headings, as listed in Table 7. The primary profile forms are:

* uniform soils: profiles exhibiting little, if any, texture changes
* gradational soils: profiles exhibiting no sharp changes in texture, but gradually becoming more clayey with depth
* duplex soils: profiles exhibiting a marked texture change between the A and B horizons, the subsoil being much more clayey than the topsoil

Uniform Soils

Uniform medium-textured soils

Brown or reddish brown loams to sandy clay loams - often with high contents of stones or gravel, and moderately acid throughout - occur as the dominant soil in all of the mountainous and high hill country of the area. Their surface horizons generally have a well-developed crumb structure, but the subsoils may vary from a structureless but cohesive condition to a strong granular or fine blocky structure, with either smooth or rough peds.

In protected, more humid situations, where the vegetation is more vigorous, it is common to find surface soils, with high organic matter contents, that are black or nearly black in colour.

Depth is extremely variable. Generally, the shallowest soils occur where the bedrock is most resistant to weathering - for example, on quartzites - but shallow soils also tend to be associated

Typical skeletal soil with slowly weathering shales and siltstones

with very steep slopes and with certain topographic positions, such as sharp ridge crests and exposed, dry slopes.

These soil materials generally have moderate water-holding capacity, although the total amount of available water in the profile at any one site obviously depends greatly on the total depth of the profile and the stoniness. They are well drained and are considered to have mainly low levels of plant nutrients.

Their permeability, rapid internal drainage, and cohesiveness make the soils less prone to erosion, but the fact that they generally occur on long, steep slopes does create a sheet erosion hazard when the vegetative cover is removed by, for instance, fires or intensive logging operations.

Uniform fine-textured soils

These are mainly confined to active flood plains, where they occur in conjunction with other soils. They have a clayey texture throughout and are usually dark grey-brown or grey in colour, with brighter yellow, light-grey, and

Table 7

MAIN SOIL GROUPS OF THE GIPPSLAND LAKES HINTERLAND AREA

Primary profile form	Other distinguishing features	SCA descriptive name *	Other synonyms and included soils*
I UNIFORM SOILS (uniform texture throughout	medium-textured:		
	- very stony, generally shallow	stony loam soils	lithosols or skeletal soils
	- less stony or no stones or gravel, with or without subsoil structure	brown and red loam soils	brown earths, and red earths
	fine-textured:		
	- dark grey-brown with mottled subsoils	mottled dark clay soils	wiesenboden; minimal prairie
	- highly plastic when wet; wide cracks when dry	black or dark cracking clay soils	black earths; prairie soils; chernozems
	coarse-textured:		
	- sandy, often variably bedded alluvial deposits	brown undifferentiated sand soils	alluvial soils; siliceous sands
	- sandy, whitish with shallow dark topsoil	pale, weakly differentiated sand soils	siliceous sands
	- bleached sand, with black and dark-brown nodules or hardpan at depth	leached sand soils with coffee-rock	podzols
II GRADATIONAL SOILS (gradational increase in clay with depth)	- developed on basalt and limestone, dark red-brown and very friable	red gradational soil, fine structure	krasnozem or 'chocalate soil' (popular)
	- on other igneous rocks, red or brown	red or brown gradational soils, weak structure	red earths and brown earths
	- on sedimentary rocks, excluding limestone, yellow or brown (but rarely red), weakly structured to structureless	yellow or brown gradational soils	yellow earths and brown earths; yellow podzolics and brown podzolics
III DUPLEX SOILS	- yellow-brown mottled sodic subsoil, with deep sandy topsoils	yellow sodic duplex soils	solodic soils; solodized solonetz
(abrupt increase in clay content at depth)	- yellow or brown, acid subsoils	yellow or brown duplex soils	yellow podzolic; brown podzolic
	- red, acid subsoils	red duplex soils	red podzolics

* Note: The various classifications or descriptive categories correspond to one another only in part.

rusty mottles in their lower horizons. Because of its organic matter, the topsoil tends to have a crumb or fine subangular blocky structure, but the subsoil is more likely to have a blocky structure if internal soil drainage is reasonably good.

The soils have moderate water-holding capacity, and groundwater may occur at shallow depths in the profile at least seasonally, when moisture levels are high. Their natural nutrient status is probably moderate.

Where they occur on irrigable flood plains, they are used for irrigated pastures and crops. Sound irrigation techniques and agronomic methods are important, both to maintain good soil structure in the surface horizon and to avoid waterlogging. Black clay soils with a strong shrink--swell capacity occur near Lake Glenmaggie.

Uniform coarse-textured soils

Within the study area, these are represented by three distinct soil types.

First, although not the most important in area, are the undifferentiated brown, brownish grey, or yellowish sands that typify young sand deposits, laid down by rivers, the sea, or the wind. Here, the majority of these undifferentiated sands have alluvial origin. Clays and silts may occur below them at relatively shallow depth. These sands are freely drained and of low fertility. Erosion by wind can take place if large enough areas are stripped of their protective vegetation cover.

A second type is the undifferentiated sandy soil formed by Recent wind-blown sands derived from the upper parts of older marine and aeolian deposits. This sand has undergone a phase of soil formation that stripped mineral coatings off the quartz grains, causing them to become bleached, almost white in colour. During a subsequent stage of landscape instability, the sands were blown away and accumulated elsewhere, and only a thin layer of organic matter has developed on the top of a deep, uniformly coloured white sand.

Such white sands are prone to drought and have extremely low inherent fertility. This is frequently reflected in the vegetation they support, which is often a stunted shining peppermint (*Eucalyptus nitida*) woodland with an understorey of heathy shrubs.

The third type of uniform-textured soils, in contrast to the others discussed above, possess horizons strongly differentiated by colour and consistence. They have formed on sands that have been stable in the landscape for a long period after they were deposited.

Leaching by rain-water eventually caused the mineral coatings to be stripped off the sand grains. The iron contained in the coatings was redeposited and concentrated at a greater depth in the sandy profile, forming brown hard nodules or a pan, commonly called 'coffee rock'.

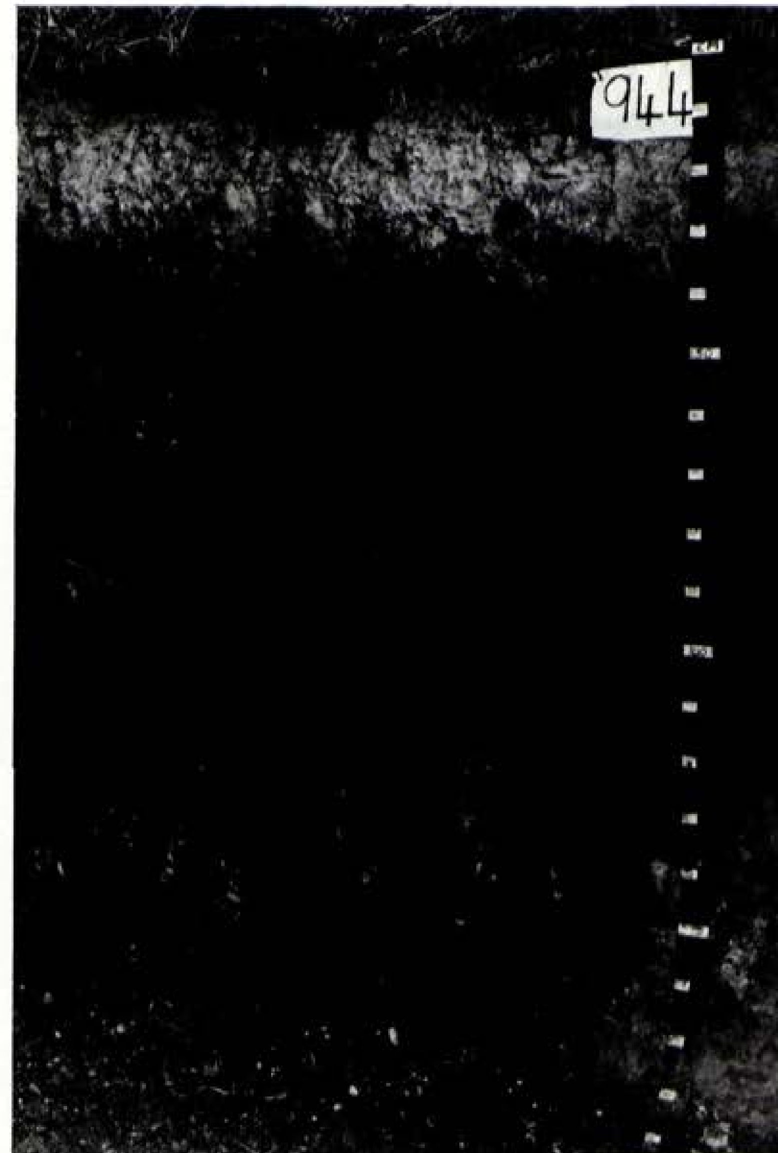
In addition, part of the humus forming in the topsoil is often transported and redeposited just above the coffee-rock layer, creating a black, fairly hard, cemented layer of sand. The sand above these humus and iron pans becomes very bleached.

Understandably, these highly leached soils are strongly acid and extremely low in plant nutrients. They carry a heathy, drought-tolerant vegetation, in which saw banksia (*Banksia serrata*), shining peppermint, and rough-barked manna gum (*E. viminalis* var. *racemosa*) are often the only tree species.

The soil-forming processes that have operated on this soil type have often also occurred in the surface horizons of some duplex soils on Tertiary deposits - provided these horizons were sandy and deep enough - for example, in parts of the Colquhoun forest and Stockdale hills.

Gradational Soils

Gradational soils tend to predominate in freely draining environments where active chemical weathering of parent materials capable of producing significant amounts of clay is occurring but where the soil profile is not undergoing a high degree of vertical mixing.



Solodic soil of an old alluvial terrace displaying bleached, seasonally waterlogged subsurface horizon.

In such an environment, the intensity of many soil-forming processes gradually lessens with depth.

During soil formation, clay particles are subjected to slow chemical dissolution, to downward translocation, to a winnowing effect from water flowing over the soil surface, which preferentially leaves the sand and silt fractions, and to aggregation or even fusion due to forest fires.

Such processes are most intense close to the surface of the soil, and contribute to a gradual coarsening of textures towards the top of the soil profile. At the same time the iron released by weathering is rapidly redeposited as iron oxides around clusters of clay, silt, and sand particles, which assists aggregation and maintains porosity and permeability.

Gradational soils have developed on a wide range of parent rocks, and usually occur on the more stable slopes, in hilly and mountainous terrain. Because these more stable sites often intermingle with slopes where soil mixing is more prevalent, gradational soils can occur in the same landscape with the uniform-textured brown or reddish brown loams or sandy clay loams.

Gradational soils are not a homogeneous category, but vary depending on the parent materials on which they developed.

Gradational soils on igneous rocks

The gradational soils formed on granitic rocks, rhyolites, and basalts generally have brown and reddish brown and red profiles without mottling, and are structured throughout.

Those on basalt have the darkest red or red-brown colour, the best-developed structure, and a very friable topsoil. They are sought after for intensive cropping because their stable, good structure makes them well drained and easy to work into a good seed-bed, and allows root crops to be harvested cleanly without much soil attaching to tubers or bulbs.

Those on granitic rocks have a less-stable structure that is more easily destroyed by frequent cultivation. This soil type supports mostly native forests.

Gradational soils on sedimentary rocks

These may have mottled subsoils with a weaker structure (sometimes with no structure) than those on granite. Native forests predominate on these soils.

Duplex Soils

Duplex soils are widespread throughout the study area, occurring on land with slopes ranging from moderately steep to flat. They have developed on all parent materials except sand.

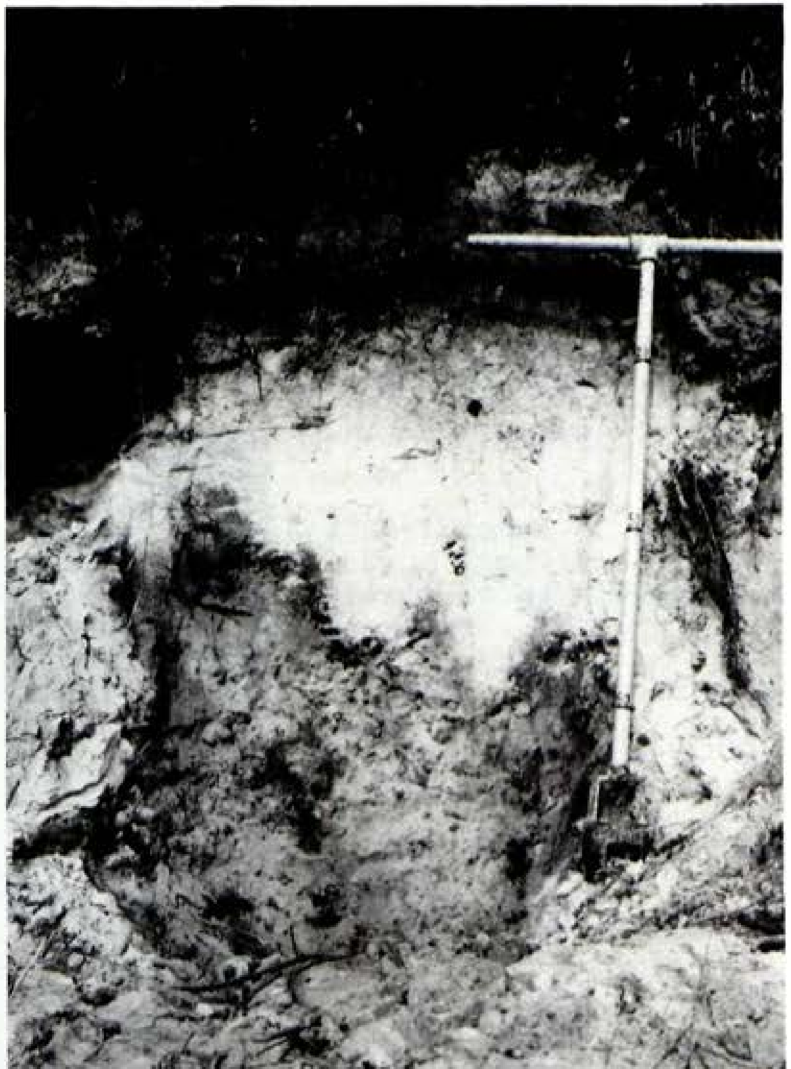
Their formation appears to require periodic waterlogging of the surface horizons. Thus, the presence of a subsoil with sufficiently low permeability to cause a temporary perched water table, in conjunction with moderate slopes that slow down both surface drainage and lateral internal drainage, is conducive to the formation of duplex soils.

They can occur side by side with gradational soils, and some areas contain soils that are intermediate between the two groups. The Dargo land system (at Ensay, Tambo Crossing, and Dargo) provides a case in point. Here, both soil types occur together on a homogeneous parent material, in this instance granite, and rolling to gentle topography. Indeed, sometimes it is difficult to decide in the field whether the profile is duplex or gradational. Elsewhere, minor differences in parent material produce the same type of variation.

Many quite distinct soils belong to the duplex category, their peculiarities reflecting differences in parent materials and other soil-forming factors of their environment. The study area contains the following main groups of these duplex soils.

Sodic duplex soils, deep sandy topsoil

Yellow-brown mottled sodic duplex soils with deep sandy topsoils are common over extensive areas of Tertiary colluvial and alluvial deposits of sand, gravels, and clays, and also in areas of Pleistocene sediments where wind-blown sand sheets cover clayey substrata.



Sodic duplex soil with deep sandy topsoil, developed on sand sheets

Here the presence of large amounts of sand in the parent materials, and/or the ingress of sand from elsewhere, promotes the formation of thick sandy topsoils. The passage of long periods of time for the soil-forming process to do its work, which would imply very stable landscapes, also contributes to this formation.

These deep sandy topsoils provide an infertile and drought-prone rooting zone for shallow-rooted plants, including certain pasture species. As water tends to perch on top of the underlying clay after wet periods, however, deep-rooting plants such as trees and shrubs can get moisture long after rain has fallen.

When nutrient levels are inadequate - or if these soils are too acid for a given crop - fertilizers or lime can be added as required. The sandy topsoils are prone to sheet and wind erosion when disturbed, while the sodic subsoil is especially susceptible to gullying.

Yellow or brown acid duplex soils

Yellow duplex and brown duplex soils with fully acidic profiles are common in country with low rounded hills on a

Acid yellow duplex soil supporting a yertchuk open forest range of parent materials, including Pleistocene and Tertiary colluvial and alluvial deposits that are not as sandy as those discussed above. Rainfall tends to be higher than in the areas where soils in that first group occur.

These soils tend to have mottled clay subsoils, with fine to medium blocky structure, and loamy topsoils that vary in thickness from 100 to 300 mm. Due to the loamy textures in their surface horizons and the better structure in the subsoils, they are more suited to plant growth than the sodic duplex soils with deep sandy topsoils.

Sheet erosion is a hazard when the soils are left without a vegetative cover. Gully erosion can also occur, but because the subsoils are not sodic they are less susceptible to gullying. In their virgin state, they have variable fertility, depending in large measure on the parent material.

Red acid duplex soils

Although restricted mainly to freely drained hilly country with relatively high rainfall, these soils occur on a range of parent rocks. Their properties are very similar to those of the yellow and brown duplex soils, the red colour and absence of mottling providing the basis for separation. These soil types may be intermixed, with the red duplex soil occupying the better-drained sites. Absence of mottling is associated with the better drainage. The two soil types probably do not differ in inherent fertility and susceptibility to erosion.

Unclassified Soils

Small areas of peaty soils and mineral soils with high organic matter occur in swamps and poorly drained sites subject to permanent or seasonal flooding.

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VEGETATION

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

The major environmental factors that influence vegetation - described in previous chapters - show considerable variation throughout the study area. This is reflected in the diverse nature of the plant communities, ranging from tall mountain forests to low coastal swamps.

Reliable records of 1,000 native flowering plants and fern species have been made in the Gippsland Lakes hinterland.

Most of the area's public land is covered by flora typical of the foothills to the Eastern Highlands, consisting mainly of stringybark--gum forests. Within these forests the more protected gullies (mainly in the east of the study area) contain pockets of warm-temperate rainforest, or 'jungle' gullies as they are commonly referred to in East Gippsland. Mountain ash forests at the higher elevations in the north of the study area represent cool, wet, southern elements, typical of Tasmania and the Central Highlands.

Prior to European settlement, most of the Gippsland plain - between the foothills and the lakes - carried a woodland of forest red gum with rough-barked manna gum and/or white stringybark on most of the sand ridges. On the deeper sands, the latter were in turn occasionally replaced by the yertchuk--shining peppermint--saw banksia woodland typical of the aeolian sands of South Gippsland. Most of the forest red gum has now been cleared for agriculture.

Vegetation on public land surrounding the Gippsland Lakes ranges from swamp communities to coastal woodland and grassland communities.

Importance of vegetation

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

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

Classification

The vegetation has been classified into a number of structural forms based on the height and form of the tallest stratum and on the percentage of projective foliage cover (see Table 8).

The classification is based on that developed by Specht, but has been modified to better describe the particular vegetation of the study area, to enable use of the data available, and to meet land-use planning goals.

Within the structural framework, the vegetation has been grouped according to commonly occurring combinations of species. These have been chosen subjectively and have been termed vegetation units. They are not based on detailed study of species relations. Each unit is readily recognized in the field and reflects the operation of a certain set of environmental factors.

The distribution of these vegetation units is shown on Maps 6a and 6b.

Vegetation Units

The main vegetation units are set out in Table 9 and briefly described below.

Closed forest II

Scattered throughout the study area, from Mount Moornapa in the west to Lake Tyers in the east, are small pockets of the closed forest unit commonly referred to as jungle gullies.

More accurately described as warm-temperate rainforest, this vegetation type occupies the most protected and sheltered sites below 600 m elevation. The pockets of rainforest are very small (in most cases occupying no more than a few hectares).

With the exception of outlying stands on Wilsons Promontory, the study area represents the western limit of warm-temperate rainforest in Victoria.

The unit is characterized by a dense and shady canopy (dominated by non-eucalypt species) and an associated understorey, including lianes and epiphytes, that has adapted to a dark, humid environment.

Table 8

STRUCTURAL FORMS OF VEGETATION
(after R.L. Specht)

Form and height class of tallest stratum	Projective foliage cover of tallest stratum		
	Dense (70--100%)	Mid dense (30--70%)	Sparse (10--30%)
Trees (over 40 m)		Open forest IV	
Trees (27--40 m)		Open forest III	
Trees (15--27 m)	Closed forest	Open forest II	
Trees (8--15 m)		Open forest I	Woodland
Shrubs (2--8 m)	Closed scrub	Open scrub	
Shrubs (under 2 m)	Closed heath	Open heath	
Grasses (0--2 m)		Grassland	
Herbs	Closed herbland	Herbland	Open herb-land
	1. Closed sedgeland	1. Grassland 2. Tussock sedgeland 3. " rushland 4. Rushland 5. Herbfield	

The major component of the tallest stratum at most sites is lilly pilly (*Acmena smithii*). Associated tree species of the canopy include blackwood (*Acacia melanoxylon*), which is often subdominant and emergent, mutton-wood (*Rapanea howittiana*), which can become dominant along fertile river banks, and sweet pittosporum (*Pittosporum undulatum*), which, because of its relatively hardy nature, can dominate rainforest in drier environments that are unsuitable for more sensitive species. *Pittosporum* can act as a pioneer species as evidenced by its apparent colonization of rocky slopes in the Mitchell River gorge. Another important canopy tree of sheltered sites is yellow-wood (*Acronychia oblongifolia*).

Another, less-common associate of *Acmena* is kanooka (*Tristania laurina*), which itself is the sole dominant of a characteristic riparian community (not mapped) whose affinities lie more with rainforest than with open forest. It occupies a narrow strip along some of the study area's major streams.

Shrub species of the rainforest understorey include blue olive berry (*Elaeocarpus reticulatus*) and large mock-olive *Notelaea venosa*), as well as many that are typical of wet open forest gullies. The most widespread woody lianes are milk vine (*Marsdenia rostrata*), wonga vine (*Pandorea pandorana*), staff climber (*Celastrus australis*), forest clematis (*Clematis glycinoides*), and jasmine morinda (*Morinda jasminoides*). Epiphytes include both orchids and ferns, as well as a wealth of lichens and mosses.

Open forest IV

The alpine ash (*Eucalyptus delegatensis*) unit occurs at only one location in the study area, on the southern slopes of Mount Useful. This is close to Victoria's southern extremity of alpine ash forests, which stretch into the mountainous country to the north where they are widely distributed.

While the unit usually occurs as pure stands, often with herbaceous understoreys, in this area alpine ash is associated with shining gum (*E. nitens*) and has a shrubby understorey.

It occupies a moist sheltered site in the only part of the study area with elevations above 1,200 m. Annual precipitation varies between 1,000 and 1,200 mm, part of which regularly falls as snow.

While sharing the preference of the alpine ash unit for a moist, protected site with relatively deep, friable soils, the mountain ash (*E. regnans*) unit occurs at lower elevations. In the study area it is usually found between 800 and 900 m.

Mountain ash is the dominant tree species and in this area, unlike examples elsewhere, it rarely occurs as pure stands, being associated with messmate (*E. obliqua*) and candlebark (*E. rubida*). In an understorey typical of wet sclerophyll forests, an intermediate stratum of silver wattle (*Acacia dealbata*) and blackwood is associated with a dense stratum of shrubs such as hazel pomaderris (*Pomaderris aspera*), musk daisybush (*Olearia argophylla*), blanket-leaf

TABLE 9 VEGETATION UNITS

Structural Form	MAP SYMBOL	Major Species of Tallest Stratum	Associated Tree Species	Common Species of Lower Stratum
Closed Forest II	1	Lilly pilly	Blackwood, muttonwood, sweet pittosporum, kanooka, yellowood	Hazel pomaderris, musk daisy bush, tree ferns, blue olive berry, large mock olive, blanket leaf, milk vine, staff climber wonga vine, forest clematis.
Open Forest IV (>40 m height)	2a	Mountain ash	Messmate, candlebark.	Silver wattle, hazel pomaderris, musk daisy bush, blanket-leaf, Australian clematis, soft tree fern, bracken, common shield fern, bidgee widgee, hairy pennywort.
	2b	Messmate, mountain grey gum	Narrow leaf peppermint, blue gum, manna gum.	Silver wattle, bracken, dogwood, hazel pomederris, ivy leaf violet, Australian clematis, prickly current bush, hop goodenia, snowy daisy bush, soft tree fern.
	2c	Alpine ash	Shining gum.	Silver wattle, hazel pomaderris, soft tree fern, prickly currant bush, mountain hickory wattle, dogwood, button everlasting, ivy leaf violet, tussock grass.
Open Forest III (27-40 m height)	3a	White stringybark silvertop	Mountain grey gum, red stringybark, red iron bark, fuzzy box, brittle gum, but but.	Bracken, shiny cassinia, sunshine wattle, saw banksia, black she-oak, broad saw sedge, cluster-flower geebung, silky tea tree, common heath, thatch saw sedge.
	3b	White stringybark	Silvertop, red stringybark, mountain grey gum, red box, yertchuk, red ironbark.	Bracken, shiny cassinia, broad saw sedge, silky tea tree, nodding blue lily, guinea flower, pomaderris, pink bells, common apple-berry.
	3c	Mountain grey gum, white stringybark or yellow stringybark (at lower elevations), messmate (at higher elevations)	Silvertop, narrow leaf peppermint, blue gum, but but, river peppermint, (in the east), manna gum.	Bracken, hazel pomaderris, silver wattle, hop goodenia, snowy daisy bush, Australian clematis, spiny-headed mat-rush.
	3d	Silvertop	White stringybark, red stringybark.	Bracken, shiny cassinia, handsome flat-pea, guinea flower, blue dampiera, blue bottle-daisy, nodding blue lily.
	3e	Yellow stringybark	Mountain grey gum, yertchuk, silvertop, red box, red stringybark, but but, red ironbark.	Bracken, shiny cassinia, narrow leaf bitter pea, guinea flower, nodding blue lily, broad saw sedge, common heath.
	3f	Gippsland grey box	but but, fuzzy box, blue gum.	Black wattle, kangaroo grass, hop bush, shiny cassinia, slender lagenaphora, snowy daisy bush, common raspwort, tussock grass.
Open Forest II (15-27 m height)	4a	Red stringybark, red box	Silvertop, yertchuk, white stringybark, but but, brittle gum, broad leaf peppermint.	Nodding blue lily, shiny cassinia, austral indigo, dusty miller, pink bells, clustered everlasting, common rice flower, purple coral pea.
	4b	Yertchuk	Red stringybark, red box, white stringybark, silvertop, red ironbark.	Nodding blue lily, sunshine wattle, common heath, bracken, shiny cassinia, pink bells, hop bitter pea, spiny headed mat-rush.
	4c	Yellow stringybark	Silvertop, yertchuk.	Bracken, common heath, guinea flower, common rice flower.
	4d	Silvertop	Yertchuk, red stringybark.	Narrow-leaf wattle, sunshine wattle, narrow-leaf bitter pea, heath milk-wort, pink bells, blue dampiera, common heath, wattle, guinea flower, mat-rush, slender saw-sedge.
	4e	Red box, red ironbark	Red stringybark, white stringybark.	Golden wattle, pomax, guinea flower, tussock grass, fibrous spear grass, nodding blue lily, daphne heath, heath platysace.
	4f	Southern mahogany		Bracken, saw banksia, black wattle, common raspwort, common heath, honey pots, ivy leaf violet, tree broom-heath, kidney weed.
Open Forest I (<15 m height)	5	Red stringybark, red box	Silvertop, red ironbark.	Daphne heath, digger's speedwell, spreading flax lily, variable sword-sedge, box-leaf bitter-pea, guinea flower, showy parrot pea.
Open Forest II Woodland II (15-27 m height)	6a	Forest red gum		Spear grass, kangaroo grass, thatch saw sedge, black wattle, burgan, wallaby grass.
	6b	White stringybark		Bracken, silky tea tree, blady grass, variable bossiaea, crimson bottlebrush, saw banksia, common heath, prickly tea tree, guinea flower, thatch saw-sedge.
	6c	Yellow box	Red box, red stringybark, white stringybark.	Tussock grass, black wattle, stinking pennywort, rock fern.
	6d	Brittle gum		Sedges, common heath, kangaroo grass, tussock grass, common rice flower, prickly tea tree.
	6e	Mealy stringybark, yertchuk, swamp gum.		Pale twig rush, thatch saw sedge, zig-zag bog rush, crimson bottlebrush, burgan, prickly tea tree.
Open Forest I Woodland I (<15 m height)	7a	Shining peppermint	Yertchuk.	Silky tea tree, saw banksia, pink beard heath, silver banksia, common correa, pink bells, common beard heath, spike wattle, showy bossia, bundled guinea flower.
	7b	Manna gum (rough-barked form)	Shining peppermint.	Saw banksia, bracken, wallaby grass, sand-hill sword-sedge, bundled guinea flower, common heath, common raspwort, honey pots.
	7c	Saw banksia		Bracken, sand-hill sword-sedge, spiny-headed mat-rush, blady grass, daphne heath, common heath, common raspwort, kidney weed.
	7d	Coast banksia		Coast wattle, blackwood, black wattle, coast tea tree, bracken, seaberry saltbush.
	7e	Silver leaf stringybark		Thatch saw sedge, silky tea tree, crimson bottlebrush, zig zag bog rush, common apple berry.
Closed Scrub	8	Silver wattle, red wattle.	Emergent eucalypts occasionally present.	Rock wax flower, wallaby grass, golden everlasting, akeake, shrubby platysace.

Structural Form		MAP SYMBOL	Common Species
Swamp Communities	Closed scrub	9a	Swamp paperbark.
	Grassland	9b	Common reed, leafy twig-rush.
	Herbfield	9c	Beaded glasswort, trailing hemichroa, grey glasswort, southern sea-heath.
	Tussock sedgeland or rushland	9d	Chaffy saw-sedge, beaded glasswort, sea rush, austral seablight, selliera.
	Tussock rushland	9e	Giant rush, bullrush, common reed.
	Closed sedgeland	9f	Pithy sword-sedge, zig zag bog-rush, common scale-rush, reed bent-grass, bordered panic.
Fore-dune vegetation		10	Marram grass*, hairy spinifex, coast tea-tree, coast wattle, cushion bush, coast daisy bush, coast everlasting.
Softwood plantation		11	Radiata pine*
Grassland		12	Variety of grasses and herbs with scattered eucalypts.

* Introduced species.

(*Bedfordia arborescens*), and tree ferns. Because little light penetrates below this level, the ground layer contains few species.

The most extensive areas of mountain ash forests are found in the headwaters of the Nicholson River and the Haunted Stream, with more isolated occurrences at Mount Elizabeth, at Mount Steve, and below Mount Useful. They represent outlying populations of extensive even-aged forests that commence on the slopes of the Baw Baws and extend to Noojee, Marysville, and Toolangi.

The other vegetation unit of this structural form is the mixed-species forests dominated by messmate and mountain grey gum (*E. cypellocarpa*). This unit is better adapted to lower soil moisture, shallower soils, and greater temperature variation than either of the ash units. Consequently it has a much wider distribution, with occurrences throughout the study area ranging from elevations up to 1,100 m and down to less than 100 m. Between about 900 and 1,100 m, it occupies both exposed and sheltered aspects. It is uncommon below 900 m on northern and western aspects, and occupies only the most protected gullies where it is represented close to sea level, near Lake Tyers.

Because of the unit's relatively wide environmental tolerances its understorey can be quite variable. It may be dominated by bracken (*Pteridium esculentum*), contain shrubs with a ground layer of herbs, or be a wet gully type. The frequency of bracken in the understorey of this and other vegetation units usually indicates significant disturbance from fire.

Open forest III

This structural form, the most common in the study area, is ubiquitous and covers more than 65% of the public land. Six separate vegetation units have been recognized, which consist in the main of forests containing a mixture of stringybark species of uneven age. They occupy

Open forest dominated by mountain grey gum drier, less favourable sites than open forest IV units.

The mountain grey gum--stringybark unit is the most widespread of these units. It occurs most commonly along drainage lines and on sheltered slopes throughout the study area. The dominant stringybark species at higher altitudes is messmate; at lower altitudes yellow stringybark (*E. muellerana*) dominates to the north and west of Lake Glenmaggie and north-west of Bruthen, and white stringybark (*E. globoidea*) in eastern and central portions of the study area.

Understorey composition varies with aspect, soils, elevation, and fire history. Common species range from bracken and silky tea tree (*Leptospermum myrsinoides*) on the low sandy hills that are regularly burnt to dense stands of shrub species such as hazel in the wetter gullies.

The white stringybark--silvertop unit is confined to the low hills of Colquhoun forest north of Lakes Entrance. White stringybark and silvertop (*E. sieberi*) dominate the upper stratum on the intermediate slopes between the ridge tops and gullies, and on dry ridge tops where the soils consist of deep sands.

On those ridges with shallow topsoil the species are associated with red ironbark (*E. sideroxylon*) and red box (*E. polyanthemos*). Understorey species reflect the site's sandy topsoil, overlying either dense clay or iron pan, and its history of frequent fires. Common species include saw banksia (*Banksia serrata*), sunshine wattle (*Acacia botrycephala*), and shining cassinia (*Cassinia longifolia*). Bracken dominates the ground layer.

Both the white stringybark and the silvertop units also occur on the low sandy hills in the south-east of the study area. They are also represented at higher altitudes (up to 900 m), on steeper slopes, and on shallower soils. The understorey species are more sensitive to these environmental changes than are the dominants: the sandy soils commonly support a low heathy understorey; in contrast, sparse shrubs and herbaceous species commonly grow on the shallower soils at higher altitudes.

Silvertop forests are best-developed on broad flat ridge-tops, where the species may grow in pure stands. On the drier more exposed ridges and slopes it often grows in association with other eucalypts, mainly stringybarks.

White stringybark, on the other hand, never forms pure stands and usually grows in association with a variety of other eucalypts. It should, however, be mentioned that the white stringybark forests on the low Stockdale hills come close to being pure stands in places.

The yellow stringybark unit is confined to north-west of Bruthen and areas north of Heyfield. It seems to occupy intermediate sites between messmate and white stringybark and shares with the white stringybark unit a similar group of associated eucalypt and understorey species.

The distinctive Gippsland grey box (*E. bosistoana*) unit is now confined to small areas fringing Lake Tyers and remnant stands between Eagle Point and Lakes Entrance. This unit generally favours well-drained soils. Around Lake Tyers it is mostly found on northern and western aspects with a shallow topsoil overlying a freely draining limestone or gravelly sediment. In this area the understorey is typically grassy.

Open forest II

Forests of this class occupy a wide altitudinal range (from sea level to about 1,000 m in some localities) throughout the study area.

Four of the six vegetation units identified for this structural form occur either on the dry exposed aspects of the deeply dissected foothills or in the deep valleys of the major rivers that are subject to a rain-shadow effect. Slopes are steep and soils almost invariably shallow and stony, with low fertility and poor moisture-retention properties. The understoreys, which are generally sparse and dominated by low

White stringybark open forest near Stockdale

Red box--red ironbark open forest at Heyfield flora and fauna reserve

Right: *Forest red gum open forest in Moormurng forest park*

shrubs and grasses, reflect these harsh growing conditions.

Of those four, the red stringybark (*E. macrorhyncha*)--red box unit is the most common and widespread. While found throughout, it is most common in the eastern and central portions of the study area.

The yertchuk (*E. consideniana*), silver-top, and yellow stringybark units are all confined to the western section.

The red box--red ironbark unit found near Heyfield occupies one of the lowest-rainfall zones in the study area. Its major representatives occupy relatively flat land at low elevations, growing in sandy soils developed from Tertiary sediments. Although the understorey is generally sparse, the low shrubs and grasses that predominate exhibit a greater diversity than those in other units of the structural form.

Southern mahogany (*E. botryoides*) dominates the sixth unit. Its major occurrence on public land in the study area is at Raymond Island. This coastal form of the species is an outlier of the extensive stands that occur on the Boole Poole peninsula. In general, southern mahogany forests grow on the edges of sheltered gullies and on sand sheets of low relief.

Open forest I

Examples of the red stringybark--red box unit - the only one described for this structural form - are scattered throughout the western part of the study area, especially south of Dargo and north of Ben Cruachan. These low forests occur on the poorest of sites with the driest, steepest, most exposed slopes. Soils are extremely shallow and indeed non-existent in many places, where the parent material is exposed at the surface in the form of blocky outcrops or scree.

Understorey is sparse with, in places, bare ground exposed over more than 50% of the site. In areas affected by fire, box-leaf bitter-pea (*Daviesia buxifolia*) dominates the shrub stratum.

Open forest II--woodland II

The once-widespread forest red gum (*E. tereticornis*) unit now only exists as remnants on the Gippsland plain at Briagolong, Stratford, and Bairnsdale. It occurs on flat land with heavy soils that are often seasonally waterlogged. The main ground cover consists of grasses and sedges, and areas particularly subject to waterlogging support tea-tree species.

The white stringybark unit covers east--west trending dunes less than 20 m high on plains east of the Perry River. Its understorey contains saw banksia, silky tea-tree, and a number of colourful small shrubs, but because of frequent disturbance by fire the ground stratum is dominated by bracken.

Neither the yellow box (*E. melliodora*) nor the brittle gum (*E. mannifera*) units are extensively represented in the study area. The latter occurs only near Cobbannah, although the former is more widespread. Both these units grow on a range of soil types, but generally are found on moderate slopes with a grassy understorey.

Open forest I--woodland I

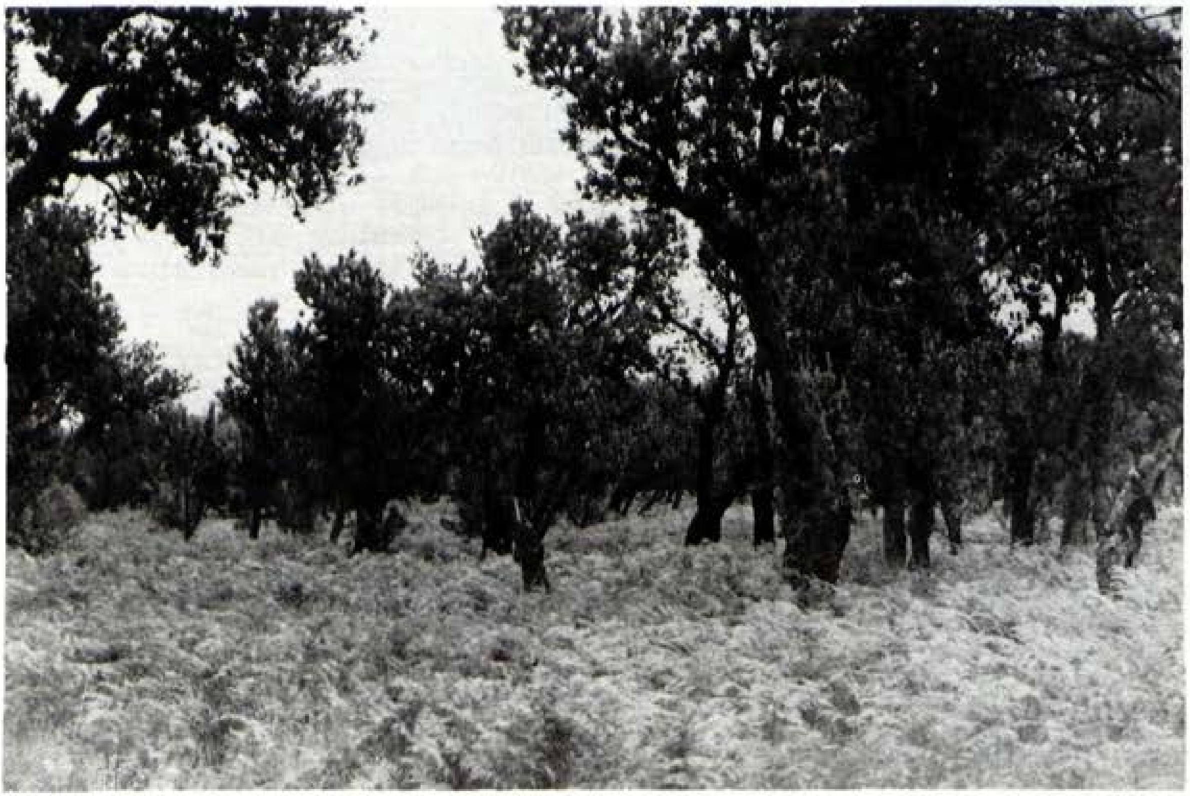
Both the shining peppermint (*E. nitida*) and manna gum (*E. viminalis* var. *racem-*

osa) units have developed on deep sands - the former on east--west dunes in the Moormurng forest and east of the Perry River, and the latter on sandy plains and ridges north of Lake Victoria and on Raymond Island. The manna gum unit occupies the wetter sites.

With the exception of the manna gum forests on Raymond Island, which have a bracken-dominated understorey, heathy understoreys and saw banksia are common to both units.

North and west of Lake Victoria, the saw banksia unit occurs on deep sand sheets between the lake shores and the plateau hinterland. This unusual vegetation type is linked with the above two units as one extreme of a continuum.

Although found in the lee of the barrier dune for almost the total length of the Ninety Mile Beach, the coast banksia (*Banksia integrifolia*) unit, is represented in the study area by only two small stands (at Lakes Entrance and



Saw banksia woodland with bracken understorey at Wattle Point

Rigby Island), which have developed on deep, unstructured sand.

The silver-leaf stringybark (*E. cephalocarpa*) unit is confined to small areas north of Nowa Nowa and south of Lake Glenmaggie. It occupies poorly drained sites, usually with a shallow sandy topsoil overlying a heavy clay or hard pan layer. Understoreys reflect the soil's poor drainage characteristics, with sedges, rushes, and bottlebrush being common.

Closed scrub

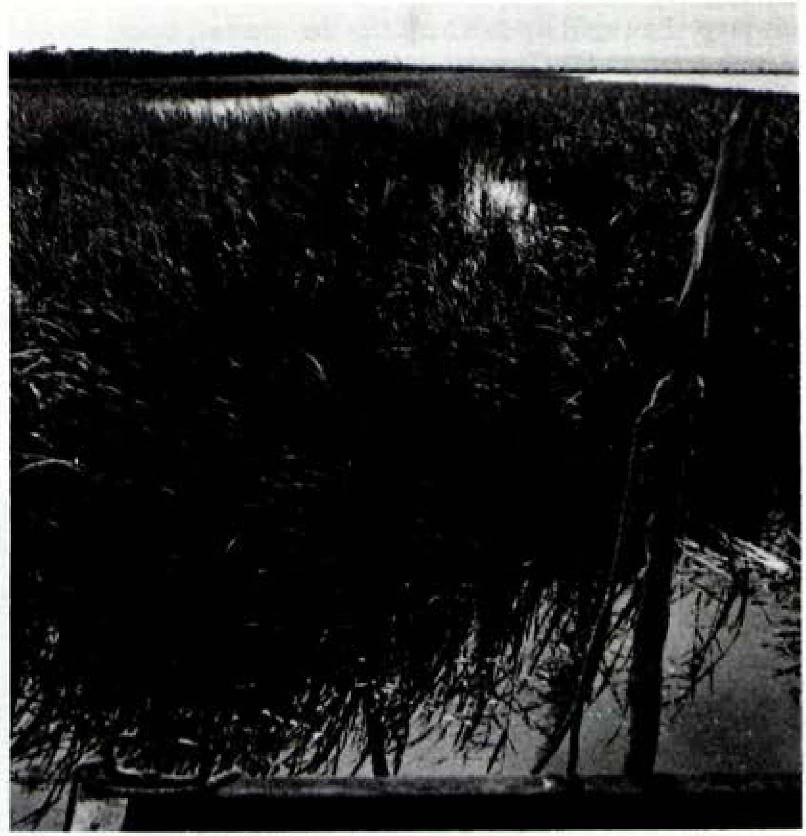
Wattle scrub occupies primarily steep exposed aspects in the north-east and north-central portions of the study

Above: *Silverleaf stringybark woodland north of Heyfield flora and fauna reserve*

Shining peppermint woodland on road reserve adjacent to Moormurng forest park area. While some of these stands have resulted from regeneration on previously cleared farm land, the majority have probably grown following repeated fires, which have favoured the replacement of eucalypt forest by acacia scrub.

Given extended periods free from wildfires, it could be expected that eucalypts would recolonize these areas. Such a reversion to open forest is al-

Swamp paperbark closed scrub near Eagle Point



Phragmites *grassland in Andrew Bay, Lake Wellington*

ready evident in some areas where emergent eucalypts are present.

Swamp communities

The six swamp communities identified occur almost exclusively around the Gippsland Lakes and the streams that drain into the lakes.

Swamp paperbark (*Melaleuca ericifolia*) closed scrub is widespread around the lake shores, with its best development being on the advancing shores of Lake Wellington as these build up, encroaching on the Lake. The dense thickets formed by this unit grow on poorly drained land where the water table is near the ground surface. It is a feature of such shorelines or deltas and occurs on the landward side of either a grassland of common reed (*Phragmites australis*) or saltmarsh.

Phragmites grassland grows on the margins of swamps, streams, and the Gippsland Lakes where salinity is not excessive. It was once widespread around the lakes, but increasing salinities following the opening of the artificial entrance have significantly reduced its distribution.

P. australis can form dense stands up to 2 m tall. It grows best in waterlogged, anaerobic soils where water often covers the surface; indeed it has been recorded growing in water up to 1.2 m deep.

While the species often forms pure stands, it can be associated with the semi-aquatic leafy twig-rush (*Cladium procerum*), which is the first emergent vegetation along river banks, for instance on the Perry and Avon Rivers.

Glassworts (*Salicornia* spp.) dominate the saltmarsh species of herbfield - the fourth unit. This vegetation occupies low-lying saline areas that are subject to flooding.

Saline swamplands

Tussock sedgeland or rushland unit occurs between *Melaleuca* closed scrub or *Phragmites* grassland and *Salicornia* herbfield. It occupies sites with soil salinity intermediate between these units.

Tussock rushland dominated by giant rush (*Juncus ingens*) is found only in Macleod

Fore-dune vegetation

Morass south of Bairnsdale and is restricted to an area that contains shallow standing water in all seasons.

Closed sedgeland is found in fresh-water swamps, which in the study area occur in the depressions between east--west dunes overlying a clay basement. Examples may be found at Providence Ponds, at Moormurng forest, and north of Lake Victoria.

This unit, dominated by pithy sword-sedge (*Lepidosperma longitudinale*), is typical of the wet depressions on sand sheet and dune areas throughout Gippsland.

Fore-dune vegetation

Along the Ninety Mile Beach between Lakes Entrance and Lake Tyers, the primary dune vegetation ranges from the low hairy spinifex (*Spinifex hirsutus*) and introduced marram grass (*Ammophila arenaria*) closest to the sea, through to a closed scrub of coast tea-tree (*Leptospermum laevigatum*), which can grow to

6 m tall on the leeward side of the dune. Between these, on the mid slopes of the fore dune, grows the prostrate form of coast wattle (*Acacia longifolia* var. *sophorae*) with other low shrubs.

Softwood plantation

With the exception of a number of small trial plots, the only softwood plantations on public land in the study area are school plantations of *Pinus radiata* at Mount Taylor and south of Sarsfield.

Grassland

The grassland unit includes public land that has little or no tree cover. Cleared farmland, such as at the Nyerimilang Estate, or public-purpose reserves provide examples.

Aquatic vegetation

While recognizing its importance to the ecology of the Gippsland Lakes, this publication does not attempt any detailed account of aquatic vegetation (that is, totally submerged).

In general, this aquatic vegetation is typically estuarine, falling into two broad categories: the macrophytes, such as sea grasses, which are large enough to be seen by the naked eye; and the microscopic plants, consisting mostly of algae.

Studies have indicated that the aquatic flora of the Gippsland Lakes is in a healthy condition, except in Lake Wellington. Declining water quality there has led to a dramatic reduction in aquatic vegetation, which now has a very restricted planktonic flora and virtually no macrophytes.

For a more comprehensive account of the Gippsland Lakes' aquatic flora, the reader is referred to the booklet by Ducker, Brown, and Calder.

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FAUNA

The Gippsland Lakes hinterland contains substantial areas, and considerable diversity, of potential faunal habitat. In addition to large contiguous areas of public land, mostly forested, it contains a wide variety of environments: pockets of warm-temperate rainforests; large areas of open forests and woodlands; coastal scrub; large and varied areas of wetland; cleared farmland; and towns. This variety is reflected in the diveristy of terrestrial vertebrate species, including about 54 non-marine mammals (of which 13 are introduced), 298 birds (of which 12 are introduced), 32 reptiles, and 18 amphibians. Moreover, a wide diversity of aquatic habitats ranges from swiftly flowing mountain streams to salt-water lakes. A full list of the species recorded can be found in Appendices 2-6.

Skeletal remains at Buchan show that during the Pleistocene era, the study area contained giant, now extinct, marsupials and many other species of small marsupials and rodents now found only in other parts of Australia.

European settlement caused the most abrupt change in the fauna. Changes in land use - including cultivation, animal husbandry, and introduction of exotic species - had a more immediate effect than the gradual influence of climatic change and evolution.

Selective clearing and grazing of forests and woodlands on the Gippsland plains and in river valleys eliminated the eastern quoll, red-bellied pademelon, rabbit-eared tree-rat, brolga, and Australian bustard, and caused the brush-tailed phascogale and red-necked wallaby to be restricted and rare.

The mountain forests were affected by a change in the pattern of burning, but were not heavily logged until after the 1930s. Most of the vertebrate species of the ranges still remain, although the brush-tailed rock-wallaby is now restricted to the Snowy River gorge. Tiger quoll, koala, dingo, and regent honeyeater have all become restricted or rare.

Following an introductory section on habitats, this chapter briefly outlines the distribution of the major faunal groups within the study area. It then discusses characteristic species occurring in each habitat and the niches they fill.

Data for this chapter and for the tables showing habitat preferences have come from field work conducted by the Fisheries and Wildlife Division, extensive literature and specimen data compiled by the National Museum of Victoria, and observations of local naturalists.

Habitats

Animal distribution reflects both the physical and biological nature of the environment, with each species having habitat requirements peculiar to itself. Sometimes the suitability of an area for a species may depend on features such as the presence of scattered rock outcrops or decaying logs. Many habitat preferences, however, are related to the vegetation - either directly, through the food, shelter, or breeding sites that it provides, or indirectly, through physical factors such as topography, temperature, and soil type, which influence the vegetation type.

Thus, a classification of habitats based mainly on vegetation structure is a valid and useful approach in the assessment of faunal distribution within the study area. While the shortcomings of treating fauna in terms of these broad habitats is recognized, present data indicate that this approach is the best available and is widely used by workers in this field.

Ten primary habitat types have been identified in the Gippsland Lakes hinterland. Table 10 shows the relation of seven of these to the vegetation communities described in chapter 9. Vegetation has no bearing on the remaining three (towns, ocean, and inland wetlands.)

Mammals

The species of native mammals include two monotremes (platypus and echidna), five dasyurids (marsupial carnivores and insectivores), two bandicoots, eight possums, four macropods (kangaroos and allies), koala, wombat, twelve bats, four rodents, and dingo.

There are also occasional records of marine mammals (seals, dolphins, and whales) from the Ninety Mile Beach and Bass Strait.

Many species of mammal occur widely throughout most types of forest and are referred to as general forest species. They include such widespread and commonly observed species as the echidna and common wombat - the former insectivorous, the latter feeding on roots and other vegetable matter, and both being strong burrowers - and the swamp wallaby (which browses on grasses and low shrubs and is common wherever dense thickets provide shelter).

Five of the possum species are widely distributed in the forest areas. All are nocturnal and nest mostly in tree hollows

Table 10

CORRELATION BETWEEN HABITAT TYPES AND VEGETATION

Habitat type	Vegetation Units
Closed forest	Lilly pilly closed forest II
Tall open forest	Alpine ash open forest IV, mountain ash open forest IV, messmate--gum open forest IV
Open forest	All open forest III units and some parts of open forest II units
Riverine forest	Riparian sections of open forest IV units and the mountain grey-gum--stringybark open forest III unit
Foothill woodland	Some parts of open forest II units, red stringybark--red box open forest I, forest red gum open forest II--woodland II, yellow box open forest II--woodland II, brittle gum open forest II--woodland II, silver-leaf stringybark open forest I --woodland I
Coastal woodland and scrub	White stringybark open forest II--woodland II, shining peppermint open forest I--woodland I, manna gum open forest I --woodland I, saw banksia open forest I--woodland I, coast banksia open forest I--woodland I, swamp paperback closed scrub, closed sedgeland, foredune vegetation
Farmland	Grassland

The mountain brushtail, Victoria's largest possum, is found in areas of thick understorey where old and dead eucalypts provide adequate nesting sites. It is a vegetarian and often forages on the ground. Common ringtails, although primarily herbivorous, will eat fruit such as the introduced blackberry. Their nests, usually built in thick scrub, are often grouped closely together, the ringtails' social system allowing females to share them with each other.

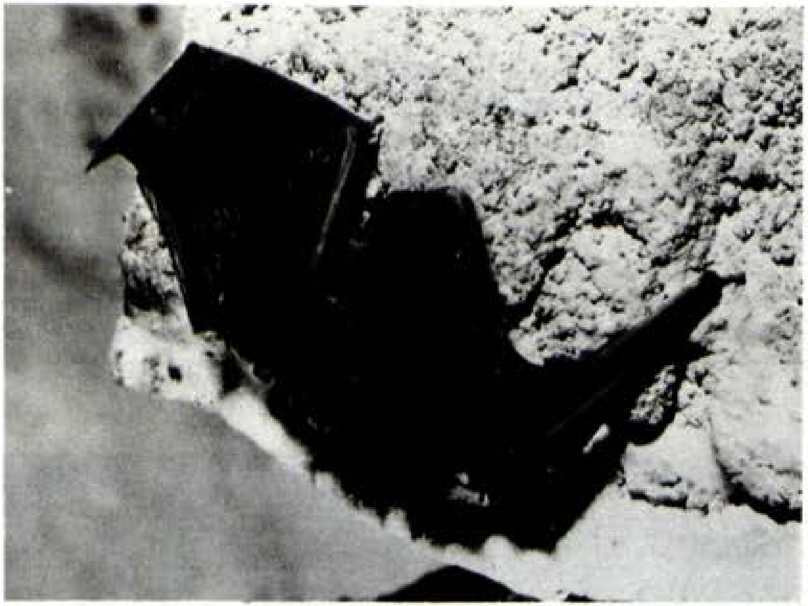
Sugar gliders also have a well-developed social system, with family parties sharing the one nest. They feed on insects, blossoms, and sap. Both the feathertail glider and the eastern pigmy possum feed on insects and nectar and, because of their small size, require only small hollows or cracks for nesting sites (the latter species often uses abandoned birds' nests). The eastern pigmy possum does not glide and therefore prefers a well-developed medium tree layer or understorey.

Two widespread ground-dwelling species - the dusky antechinus and the brown antechinus - both inhabit the litter on the forest floor and nest in tree hollows or fallen logs.

Other common terrestrial mammals are the long-nosed bandicoot and the bush rat. Both are nocturnal and prefer a dense ground cover. The long-nosed bandicoot is solitary and territorial and feeds mainly on invertebrates, but will take berries when these are available. The bush rat is omnivorous, with invertebrates forming the major dietary component during spring and summer, and fungi and fibrous plant material during the winter.

Five insectivorous bats are common in the study area throughout most of the forest habitats: white-striped mastiff bat, Gould's wattled bat , chocolate wattled bat, little forest bat, and

Feathertail glider



Common bent-wing bat

lesser long-eared bat. Each of these small bats is classified as a forest bat due to the fact that their preferred daylight roosting sites are hollow limbs or trees.

Tiger quoll and the dingo are rare, but are probably also general forest species.

Cave bats

As it is difficult to allocate a particular habitat type to these bats, they are discussed separately.

Three species of cave bat occur in the study area, common bent-wing bat, eastern horseshoe-bat, large-footed myotis. They are all small insectivorous species that have an important regulatory control on insect populations. Some of them leave the study area and spend the winter in New South Wales, but some stay and remain inactive with a reduced body temperature (torpor).

The study area contains the largest colonies of cave bats in Victoria, which utilize more caves here - both natural caves and mine tunnels - than in any other comparable area of the State.

Cave bats breed in the summer, and the biological centre of a population is the breeding colony. There are four known maternity caves in the study area.

Nargun Cave near Nowa Nowa contains the largest breeding colonies of common bent-wing bat (about 60,000 females) and eastern horseshoe-bat (about 10,000 females) in Victoria. Also, two smaller breeding colonies of common bent-wing bat occupy caves on the Snowy River at New Guinea Point. Large-footed myotis has a small breeding colony in Clogg Cave near Buchan.

Many other nearby caves are used as staging areas, as occasional roosting sites, or for overwintering.

Conservation of cave bats must include the protection from human disturbance of caves used for breeding and overwintering.

Closed forest

No species are peculiar to this habitat, which supports most general forest species. Grey-headed flying foxes, which require seclusion and shade for their camps, used to roost in closed-forest gullies near Metung.

Tall open forest

Characteristic mammals here are generally the wide-ranging forest species, with dusky antechinus, mountain brushtail possum, and bush rat being the most common.

Two of the largest gliders (greater glider and yellow-bellied glider) are found in this habitat type. The sedentary greater glider is a vegetarian with a koala-like preference for leaves of certain eucalypts. A combination of suitable feed trees (such as narrow-leaf peppermint) and tree hollows for nest sites can result in large numbers of the species in relatively small areas.

The slightly smaller (but much more active) yellow-bellied glider feeds on insects and blossoms, and during winter cuts characteristic V-shaped incisions in the trunks of particular eucalypts.

Open forest

Most of the indigenous, terrestrial mammals occur in at least some types of open forest.

Two macropods of contrasting abundance and distribution are represented: the eastern grey kangaroo is widespread in open forest having a grassy understorey, whereas the red-necked wallaby is restricted to the Colquhoun State forest and an area noth of Buchan. Like other large wallabies, this animal prefers a heathy understorey adjacent to open or patchy clearings.

The koala, an arboreal mammal that feeds on the leaves of certain eucalypts, is

Red-necked wallaby and joey

re-establishing itself in this habitat following liberation in the eastern portion of the study area. The species is now widespread but uncommon from Buchan to Nowa Nowa.

Several other species prefer open forest that has a heathy understorey. For instance, the white-footed dunnart inhabits areas with a dry heath understorey, while the southern brown bandicoot is found in areas with a wet heath understorey near Lakes Entrance and Lake Tyers.

Riverine forest

The remaining stream-side forests contain a higher concentration of forest mammals than other habitat types.

Apart from the general forest species, all of which are present, characteristic mammals of this habitat include the yellow-bellied glider, for which manna gum and but but are essential as winter food, and the koala, which also has a preference for manna gum foliage.

Foothill woodland

A lack of dense understorey and the unsuitability of the tree species in this habitat combine to exclude the dusky antechinus, mountain brush-tail possum, yellow-bellied glider, and greater glider. Most other general forest species occur, but are less numerous than in other habitats.

Common mammals here include the eastern grey kangaroo and the arboreal and nocturnal common brushtail. This possum feeds on the leaves, buds, and fruit of various trees and shrubs, and spends much of its time on the ground.

The brush-tailed phascogale is also a possible inhabitant. It is mainly nocturnal and feeds on insects and small vertebrates; it uses hollows in trees or logs as nest sites.

Coastal woodland and scrub

The coastal heath provides a dense scrub layer and supports the southern brown bandicoot, which builds tunnels through the thick undergrowth, along which it searches for various invertebrates such as arthropods and earthworms. It favours a sandy soil.

Dry heath is inhabited by the New Holland mouse, until 10 years ago only known to occupy one location in New South Wales.

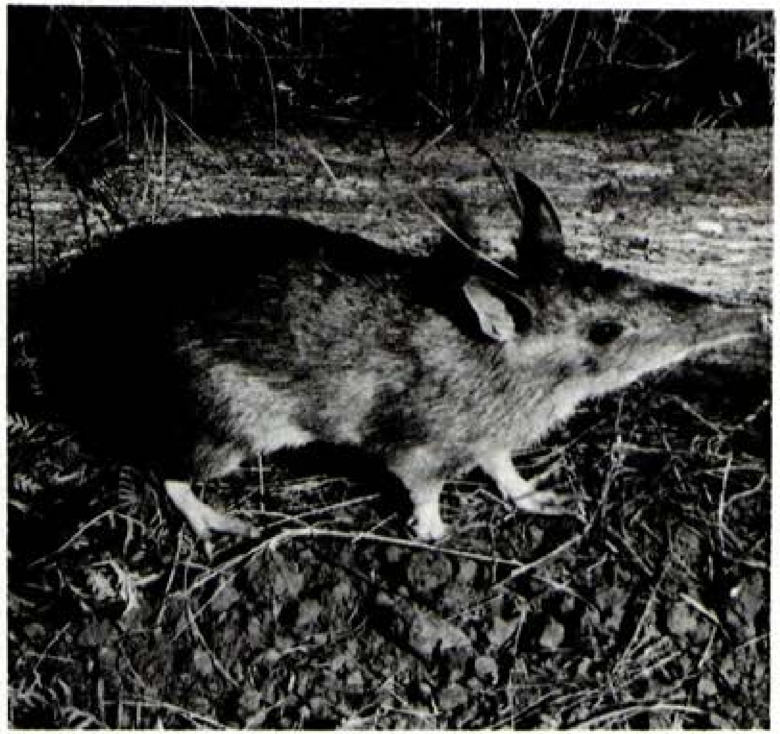
The dusky antechinus is common in wet heath (swamplands), a niche that also supports the long-nosed potoroo and the swamp rat. The potoroo, a small nocturnal macropod, requires dense vegetation - perhaps as a protection against potential predators. The swamp rat, a medium-sized native rat, lives in colonies whose members construct elaborate runways and burrows through dense undergrowth.

Two species of possum are also quite numerous throughout this habitat; the eastern pigmy possum, although rarely seen, is most common in saw banksia and coast banksia woodland; the common ring-tail's ability to build a nest (drey), where suitable tree hollows are not available, allows it to colonize thin-stemmed scrub, such as tea tree and paperbark, where other possum species are excluded.

Farmland

Many species that inhabit farmland are introduced. Of the native species, com-

The potoroo often forages on the lawns of houses in the Lake Tyers area



Long-nosed bandicoot

mon brushtail possum and most species of insectivorous bats are common where trees are present. In some areas, swamp rat occurs in ungrazed lush grassland. Echidna, long-nosed bandicoot, eastern grey kangaroo, swamp wallaby, wombat, and dingo occupy the margins of farmland in many areas.

Towns

Although towns also generally support only introduced mammals, some do contain a few native species. Most have populations of common brushtail and common ringtail possum and some species of insectivorous bat. At Lakes Entrance, potoroos forage in gardens of homes near wet heath. At Metung and Kalimna, long-nosed bandicoots forage on lawns.

Ocean

New Zealand fur seal, Australian fur seal, leopard seal, elephant seal, sperm whale, minke whale, common dolphin, pilot whale, and bottle-nosed dolphin have all been recorded along the Ninety Mile Beach, but only common dolphin and bottle-nosed dolphin are observed regularly.

Inland wetlands

The platypus is common in Victoria, but its crepuscular (twilight) habits make observation difficult and give a false impression of poor abundance. These animals require soft, friable river-bank soils in which to dig burrows for shelter during the day and to lay eggs in the breeding season. They feed on aquatic invertebrates such as molluscs, worms, and yabbies, obtained by sifting through bottom sediments.

Unlike the platypus, which is restricted to fresh water, the eastern water rat is most common in lowland rivers and swamps and around the saline Gippsland Lakes.

Common dolphins have also been observed in the Gippsland Lakes.

Introduced mammals

Fox and feral cat are widespread through the study area. Rabbits are also widespread, but prefer grassy ground cover and seldom inhabit forests except along roadsides and disturbed areas. Ferrets, probably escapees from ferreters, have been found in farmland, as have hares, which are restricted to the plains. The house mouse and black rat are widespread but mainly found around towns, farmland, and the margins of the Gippsland Lakes.

Deer are well established in the study area, with sambar deer being widespread in tall open forest and open forest. Small numbers of red deer have been reported in the Snowy River area and fallow deer have been shot near Buchan. Hog deer are common in coastal woodland around the Gippsland Lakes.

Feral pigs occur on Boole Poole peninsula, adjacent to the study area. Feral goats have been recorded in the Tambo River valley and along the Snowy River gorge, and possibly exist in the Mitchell River valley near Dargo. Wild dogs (free-living domestic dogs and dingo hybrids) are common in the tall open forests of the eastern highlands.

Birds

Of the 298 species of bird found in the study area, 95 depend partially or totally on wetlands. The non-wetland birds typify those inhabiting terrestial environments throughout Gippsland, although the study area is at the southern limit of the range of several species (including painted honeyeater, scarlet honeyeater, and spangled drongo).

Bird Movements

Many have seasonal movements, which vary from the very restricted range of feeding flocks of thornbill to the trans-equatorial movements of white-throated needletail and most species of wader. Conservation of these species requires knowledge of their movements and the environments they need at different times of the year.

Australia has an international obligation to provide adequate refuge for intercontinental migrants, a national responsibility to provide for species that migrate from the north or from Tasmania, and a regional responsibility to provide for those species that migrate altitudinally or are seasonal nomads.

Bird communities

Appendix 3 lists the habitats for all the species of birds. A few characteristic species of each environment category are discussed below.

Widespread bird species

Many species of bird are widespread throughout the study area. Birds of prey, including brown goshawk and wedge-tailed eagle, occur over all habitats and peregrine falcon hunts over all open areas but often nests on cliffs in the ranges. White-throated needletail and fork-tailed swift both migrate from the Himalayas to Australia for the summer and feed over all habitats.

Species that can be found wherever trees grow include gang gang cockatoo, crimson rosella, southern boobook, Australian owlet-nightjar, and laughing kookaburra, all of which nest in tree hollows; the striated thornbill, red wattlebird, yellow-faced honeyeater, and spotted pardalote feed among the crowns of the trees; the white-throated treecreeper feeds in the branches and along trunks; and the grey fantail feeds in the air beneath the tree canopy.

Other widespread species include eastern yellow robin, golden whistler, rufous whistler, grey shrike-thrush, striated pardalote, and grey-breasted silvereye. Two species of bronze cuckoos migrate from northern Australia to all treed parts of the study area.

Closed forest

Lewin honeyeater, rufous fantail, black-faced monarch, large-billed scrub-wren, and brown gerygone (which have the southern limit of their range in the study area) all inhabit dense undergrowth and are rarely found outside closed forest or dense tall open forest gullies. Both the rufous fantail and

A female rufous whistler: a species that is widespread in the shady area

black-faced monarch migrate to the study area from northern Australia.

King parrot and satin bowerbird feed in closed forest gullies, especially when lilly pilly trees are fruiting.

Other characteristic species include superb lyrebird and pilot bird, both of which nest close to the ground, and wonga pigeon, which feeds on fallen fruits and seeds.

Tall open forest

This habitat contains species typical in similar areas throughout eastern Victoria. It varies in quality for birds. The most favoured environment is the gullies, with their dense understorey and tree ferns, where characteristic species include powerful owl, white's thrush, red-browed tree-creeper, rose robin, pink robin, pilot bird, and crescent honey-eater. Brush cuckoo, shining bronze cuckoo, and rufous fantail all migrate to this habitat from northern Australia for the summer.

Tall open forest of alpine ash with low shrub understorey has few resident species of bird, the main ones being spotted pardalote, gang gang cockatoo, crimson rosella, and white-browed scrub-wren.

Open forest

The more open nature of the understorey here compared with either closed or tall open forest favours several species, including white-throated nightjar, spotted quail thrush, buff-rumped thornbill, and white-throated treecreeper.

Its flowering red ironbark is favoured by nectar-eaters and attracts all forest honeyeaters, lorikeets, and king parrots. Silvertop open forest is the most widespread form of the habitat but is the least preferred by birds, although yellow-tailed black cockatoo and spotted pardalote are common residents.

Within the study area, this is the only habitat in which fuscous honeyeater and grey goshawk have been recorded. The fantailed cuckoo and olive-backed oriole migrate primarily to open forest in summer.

Riverine forest

This is the richest bird community in the ranges, as the proximity to water introduces water-dependent birds, and the lushness and diversity of vegetation provide for birds from many ecological niches.

Species characteristic of this habitat include tree martin and rose robin, both of which feed on insects caught on the wing beneath the canopy. Both also require this habitat for breeding, the rose robin building its nest in the dense understorey, while the tree martin nests in small hollows of mature eucalypts.

Other characteristic species are yellow-tufted honeyeater, inhabiting the canopy, and bell miner, found in no other habitat. Azure kingfisher, which dives into the water for its food, and fork-tailed swift, which feeds on insects above the canopy, are both present during summer.

Foothill woodland

This open dry habitat is suitable for most open forest species, but the several characteristic birds include weebill, which feeds in the tree canopy, brown treecreeper, which feeds on tree trunks, and the chestnut-rumped hylacola and speckled warbler, both of which feed on or near the ground. White-winged triller migrates from northern Australia to the woodlands and open forests for summer.

Coastal woodland and scrub

With banksia in the tree stratum and heath as an understorey, this provides an ideal environment for many species of honeyeater and some ground-dwellers. Little wattlebird, rainbow lorikeet, and calamanthus are widespread in coastal areas, and the rare ground parrot and southern emu-wren are found in wet coastal and inland heath, mainly at the eastern end of the Gippsland Lakes.

Spangled drongo and scarlet honeyeater occasionally migrate here from the north-east, and spiny-cheeked honeyeater occasionally migrates from the west, although the study area is not an important part of its range. There are some unconfirmed records of the very rare orange-bellied parrot in scrubland on the Ninety Mile Beach and around the Gippsland Lakes.

Farmland

Suitability of farmland for different species of bird depends on a variety of factors, including rainfall, type of crop or pasture, number and quality of trees, amount of surface water, and time of year.

Eastern rosella, sulphur-crested cockatoo, galah, peregrine falcon, Australian hobby, brown falcon, nankeen kestrel, Australian magpie, Richard's pipit, and stubble quail are often observed on farmland. Noisy miner, willie wagtail, yellow-rumped thornbill, and grey shrike thrush are common on farmland near treed roadside reserves.

Towns

Gardens, houses, and streets are traditionally the habitat for introduced species of bird.

Recently, however, the increased cultivation of native plants, particularly species that are rich with nectar, makes towns suitable for several honeyeaters and small insectivorous species, including white-eared honeyeater, yellow-faced honeyeater, eastern spine-bill, grey-breasted silvereye, grey fantail, superb fairy-wren, brown thornbill, and striated thornbill.

Species that visit towns periodically usually depend on the proximity to forest. Rainbow lorikeet, musk lorikeet, satin bowerbird, and pied currawong are all seasonal visitors to some town gardens.

Ocean

Many sea-birds feed in Bass Strait off the Ninety Mile Beach, despite the absence of ocean islands or rocky headlands for breeding. The most commonly observed species are the Australian gannet and fairy penguin, but at different times of the year short-tailed shearwater, fluttering shearwater, and shy albatross are common.

Inland wetlands

The Gippsland Lakes and surrounding wetlands comprise one of the State's most important water-bird habitats. They contain resident populations of many species of water-bird, and in time of drought provide a permanent refuge for nomadic species of the inland, including most species of duck. These areas, as well as large water storages, farm dams, and the many rivers and streams, combine to provide a wide variety of wetland habitats.

Water-birds on Sale common

The study area contains important breeding colonies of little tern, great cormorant, pied cormorant, sacred ibis, straw-necked ibis, and yellow-billed spoonbill. Other characteristic species of the wetland habitat include white-faced heron, Australian pelican, little black cormorant, and black swan.

Small numbers of intercontinental migrants, including most species of wader, use parts of the Gippsland Lakes during summer. Many species breed in northern Asia and spend summer along the Australian coast - including parts of the study area.

Black duck and young

Straw-necked ibis

Introduced birds

The mallard has been recorded on marshes near the Gippsland Lakes. Feral pigeon is restricted to towns and farm buildings. Spotted turtle-dove is common near towns, and in farmland and coastal scrub. Skylark is widespread in farmland. Blackbird, although mainly restricted to town gardens, also occurs on farms and in blackberry along streamsides. Song thrush has been recorded in a few towns.

European goldfinch - common in towns and farmland - extends along road clearings into the ranges. European greenfinch has been recorded in towns and in coastal scrub. House sparrow occurs widely in towns and farmland. Tree sparrow is uncommon, but occurs in some farmland areas.

Common starling, found throughout farmland and towns, competes successfully with native parrot species for nesting hollows. Common mynah has spread eastwards along the highways and has now reached Lucknow.

Reptiles

Reptiles acquire most of their body heat from their environment. They do this either actively by absorbing solar energy when basking or passively from the air or substrate in or on which they live. All reptiles have a preferred range of body temperature within which they forage for food and breed. If they cannot maintain their body temperature within the preferred operating range, then they seek shelter - either in shade if it becomes too hot, or in a safe niche if it becomes too cold. Because of this, distribution of reptiles tends to reflect such physical features of the environment as the amount of sunlight, average air temperature, and availability of basking sites (such as rock outcrops) rather than biotic features.

There have been recent records of 32 species of reptile including 1 turtle, 3 dragons, 1 monitor, 19 skinks, 7 land snakes and 1 sea snake. No groups characteristic of hot environments - marine turtles, crocodiles, legless lizards, geckoes, and pythons - are found regularly in the study area.

Closed forest

Despite its relative warmth, this habitat has no characteristic species of reptile. Eastern water dragon and a warm-temperate form of eastern water skink occur along streams, and black rock skink is found on rock outcrops. McCoy's skink, which does not bask, is probably present in moist litter. Tiger snake and red-bellied black snake are sometimes observed.

Tall open forest

The characteristic denseness of its tree canopy and its coolness make the environment unsuitable for most species of reptile. McCoy's skink lives in leaf litter, while Coventry's skink, Spencer's skink, and the cool temperate form of eastern water skink occur in any sunlit areas. Tiger snake is sometimes observed in tall open forest on hot days.

Open forest

Its open nature makes this habitat more suitable than tall open forest. The distribution of several reptile species here is determined by altitude. Three-lined skink, Spencer's skink, a highlands form of copperhead snake, and small-eyed snake are found throughout open forests; the grass skink, however, is restricted to high altitudes, and lace monitor and garden skink are restricted to low ones. Red-throated skink and copper-tailed skink are found in stony open forest in the east of the study area.

The grass skink is only found at high altitudes

Riverine forest

This habitat has a rich reptile fauna: lush vegetation provides abundant food - both fruit and insects; the litter is usually thick; and streams break the canopy of trees and provide many basking sites on rocks and logs along their banks.

Air temperature and therefore altitude determine which reptile species are present. At lower altitudes, eastern water dragon, warm-temperate form of eastern water skink, weasel skink, and red-bellied black-snake are common, but at higher altitudes the cool-temperate form of eastern water skink, Coventry's skink, and highlands form of copperhead replace these. Long-necked tortoise occurs in anabranch swamps of most rivers in the lowlands.

Foothill woodland

The open nature of this habitat is suitable for some of the larger reptile species, including Cunningham's skink and lace monitor. Garden skinks are common throughout foothill woodland, but red-throated skink, copper-tailed skink, and brown snake are restricted to the east. Three-toed skink is restricted to foothill woodland in the north-east of the study area.

Coastal woodland and scrub

Heath understorey and sandy substrate are suitable for three small semi-burrowing skinks, Bougainville's, delicate, and weasel skink. Three-lined skink and white-lipped snake often occur in open areas and common bluetongue in coastal scrub. Black rock skink and brown snake are found in some dry coastal woodland localities. Tiger snake and lowlands form of copperhead are common.

Farmland

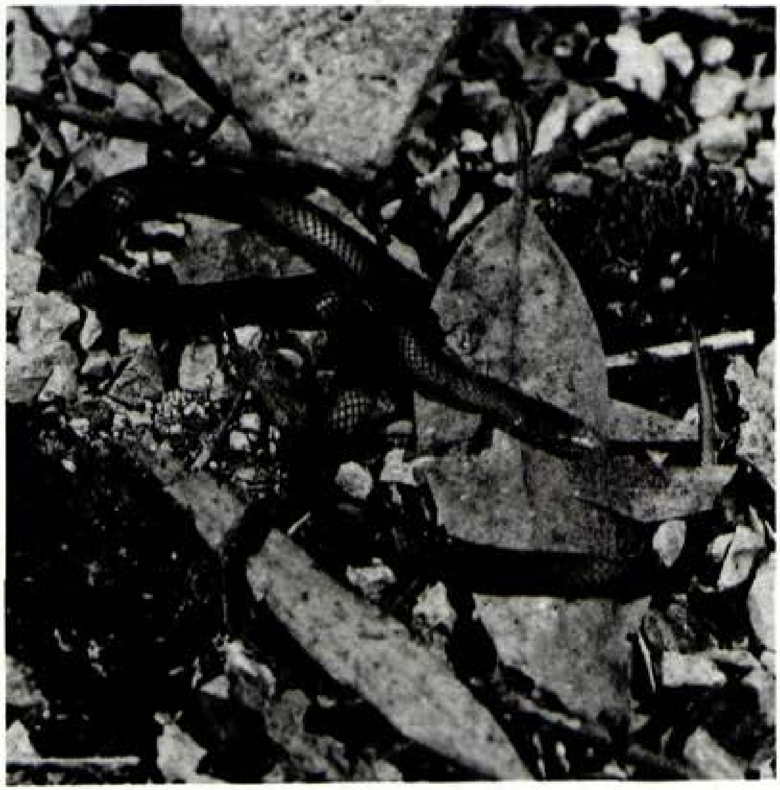
The species of reptile present in farmland depend on parameters like altitude, frequency of grazing, rainfall, and amount of rubbish or litter. Tiger snake is common throughout. Garden skink, delicate skink, weasel skink, southern bluetongue, the lowland form of copperhead, red-bellied black-snake, and white-lipped snake are common in lush grassland. Brown snake and common bluetongue often occupy warm dry areas, Three-lined skink is common around rubbish and in rank grassland. In eastern areas, red-throated skink, coppertailed skink, and Cunningham's skink are found near rocky outcrops and logs.

Towns

Reptiles are not welcomed in most home gardens,although several harmless skinks thrive there, including delicate skink, garden skink, weasel skink, southern bluetongue, and common bluetongue. Tiger snake and lowlands form of copperhead snake are occasionally found in towns.

Ocean

Yellow-bellied sea-snakes, recorded in the Gippsland Lakes, are probably vag-



White-lipped snake is common in lush grassland

The leaf-green tree-frog, Litoria raniformis, *is common throughout the study area*

rant specimens from their more usual range on the north-eastern coast of Australia.

Inland wetlands

Long-necked tortoise is the only species of reptile totally dependent on water and is found in fresh-water and brackish swamps around the Gippsland Lakes and along river flats.

The lowlands form of copperhead snake, tiger snake, and red-bellied black snake are common in marshes and along streams in the lowlands. Eastern water dragon and both forms of eastern water skink are common along streams.

Amphibians

All amphibians found in the study area are frogs. Australia lacks toads (except the introduced cane toad), newts, and salamanders.

Amphibians' main environmental requirement is water. Most frogs require surface water for breeding; all have skin that is relatively permeable to water, and will desiccate in other than moist or humid environments.

In the study area, few frogs have a distribution that follows the distribution of vegetation communities. Jervis Bay tree frog is restricted to tall open forest pockets, where it breeds in fire dams and roadside puddles. *Geocrinia victoriana* is most common in tall open forest.

The distribution of most species is determined by the quality of surface water available and ambient temperature.

Fast-flowing mountain streams are suitable for the Rocky River tree-frog, which also extends down to the edge of the lowlands. Lowland and foothill streams surrounded by Kanooka are ideal for leaf-green tree-frog. Blue Mountains tree-frog, a rare species, has been found near mountain streams in dry foothill woodland.

Most other frogs prefer still water, either among reeds on the edge of streams or in fresh-water marshes in the lowlands. The presence of fire dams throughout forested land and farm dams on agricultural land has increased the available breeding sites for all these species.

Fish

The study area contains five distinct types of fish habitat: upland fresh-water rivers; lowland fresh-water rivers; estuarine rivers; fresh-water lakes; and estuarine lakes. Each of these habitats carries a characteristic fish population, although several fish species occur in a number of different types of habitat, and others utilize all habitats at some stage in their life cycle.

At least 38 fish species are usually present in the estuarine habitats and 14 species regularly occur in the fresh-water habitats.

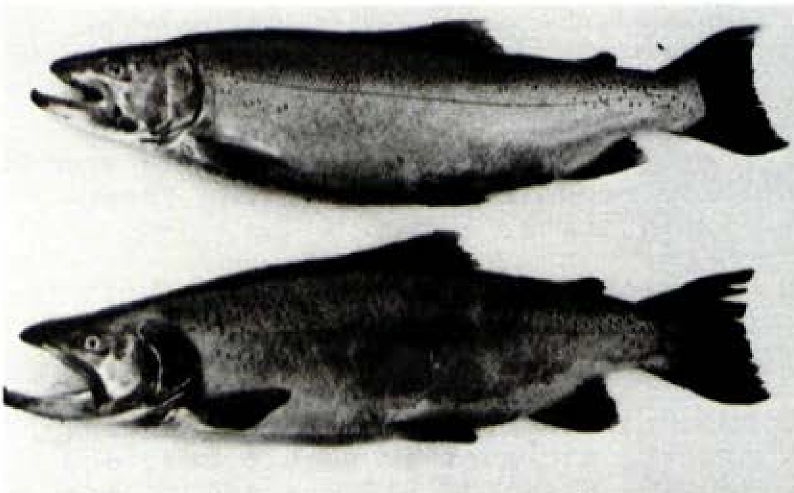
Upland rivers

This habitat type encompasses fast-flowing, cold, fresh-water rivers, often flowing in forested mountain country. They have a gravel or rubble bed, and extensive areas of riffles and rapids.

The study area has substantial amounts of this habitat in a relatively natural condition. Examples include the middle reaches of the Tambo River and its two main tributaries, the Timbarra River and Haunted Stream; the Mitchell River upstream of Glenaladale and its tributaries the Dargo, Wentworth, and Wonnangatta Rivers; and the Macalister River upstream from Lake Glenmaggie.

Native fish species such as tupong, eels, blackfish, grayling, galaxiids, and smelt are widespread and often abundant.

Brown trout is the only introduced fish species that is widespread, but it is abundant in only five localities - the Timbarra, Wentworth, Moroka, and Macalister Rivers and the Haunted Stream - where well-established, self-supporting populations occur. The only other in-



The rainbow trout is a popular fresh-water angling species

troduced species, rainbow trout, is not abundant.

Lowland fresh-water rivers

Slow-flowing, turbid water and extensive pool areas characterize these rivers. They usually have muddy or sandy beds and mainly flow through cleared agricultural land.

Such habitat occurs in the Macalister River downstream of Lake Glenmaggie, the Mitchell River between Glenaladale and Bairnsdale, the Perry and Avon Rivers, and the Latrobe River downstream of Sale.

This type of habitat suits the requirements of many introduced fish species, which have supplanted most of the smaller native fish. Also, in some rivers such as the Latrobe, it has been so altered by Man's activites that many of the native fish species cannot survive. Fish communities are, therefore, characterized by a predominance of introduced species - particularly common carp, but also redfin, pigmy perch, goldfish, and a few brown trout.

Native fish such as blackfish and tupong still remain, but only eels and estuary perch are abundant.

In the Mitchell and Tambo Rivers, this habitat has particular value as it supports a small number of Australian bass, a species considered uncommon in Victoria. Indeed, the Mitchell River appears to be the most westerly distribution of bass in south-eastern Australia.

Fresh-water lakes

Lake Glenmaggie provides the main area of fresh-water lake habitat in the study area. It carries common carp, eels, goldfish, a few rainbow trout, and numerous brown trout. Occasional liberations maintain trout stocks.

Estuarine rivers

All the rivers discharging into Gippsland Lakes, with the exception of the Latrobe, have extensive areas of estuarine habitat, which characteristic stratification divides into surface and bottom layers of water, each with a different salinity. The rivers are deep and sluggish, with sandy beds. In the Tambo, Mitchell, and Nicholson Rivers, saline water extends as a bottom layer for many kilometres upstream of the Princes Highway at times of low fresh-water flow.

The estuarine rivers carry a highly variable fish population both in species and in number.

Bream, estuary perch, luderick, and sea and yellow-eye mullet predominate, but all other species occuring in the estuarine Gippsland Lakes have been recorded at some time in the estuarine rivers. As well as supporting many adult fish, this habitat also provides extensive spawning and nursery areas for both estuarine and some fresh-water species.

At times of very high river flows and corresponding low levels of salinity, common carp and large brown trout are occasionally present. Other fresh-water species spend part of their life cycle in the estuarine habitat. For instance, *Galaxias maculatus*, tupong, estuary perch, and Australian bass spawn in brackish water, while grayling larvae are reputed to drift down to the estuaries where the juveniles develop in their first year before returning upstream to live and spawn.

The Latrobe River remains fresh for most of each year, only becoming saline (up to 4 parts per thousand) for a short time each summer. As such it never carries the range of estuarine fish species recorded in the other rivers. Common carp, eels, and estuary perch are always abundant. At times of low salinity, brown trout and redfin are present, while at times of highest salinities some bream and mullet move into the river.

Estuarine lakes

Semi-enclosed coastal bodies of water with a free connection to the open sea present a true estuarine habitat. These include the interconnected Lakes King, Victoria, and Wellington and the separate Lake Tyers. The sea water is measurably diluted with fresh water from inflowing rivers.

Salinities can range from fresh water in Lake Wellington to sea water at Reeve Channel, and vary greatly in space and time. Although mud beds occur in the centre, the Lakes have sand concentrations along the eastern shores and at the mouths of the Avon and Latrobe Rivers.

Abundant sea grasses and algae provide the main habitat and food source for the 66 species of invertebrates recorded in the Lakes.

Fish species commonly present in the Lakes number 38, but many of the marine species found in the adjacent open sea can occur in the estuarine habitat. The most abundant fish are bream, tailor, sea and yellow-eye mullet, travalley, luderick, hardyheads, estuary perch, garfish, and anchovy.

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LAND SYSTEMS

This report has so far described 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 independently. Rather, distinct environments with characteristic patterns often occur over broad tracts. Thus large areas of land may be described in terms of units, each with a particular range of climate, topography, parent material, soil, and 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.

This approach allows other attributes of the land - such as problems of development, erosion hazard, or potential productivity - to be incorporated.

The most detailed and fundamental unit for mapping and description is the land component, in which the climate, parent material, soil, and vegetation are uniform within close limits. Components usually occur in a limited number in a repetitive sequence, and an area containing such a sequence is termed a land system.

For the Gippsland Lakes hinterland, 61 land systems have been identified and are shown on Map 8.

Table 11 gives details of the geology, (native) vegetation, soils, and climate for each one. It groups the land systems, according to land form, into geomorphological provinces, which, in turn are subdivided according to other distinguishing features.

Within each of these geomorphological provinces, the susceptibility of the land to various forms of soil deterioration is outlined. This deterioration may or may not be in evidence in the study area. More detailed descriptions of the hazards of soil deterioration may be found in Chapter 12, Hazards.

Climate has been described in terms of approximate annual precipitation range and, where applicable, according to the general environment - that is, alpine, sub-alpine, montane, or maritime.

The terms used in Table 11 to describe the approximate annual precipitation range are defined as follows:

* Wet	900--1,800 mm
* Humid	800--1,500 mm
* Sub-humid 1	700--1,200 mm
* Sub-humid 2	600--900 mm
* Sub-humid 3	500--800 mm

Table 11

GIPPSLAND LAKES HINTERLAND

LAND SYSTEMS

Geomorphological province	Distinguishing characteristics	Map symbol	Land system	Geology	Native vegetation	Soils	Climate	Soil erosion hazard
	Mountains in alpine and sub-alpine areas	Hm	Hotham	Palaeozoic sediments, rhyolites, quartzites	Snow gum woodland 1--open forest 1, 11	Lithosols; alpine humus soils	Wet; sub-alpine, alpine	Sheet erosion, slow re-establishment of vegetation
Land with 'ridge and ravine' topography	Mountains with humid forests	Bd	Baldhead	Palaeozoic plutonics, gneissic metamorphics	Messmate, mountain ash open forest IV	Structured brown earths	Wet, montane	Sheet, gully erosion (only limited erosion is apparent in study area)
		Be	Birregun	Palaeozoic sediments	Mixed stringybark--gum open forest 11; messmate--gum--ash open forest 111 & 1V	Lithosols; brown earths	Wet, montane	
		Eh	Elizabeth	Palaeozoic acid volcanics	Messmate, silvertop open forest 111; messmate, mountain ash open forest 1V	Structured red earths; brown earths; lithosols	Humid, montane	
		Mr	Macalister	Palaeozoic (Carboniferous) sediments	Mountain grey gum--messmate open forest 111; red stringybark, silvertop open forest 11	Lithosols	Wet, montane	
	Hills with humid forests	Le	Latrobe	Palaeozoic sediments	Mountain grey gum--messmate open forest 111; silvertop open forest 11	Brown earths; alluvial soils	Humid	
		Tj	Tanjil	Palaeozoic plutonics, gneissic metamorphics	Messmate--mountain grey gum open forest 111-1V; silvertop open forest 111; mountain ash open forest 1V	Brown earths; structured red earths	Wet	

Geomorpholog-ical province	Distinguishing characterist-ics	Map sym-bol	Land system	Geology	Native vegetation	Soils	Climate	Soil erosion hazard
Land with 'ridge and ravine' topography	Mountains with drier forests	Bf	Blomford	Palaeozoic plutonics, gneissic metamorphics	Red stringybark, silvertop open forest 11	Lithosols	Sub-humid 1, montane	Sheet, gully and some tunnel erosion; vegetation is slow to re-establish on exposed aspects (slight to moderately severe erosion is common)
		Ca	Carrabungla	Palaeozoic acid volcan-ics	Yertchuk, red stringybark, silvertop open forest 11	Lithosols	Sub-humid 1, montane	
		Cd	Clifford	Various	Red stringybark open forest 1,11--woodland 1	Lithosols	Wet, montane	
		Te	Talbotville	Palaeozoic sediments	Mixed stringybark--box open forest 11--111	Lithosols	Sub-humid 1, montane	
		Tn	Turton	Palaeozoic (Carbonifer-ous) sedi-ments	Red stringybark--red box open forest 11; mountain grey gum--messmate open forest 111	Lithosols	Humid, montane	
	Hills with drier forests	Cs	Collins	Palaeozoic acid volcanics	Red stringybark, yertchuk open forest 11; mountain grey gum, white stringybark open forest 111; lilly *pilly closed forest* 11	Lithosols	Sub-humid 1	
		Ge	Glenmaggie	Palaeozoic (Carbonifer-ous) sedi-ments	Red stringybark--red box open forest 11; mountain grey gum--white stringybark open forest 111	Lithosols; brown pod-zolic soils	Sub-humid 2	
		Tv	Taravale	Palaeozoic (Devonian) calcareous sediments	Yellow box open forest 11--woodland 11	Structured red earths	Sub-humid 1	
		Ta	Timbarra	Palaeozoic plutonics, gneissic metamorphics	Red stringybark open forest 11; white stringybark, blue gum open forest 111	Brown earths; yellow pod-zolic soils	Sub-humid 1	
		Wa	Wonnangatta	Palaeozoic sediments	Mixed stringybark open forest 11--111; lilly pilly closed forest 11	Lithosols	Sub-humid 1	

Geomorphological province	Distinguishing characteristics	Map symbol	Land system	Geology	Native vegetation	Soils	Climate	Soil erosion hazard
Land on prior landscape residuals with soft or pre-weathered rock	Dense humid forests	Wn	Wellington	Various, prior land-scape remnants	Messmate, mountain ash open forest 111--1V	Red earths; brown earths; lithosols; humic gleys	Wet montane	Sheet, gully erosion (erosion is uncommon on subdued topography)
	Less-dense, less-humid forests	Jn	Jamieson	Various, mainly Palaeozoic (Ordovician), sediments; prior land-scape remnants	Messmate open forest 1V	Red earths; brown earths; alluvial soils	Wet montane	
		Bp	Bulltown Spur	Various sediments prior land-scape remnants	Mountain grey gum--messmate open forest 111; red stringybark open forest 1	Brown earths	Humid, montane	
Land on soft or pre-weathered rock, contained within local base-level structures	*Lower-*elevation areas with drier forests	Bn	Bindi	Palaeozoic *(Devonian)* calcareous sediments	Long-leaf box *open forest 11*	Structured *red earths;* lithosols	Sub-humid 2	Sheet erosion (slight to moderately severe erosion is common)
		Do	Dargo	Palaeozoic (Devonian) pre-weather-ed plutonics, gneissic metamorphics	Mixed stringybark--box--gum open forest 11	Red podzolic soils; brown earths; alluvial soils; black earths	Sub-humid 2	
		Wk	Whisky Creek	Palaeozoic (Devonian) pre-weather-ed plutonics	Mountain grey gum --white stringybark--messmate open forest 111	Earthy sands; yellow pod-zolic soils	Sub-humid 1	
Land on rounded low hills at low elevations	Very sandy areas	St	Stockdale	Cainozoic (Tertiary) sands; low hills	White stringybark, silvertop open forest 111; lilly pilly closed forest 11	Podzols	Sub-humid 3	Erosion is uncommon and seldom serious
	Areas of basic volcanic rock	Nm	Neerim	Cainozoic (Tertiary) basalts; low hills	Forest red gum, yellow box open forest 11--woodland 11	Kraznozems; Chernozems	Humid	Sheet, gully erosion; trampling of wet soil by stock reduces soil structure (erosion is uncommon, although moderate gullying north of Glenmaggie)
		Wr	Wheeler	Cainozoic (Tertiary) basalt; low hills	Red box, but but open forest 11	Prairie soils	Sub-humid 1	

Geomorphological province	Distinguishing characteristics	Map symbol	Land system	Geology	Native vegetation	Soils	Climate	Soil erosion hazard
		An	Anderson	Mesozoic (Tertiary) fan deposits	White stringybark, silvertop open forest 111; lilly pilly closed forest 11	Yellow podzolic soils; podzols	Sub-humid 1	
		Av	Avon	Palaeozoic (carboniferous) sediments	Red stringybark--red box open forest 11; white stringybark, mountain grey gum open forest 111; lilly pilly closed forest 11	Red podzolic soils; yellow podzolic soils; alluvial soils	Sub-humid 1	
Land on rounded low hills at low elevations	Various parent lithologies	Bc	Buchan	Palaeozoic (Devonian) calcareous sediments	Yellow box open forest 11--woodland 11	Structured red earths	Sub-humid 1	Sheet, gully and some tunnel erosion (moderate to slight gullying is common)
		Cn	Colquhoun	Cainozoic (Tertiary) fan deposits; plateaux remnants, small spurs	White stringybark, silvertop open forest 111	Yellow podzolic soils; podzols; alluvial soils	Sub-humid 1	
		De	Deadhorse	Palaeozoic (Devonian) plutonics; low hills	White stringybark open forest 111; red stringybark--red box open forest 11	Lithosols; red podzolic soils; alluvial soils	Sub-humid 1	
		Ml	Mitchell	Cainozoic colluvium, alluvium on narrow flood plains flanked by Palaeozoic (mainly Ordovician) sediments on low erosional spurs	Mixed peppermint--stringybark--box--gum open forest 11--111	Yellow podzolic soils; lithosols; alluvial soils	Sub-humid 2	
		Sc	Salt Creek	Cainozoic (Tertiary, Pleistocene) sediments; rounded hills	Forest red gum, white stringybark open forest 11--woodland 11	Yellow solodic soils; podzols; structured red earths	Sub-humid 3	

Geomorphological province	Distinguishing characteristics	Map symbol	Land system	Geology	Native vegetation	Soils	Climate	Soil erosion hazard
Land on rounded low hills at low elevations	Various parent lithologies	Tb	Tambo	Palaeozoic sediments rounded low hills	White stringybark, mountain grey gum open forest 111; red stringybark, red box open forest 11; lilly pilly closed forest 11	Yellow podzolic soils; brown earths; brown podzolic soils; alluvial soils	Sub-humid 1	Sheet, gully and some tunnel erosion (moderate to slight gullying is common)
		Wy	Westbury	Cainozoic (Tertiary, Pleistocene) sediments; dissected, undulating plains	White stringybark, silvertop open forest 111; red ironbark open forest 11	Yellow podzolic soils; yellow solodic soils	Sub-humid 1	
Land on almost flat plains, of mainly Pleistocene age	Older terraces with strongly texture-contrast soils	Ck	Clydebank	Cainozoic (Pleistocene, Holocene) sands, clays; plains	Manna gum, saw banksia woodland 1; forest red gum open forest 11--woodland 11; tussock grassland; sedgeland; *Salicornia* herbfield	Podzols; siliceous sands; Wiesenbodens; black cracking clays	Sub-humid 3 maritime	Sheet erosion, some gullying, waterlogging; trampling of wet soil by stock reduces soil structure (deterioration commenced with settlement - uncommon and seldom serious)
		Ki	Kanni	Cainozoic (Pleistocene Holocene) almost flat plains	Silver leaf stringybark woodland 1; manna gum, narrow-leaf peppermint, but but open forest 11	Yellow podzolic soils; soloths	Sub-humid 1	
		Mu	Murrindal (also contains elements of younger terraces and arable alluvial soils)	Cainozoic (Pleistocene, Holocene) alluvium, colluvium, terraces, channels, fans	Manna gum, yellow box open forest 11	Soloths; yellow podzolic soils; alluvial soils; chernozems	Sub-humid 1	
		Rl	Redgum I	Cainozoic (Tertiary, Pleistocene) sediments; undulating plains	Forest red gum open forest 11--woodland 11; swamp paperbark closed scrub	Solodic soils; yellow podzolic soils	Sub-humid 3	

Geomorphological province	Distinguishing characteristics	Map symbol	Land system	Geology	Native vegetation	Soils	Climate	Soil erosion hazard
Land on almost flat plains, of mainly Pleistocene age	Older terraces with strongly texture-contrast soils	R2	Redgum II	Cainozoic (Tertiary, Pleistocene) sediments; almost flat plains	Forest red gum, yellow box open forest 11--woodland 11; swamp paperbark closed scrub	Solodic soils; yellow podzolic soils	Sub-humid 3	Sheet erosion, some gullying, waterlogging; trampling of wet soil by stock reduces soil structure (deterioration commenced with settlement - uncommon and seldom serious)
		Va	Valencia	Cainozoic (Pleistocene) sediments; almost flat plains	Forest red gum open forest 11--woodland 11; closed rushland	Yellow podzolic soils; red podzolic soils; chernozems	Sub-humid 3	
		Bg	Briagolong	Cainozoic (late Pleistocene) sediments; relic levees, channels, outwash fans	Forest red gum open forest 11--woodland 11	Red podzolic soils; red earths	Sub-humid 3	
	Younger terraces, often arable soils	Fr	Freestone	Cainozoic (late Pleistocene) sediments; almost flat plains	Forest red gum open forest 11--woodland 11	Stony red podzolic soils; yellow earths	Sub-humid 3	
		Se	Sale	Cainozoic (late Pleistocene) clays; almost flat plains	Forest red gum open forest 11--woodland 11	Brown podzolic soils	Sub-humid 3	
Land on sand sheets and dunes of Pleistocene age	Both sandy and clayey materials present	Ts	Tyers	Cainozoic (Pleistocene, Holocene) sands; dunes, swampy flats	Coast banksia woodland 1; *Salicornia* herbfield; rushland; swamp paperbark closed scrub	Podzols; humus podzols; siliceous sands	Sub-humid 3, maritime	Wind erosion; puddling of clayey soils by stock reduces soil structure;
		Wo	Wollaston	Cainozoic (Pleistocene, Holocene) sands; dunes, swampy flats	Manna gum, saw banksia, coast banksia woodland 1; forest red gum woodland 1; *Salicornia* herbfield	Podzols; siliceous sands	Sub-humid 3, maritime	

Geomorphological province	Distinguishing characteristics	Map symbol	Land system	Geology	Native vegetation	Soils	Climate	Soil erosion hazard
Land on sand sheets and dunes of Pleistocene age	Materials mainly sandy	Br	Barrier	Cainozoic (Pleistocene) sands, dunes coastal barrier remnants	Silver leaf stringybark open forest 1; white stringybark open forest 11--woodland 11; manna gum, shining peppermint, saw banksia woodland 1; closed sedgeland	Podzols; undifferentiated sands	Sub-humid 3	Increased salinity of Gippsland Lakes reduces protective vegetation on margins with consequent wave erosion of exposed shores (Wind erosion is uncommon wave erosion is serious)
		Nt	Nuntin	Cainozoic (Pleistocene) sands, clays ancient levees, prior streams	Forest red gum open forest 11 - woodland 11	Wiesenbodens; siliceous sands; red earths; brown earths	Sub-humid 3	
		Py	Perry	Cainozoic (Pleistocene) sands; marine aeolian sand sheets, low dunes	White stringybark, forest red gum open forest 11--woodland 11; manna gum, saw banksia, shining peppermint woodland 1; silverleaf stringybark open forest 1; closed sedgeland; *Phragmites* grassland	Podzols; siliceous sands with clay underlays; humic gleys	Sub-humid 3	
		S2	Seacombe	Cainozoic (Pleistocene, Holocene) sands; sand sheets with lacustrine reworking	Shining peppermint, saw banksia, manna gum woodland 1	Podzols; silicepus sands; soloths	Sub-humid 3, maritime	
Land on active fluviatile soils	Adequately drained areas with arable soils	Da	Delta	Cainozoic (Holocene) sands, silts, humus; levees deltas, swamps	Forest red gum, Gippsland grey box open forest 11; swamp paperbark closed scrub; *Phragmites* grassland	Alluvial soils	Sub-humid 3 maritime	Increased salinity of Gippsland Lakes reduces protective vegetation on margins with consequent wave erosion of exposed shores (Delta land system);
		M1	Maffra 1	Cainozoic (Holocene) clays, silts, sands; flood plains with small channels, levees	Forest red gum, red box open forest 11	Minimal prairie soils; red earths; alluvial soils	Sub-humid 3	

Geomorphological province	Distinguishing characteristics	Map symbol	Land system	Geology	Native vegetation	Soils	Climate	Soil erosion hazard
Land on active fluviatile soils	Adequately drained areas with arable soils	M2	Maffra 2	Cainozoic (Holocene) clays; highest parts of flood plains	Forest red gum open forest 11--woodland 11	Minimal prairie soils	Sub-humid 3	waterlogging and salting; puddling of clayey soils by stock reduces soil structure
		Wt	Walnut	Cainozoic alluvium, colluvium; terraces, channels, fans	Yellow box, manna gum, narrow-leaf peppermint open forest 11; closed sedgeland	Alluvial soils; siliceous sands	Sub-humid 2	
	Poorly drained or inundated areas, non-arable soils	Ms	Morass	Cainozoic (Holocene) alluvium; swamps	Swamp gum, forest red gum open forest 11; swamp paperbark closed scrub; sedgeland; *Salicornia* herbfield; *Phragmites* grassland	Alluvial soils; siliceous sands; solodic soils	Sub-humid 3	(Deterioration in soil structure commenced with settlement - common and moderate to severe)
		Nk	Nambrok	Cainozoic (late Pleistocene) alluvium; low-lying poorly drained flood plains	Forest red gum open forest 11--woodland 11	Wiesenbodens	Sub-humid 3	
		Sy	Sandy	Cainozoic sandy alluvium; terrace	White stringybark, yertchuk, manna gum, but but woodland 1--11; swamp paperbark closed scrub	Siliceous sands; podzols	Sub-humid 3	
		Sd	Stratford	Cainozoic (Holocene) alluvial sands; terraces, braiding channels	Grassland	Alluvial soils	Sub-humid 3	
		Th	Thomson	Cainozoic (Holocene) clayey alluvium lowest terrace, channel levees, oxbows, swamps	Forest red gum, swamp gum, red box open forest 11--woodland 11; swamp paperbark closed scrub	Wiesenbodens; red earths; humic gleys	Sub-humid 3	

Geomorphological province	Distinguishing characteristics	Map symbol	Land system	Geology	Native vegetation	Soils	Climate	Soil erosion hazard
Land in active coastal situations	Marine frontages	B1	Booran 1	Cainozoic (Holocene) marine sands; modern dunes, beaches	Foredune vegetation; coast banksia woodland 1	Undifferentiated sands; calcareous sands	Sub-humid 3 maritime	Wind erosion; wave erosion of B2 system as for Da system above and normal coastal attrition (erosion is common and is moderate to severe)
	Lacustrine frontages	B2	Booran 2	Cainozoic (Holocene) lacustrine sands; modern dunes, beaches	Forest red gum, coast banksia woodland 1	Siliceous sands	Sub-humid 3	

PART III

LAND USE

HAZARDS

Over millions of years, the interactions between such factors as climate, topography, geology, and living organisms have established a dynamic equilibrium between water regimes, soils, vegetation, and fauna.

Since European settlement, however, alterations to the natural environment have taken place. Native vegetation and fauna have been removed or displaced by exotic pastures and introduced animals, soils have been cultivated, rivers dammed, and native forests managed for intensive timber production. The land has reacted in different ways according to its characteristics, and according to the type of use and management applied. Some land types are particularly sensitive to the changes being wrought on them; others are less so.

Anything that reduces the land's ability to sustain production of commodities required by the community at satisfactory levels of quantity and quality (and that may also threaten the productivity of adjacent land) is regarded as a hazard. Hazards associated with the management of land in the area are discussed below.

Physical Hazards

Soil Erosion

Soil deterioration is a cost to the community, not only in terms of the direct costs involved in the control of soil erosion and later rehabilitation, but also in the reduction of productivity of the land, deterioration of water quality, loss of capacity of water storages, and the degradation of aesthetic values, quality of recreation, wildlife habitat, and other benefits that the land provides.

Soil conservation and water production - two basic aims of land management - may be adversely affected by land uses that cause soil disturbance and alteration of vegetative cover.

Vegetation and its litter enhance the development of a permeable soil surface and provide a barrier to overland flow, thus allowing more time for infiltration. Most water absorbed by the soil moves slowly through it to streams, promoting sustained stream flows, reducing the likelihood of damaging peak flows, and reducing the transport of particulate matter which causes turbidity and increases the sedimentation of watercourses and reservoirs.

Vegetation and litter also protect the lighter soils (such as the dynamic coastal dunes and the sand sheets on the coastal plain) from both wind and water erosion. A well-vegetated catchment provides the best conditions for soil conservation, sustained yield of high-quality water, and flood mitigation. The removal of native vegetation from the catchments of streams permits an increase in the overland flow of water. In turn, this increases the risk of down-stream flash floods and the incidence of winter and spring flooding. It may also increase the level of turbidity of the streams and the rate of sedimentation of reservoirs. Sheet and gully erosion are common hazards associated with water movement, the risk increasing rapidly with slope. In the study area, however, the incidence is low and seldom serious.

A statement of erosion hazard is an evaluation both of the probability that erosion will occur and of its likely severity. The degree of tolerance to various kinds and intensities of use has a great influence on the type of use to which land may be put.

The following section outlines the erosion hazard in each of the five major geomorphic units identified and described in Chapter 5.

Dissected highland

The steep hills that make up this unit occupy the largest area of public land in the study area. In general, soil erosion is not serious: the greatest problem occurs on the more exposed aspects, where recovery of the vegetation after clearing or fire is relatively slow. In contrast, rapid recovery of vegetation in the more humid forests keeps erosion to a minimum. The single most serious form is erosion that affects forest tracks.

A problem associated with the rapid revegetation of large areas by leguminous species, however, is the increase in nutrient transfer (particularly in nitrogen compounds) to water bodies. The nutrient status of the Gippsland Lakes has increased in this way as a result of revegetation by acacias of former farmland in the Strzelecki Ranges.

Plateaux remnants

Erosion of the small plateau remnants is uncommon because of the rapid recovery of vegetation.

Intermontane basins

Slight or moderate sheet erosion is relatively common and usually occurs following the removal of vegetation. Heavy

The erosion of forest tracks - such as this one north of Heyfield - is often the single most serious form of soil erosion

rainfalls tend to seal the surface of these soils, thereby reducing infiltration of water and aggravating the drought effects of subsequent dry weather.

The removal of local base-level structures, such as the destruction of rock bars, could cause serious erosion of this unit's colluvial and alluvial soils.

Piedmont Downs

Slight to moderately severe sheet and gully erosion are common in the majority of soils of this geomorphic unit. Tunnel erosion is occasionally evident, and the erosion of tracks can also be a problem.

In the sandy soils (such as in the Stockdale land system), however, erosion is uncommon and seldom serious. Susceptibility is greatest if heavy rains follow cultivation. Water infiltrates readily into these lighter soils, and both the loss of mechanical support and the reduction of transpiration following removal of trees increase the risk of landslips on the steeper slopes. This applies particularly when a clay substratum is present.

Near Glenmaggie, moderate gully erosion has occurred on volcanic soils;

An eroding bank on the Mitchell River silt jetties

elsewhere, the rapid recovery of vegetation on these soils has reduced the incidence of erosion. Puddling of the soil by stock destroys its structure and increases surface water run-off.

Alluvial and coastal plains

Erosion of the Pleistocene land surface of the plains commenced with settlement, is seldom serious, and is now relatively uncommon. More seriously, the gradual increase in the concentration of salt in these areas may eventually cause further reduction in tree cover and cause degradation of crop and grazing lands. The clay soils here are also susceptible to waterlogging, and to puddling by stock, with the consequent destruction of soil structure and increased run-off.

Wind erosion of the inland sand sheets and dunes is uncommon, but has serious potential once initiated. Wind and wave erosion of the coastal sands is a feature of the dynamic coastal dunes.

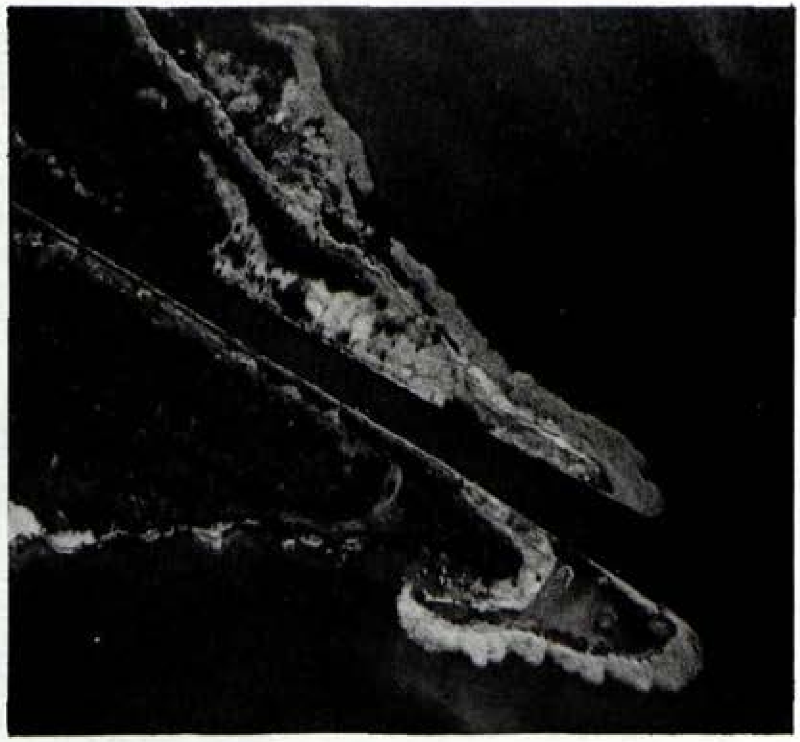
Perhaps the most obvious form of erosion is that effecting the banks of the lower and middle reaches of the major rivers, the Gippsland Lakes, and Lake Glenmaggie. While all forms of erosion, including bank erosion, are natural phenomena, the period since European settlement has seen an enormous increase in its rate and extent.

During this period, stream-bank erosion has increased as a result of Man's activities. This has been particularly apparent in the Lake Wellington catchment, where it has been estimated that, adjacent to the Avon River alone, more than 1,250 ha of rich alluvial flats have been lost by erosion. Factors that have significantly affected stability of the stream banks include the defoliation of river banks (largely as a result of grazing), increased run-off from agricultural and urban areas, the policy of widening and straightening rivers to cope with this run-off, and the removal of natural barriers such as logs and rock reefs from the river bed.

The increase in stream-bank erosion has accelerated the deposition of silt into the Gippsland Lakes, which in turn is detrimental to aquatic life in a number of ways: through reduced rates of growth, by prevention of successful development of eggs and larvae, by modification of natural movements and migration of organisms, or by the reduction of available food.

Following the cutting of an artifical opening in the outer barrier at Lakes Entrance, increased salinity in the lakes led to the destruction of the protective reed-swamp *(Phragmites)* vegetation along lake margins. As a result, wave action has caused erosion over almost three-quarters of the 320-km shoreline of Lakes Wellington, Victoria, and King. Erosion is most serious in the last two, where salinity levels are highest.

Erosion is consuming the sedimentary deltas or 'silt jetties' formed by the Mitchell and Tambo Rivers. These formerly had reed fringes and were apparently built up by river silt that the reed-swamp trapped at the mouths of the



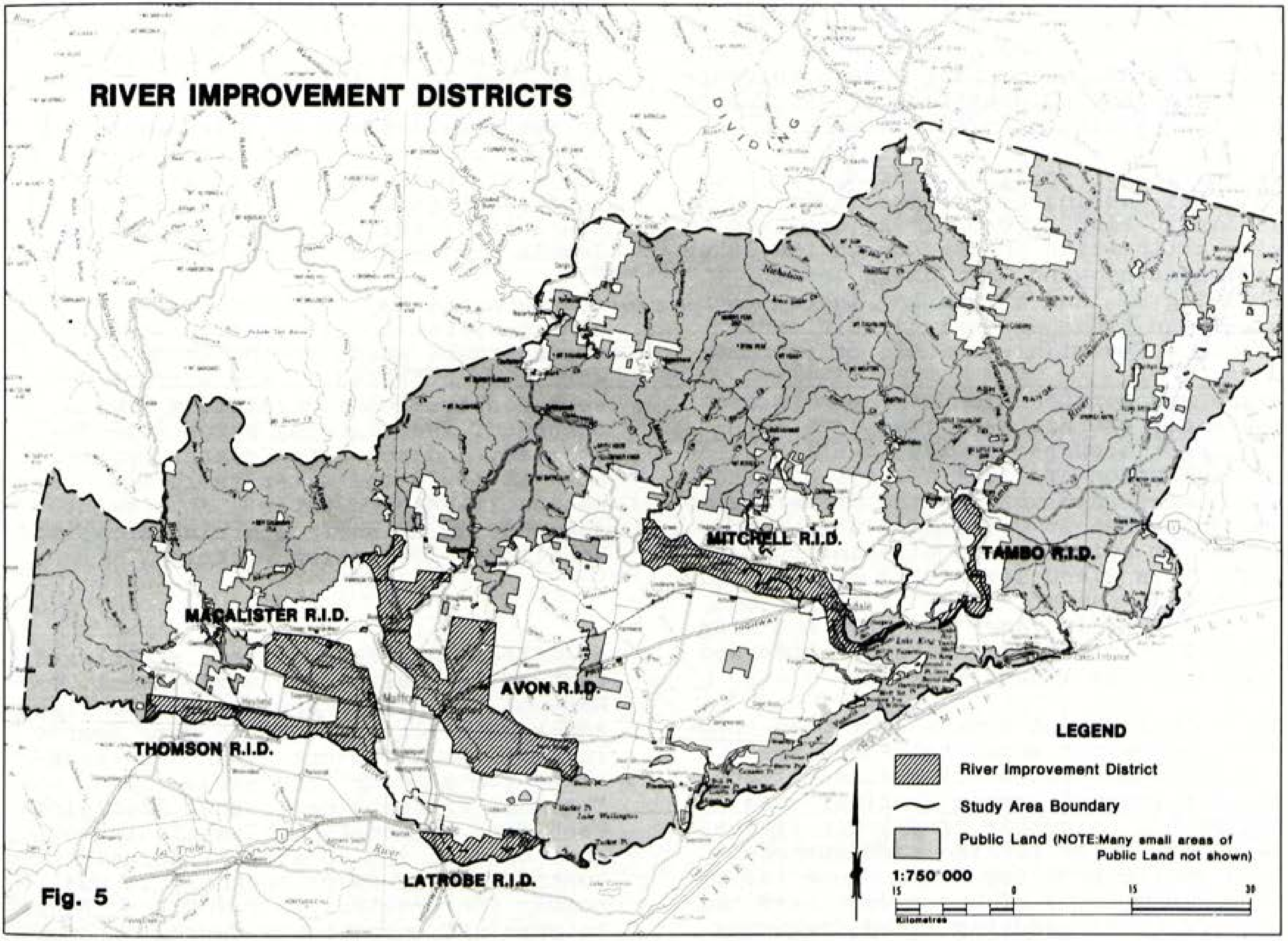
Fringing reed-swamp helps the Latrobe River delta expand into Lake Wellington rivers. Similar deltas are still being formed in Lake Wellington by the Latrobe and Avon Rivers, where a reed-swamp fringe still remains. In comparison, the internationally famous Mitchell River silt jetty is being broken up into chains of islands as waves attack its unprotected shore.

Floods

All the major rivers that flow through the study area are subject to flooding. In the opper reaches of streams, peak flows are confined to well-defined drainage lines. The lower reaches, however, are characterized by extensive flood plains that merge with the wetlands surrounding the Gippsland Lakes.

Flooding of sufficient magnitude to cause some inconvenience to landholders immediately adjacent to streams occurs quite often - on average once or twice a year. (There are periods of several years without floods, and other years with up to seven.) Generally only minor flood damage results. During major

Flooding of the major rivers can result in the inundation of large areas of valuable farm land



RIVER IMPROVEMENT DISTRICTS
MITCHELL R.I.D.
TAMBO R.I.D.
MACALISTER R.I.D.
AVON R.I.D.
THOMSON R.I.D.
LATROBE R.I.D.
LEGEND
River Improvement District
Study Area Boundary
Public Land (NOTE:Many small areas of Public Land not shown)
1:750 000
Kilometres
Fig. 5

floods, however, such as those experienced in January 1971 and June 1978, vast areas of flood plain are inundated, resulting in substantial damage to property and causing considerable disruption and inconvenience to the community.

Major floods result from prolonged high rainfall causing peak flows in catchment streams. High stream-flows, combined with a tide-like phenomenon in the lakes generated by wind, can cause local flooding of land around the lakes. Normal ocean tides are only significant within a few kilometres of the entrance.

Since the construction of the permanent entrance, the highest flood levels in the lakes occurred in 1893 and 1952. In consideration of local effects of wind, tides, and wave action, the State Rivers and Water Supply Commission uses guidlines for building and planning purposes based on a flood level of 3.0 m Australian Height Datum in Lake Wellinton and 2.0 m A.H.D. in Lakes Victoria and King (approximately 0.5 m above the recorded levels of the 1952 floods.

River Improvement Trusts have been formed to carry out works to reduce the frequency and extent of nuisance flooding for several stream sections (see Figure 5). A number of private levees have been built for the same purpose. Dams constructed for water conservation purposes on some of the rivers have had the effect of reducing flood frequency and extent, but, like the river improvement works and low levees, have only a limited effect on the larger floods.

Salting

In the Macalister Irrigation District, the use of irrigation caused a rise in the local water tables and brought salt to the surface. By 1959, toxic concentrations of salt and high groundwater levels had damaged large areas of crops.

Although the major problem arose in the Central Gippsland Irrigation Area to the south, small areas in the study area were also affected. Deep surface drains were constructed and existing drains deepened, free-flowing bores were installed, and some groundwater pumps were used to lower the water table and to remove salt-bearing water. At present some 500 km of surface drains serve the Macalister Irrigation District.

Fire

Wildfires have been and are an integral part of the Australian environment. Many of the plants are adapted to fire, and vegetation patterns to some degree reflect its influence. Man has recognized its effects from early times. There is clear evidence that Aborigines used fire to modify habitat to favour game species and to attract animals into hunting areas. More recently it was common for graziers to set forest fires to burn off unpalatable forage and to promote the growth of succulent shoots.

Both the frequency and the severity of wildfire deserve careful attention when considering land use and associated issues, because human life and property, and natural resources, are involved. Risk of fire damage depends on a combination of the likelihood of fires starting, the behaviour of the fire, and the location and extent of fire suppression resources. Each of these factors can be affected by human activities.

In the study area, records for fires involving Forests Commission forces indicate that most fires are caused by human agency and these account for the bulk of the area burnt (see Table 12). Between 1970/71 and 1979/80, at least half the

Table 12

SUMMARY OF FIRE ORIGIN AND AREA BURNT - 1970/71 to 1979/80

Year	Lightning		Deliberate		Escapes from fires on private property		Tourists/ campers		Industrial		Miscellaneous		Unknown		Totals	
	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)
1970/71	9	20	4	285	-	-	1	4	4	-	-	-	-	-	18	309
1971/72	13	10	10	400	7	1,200	1	3	1	6	1	-	1	1	34	1,620
1972/73	13	6,000	9	7,500	7	38	8	175	5	30	7	870	-	-	49	14,613
1973/74	4	2	1	40	1	6	1	4	1	-	-	-	-	-	8	52
1974/75	12	13	2	1	3	-	-	-	2	-	3	-	-	-	22	14
1975/76	-	-	-	-	3	90	1	-	2	-	-	-	-	-	6	90
1976/77	3	1	4	120	1	-	1	-	2	-	-	-	1	-	12	121
1977/78	13	45	7	574	11	6,050	3	10	3	-	6	10,105*	5	520	48	17,304
1978/79	10	92	-	-	-	-	2	-	1	-	4	30	5	20	22	142
1979/80	17	223	9	175	10	115	6	16	3	-	5	11	9	174	59	714
Totals	94	6,406	46	9,095	42	7,499	24	212	24	36	27	11,016	21	715	278	34,979
Percentages	34	18.3	16.5	26.0	15	21.4	8.5	0.6	8.5	0.1	10	31.5	7.5	2.0	100.0	100.0

* Note: Includes 10,000-ha fire starting from motoring accident on Princes Highway.

Mopping-up operations after a fire

outbreaks and more than 77% of the area burnt involved fires that stemmed from human activity. Deliberately lit and escaped fires on private property alone accounted for about 47% of the area burnt. Lightning-caused fires, which constitute 34% of the total occur mainly on ridges and exposed slopes in remote areas during dry thunderstorms in summer.

South-eastern Australia is one of the most fire-hazardous zones on the continent, and indeed in the world. Since 1956, major fires have occurred within the study area at an average interval of about 5 years, the largest one devastating about 304,000 ha of forest and rural land between Glenmaggie and Bruthen in 1965. Losses to forest values, stock, and property were high.

Fuel type, topography, and the characteristic weather combine to give the study area the potential for serious conflagrations.

Dry foothill forests form a broad belt to the north of private property - which occupies most of the coastal plain. The forests are predominantly stringybark--gum with shrubby understoreys in which the readily flammable fuels build up rapidly. Furthermore, the characteristic fibrous bark of the stringybark eucalypts provides a link between ground and crown fuel, and slivers can act as firebrands to accelerate the spread by starting numerous spot fires ahead of the main front.

The steep and broken topography of the foothills also assists the spread of fire, which burns rapidly up steep slopes. Moreover, the slow and difficult access in such terrain handicaps suppression efforts.

In mountain forests (wet schlerophyll types) the accumulation of litter can become quite high, but the risk of fire is low because the litter rarely becomes dry enough to carry fire readily. During prolonged droughts, however, high-intesity fires can sweep through these fire-sensitive forests, causing extensive damage.

The coastal forests have a high fire risk because of the eucalypt bark types and shrubby understoreys. Fuel builds up swiftly, and strong winds in spring and summer desiccate dead and living vegetation alike, to create extended periods of high fire danger.

Most of the study area is in a zone of relatively low rainfall. In years of particularly low rainfall, the annual summer drought is extended and the fire danger increases, with conditions of low relative humidity, high temperatures, and strong winds. Prevailing winds in the foothills during summer blow from the south-east. Wind direction may vary locally, however, because of topography. This makes prediction of fire behaviour more difficult and therefore complicates suppression efforts.

Fire damage on forest land

Both timber and environmental values are at risk from wildfire.

The major threat that wildfire poses to timber production on forest land in this area is to the more highly productive eucalypt stands and to the privately owned softwood plantations at Stockdale. Damage to timber resources can be considerable. Softwood plantations and mountain ash forests are fire sensitive, and severe wildfire kills many trees outright. If the trees have reached merchantable size, however, some timber can be recovered by prompt salvage operations.

Mixed-species forests are more resistant to fire, and mature trees are rarely killed. The main losses to production in these forests arise through retarded growth rates for some years following severe defoliation and through timber degrade. Unsightly gum veins and scars in timber may be directly attributed to fire damage. However, damaged trees are also susceptible to insect and fungal attack, which cause such timber degrade as termite and ant galleries, and pockets of rot. Also, high-intensity fires can cause severe damage to young regenerating forests, leading to a serious loss of productivity in the long term.

Watershed values may be impaired following severe fire. Until the vegetation recovers, the soil may be subject to erosion - particularly in steep country and when heavy rains follow soon after a fire.

Wildlife values may also suffer. Populations of many animals are depleted in severe and widespread fires and their recovery will vary according to habitat requirements of the species. Generally, effects are less severe where fire results in a mosaic of burnt areas and untouched or lightly burnt ones. This

The aftermath of a wild fire that, in November 1980, burnt a large area of forest west of Nowa Nowa

is likely to be the case for much of the study area because of the intermixing of dry north and west slopes with moister south and east slopes.

Control of fire

The Forests Commission has sole responsibility throughout the State for the suppression of fires in State forest, national parks, and protected public land and, unless specifically excluded, this fire-suppression authority extends to private property within 1.5 km of these areas. Fire prevention works on State forests are the sole responsibility of the Commission, but in national parks and other reserves such works are undertaken with the agreement of the land manager concerned.

In fire situations where the Commission is the responsible body, other fire-fighting resources are used under its direction.

In all cases, organizations equipped to fight fires are party to mutual support arrangements to ensure that substantial numbers of men and equipment are quickly available for fire suppression.

Speed of attack is critical, and therefore early detection is essential. Nine fire towers within the study area and four just outside it provide the basic detection system. Support is given by aircraft patrols after periods of thunderstorm activity in summer. A number of depots within and adjacent to the study area provide bases for the despatch of crews and equipment, which gain access to fires by a network of roads and helipads. This access system is regularly maintained.

Fire-prevention works include provision of access and the use of low-intensity fires to reduce fuel quantities. If left undisturbed, forest fuels will accumulate to levels that can result in a fire - if burning under moderate to severe weather conditions - becoming uncontrollable. Reduction of fuel quantities by controlled burning is practised to assist in the control of wildfires and reduce their severity, thereby aiding the protection of valuable assets.

Where possible, broad-area burning is done to counter the spotting behaviour of major fires. Areas of strategic importance for the protection of settlements and private property, forest assets, and districts where recreation populations are high, receive particular attention.

In the Gippsland Lakes hinterland, strategic areas include the valleys of the Tambo and Mitchell Rivers and the southern margins of the foothill forests. Within these, the variation in fire behaviour and the constraints of minimizing scorch effects result in a high proportion of the country - usually gullies and southerly slopes - remaining unburnt.

Biological Hazards

During the last 100 years, Acts of Parliament have been passed in Victoria in the attempt to control pest plants and animals.

The *Vermin and Noxious Weeds Act* 1958, which consolidated earlier legislation, is administered by the Vermin and Noxious Weeds Destruction Board, and proclaims various pest animals, birds, and plants as vermin or noxious weeds.

The majority of pest species are introduced. Animal pests were brought into the country by the then 'Acclimatization Society of Victoria', hunt clubs, or private individuals. Many of the plants were deliberately introduced as garden or hedge species; others came as contaminants of grain, fodder, or other agricultural produce. Being virtually free of the natural enemies that kept them in control in the country of origin, they established extremely well in the new environment.

Animal Pests

Within the Gippsland Lakes hinterland, the main introduced animals declared as vermin are European rabbit, red fox, wild dogs, and European starling and sparrow.

Found in virtually every settled area of the State, the sparrow and starling are aggressive and successful competitors with native birds for feeding and nesting. They can also cause damage to crops and carry disease to poultry farms. At present, no official regulatory action has been taken on either public or private land.

Predators (foxes, feral cats, and wild dogs) are widespread throughout the area. They are opportunist feeders - eating the most abundant form of food available at the time. Wild dogs are prevalent throughout the timbered mountainous country and have had a major impact on native fauna, as wallabies and wombats form a regular part of their diet. Trapping controls have kept their numbers down and they are causing little harm to stock in most agricultural areas. However, serious stock losses can occur at times, especially on farmland adjoining forested public land.

Foxes and cats prey on the smaller native birds and animals. Foxes can contract well-known bacterial and viral diseases, such as rabies (not currently present in Australia) and distemper, that affects dogs, humans, and possibly native animals. Control measures include 1080 poisoning (sodium monofluoroacetate) and shooting. The fox provides recreational value as a game animal and the winter pelt realizes high prices in the fur trade.

The European rabbit is by far the greatest single animal hazard to the Australian environment and to primary industry. Within the study area, rabbits are found mainly on cleared freehold land and for a distance of about 1 km into adjoining forests. The rapid breeding rate, coupled with the destructive grazing habit of the rabbit, has caused serious depletion in native vegetation and crops - with consequent erosion problems - throughout the State in the past; it is only the control programmes that are preventing a return to this situation.

The introduction of biological control - in the form of myxomatosis - in 1950 was a major breakthrough in rabbit control, which is still in use. This form of control, the fumigation and ripping of warrens, and the use of 1080 poison in carrot bait are cheap and effective and as a consequence the rabbit problem is at present not serious.

Carp (*Cyprinus carpio*) - a troublesome introduced fish species - are widely distributed throughout the study area.

Research conducted in other countries suggests that carp may significantly affect the aquatic environment at densities greater than 200 kg per ha, by uprooting aquatic vegetation, reducing numbers of benthic animals, and increasing turbidity by stirring sediments while feeding.

Carp probably exceeded those densities during the late 1960s and early 1970s, when they were increasing in numbers and expanding their range. It is doubtful that such densities presently exist in the study area, although they could fluctuate widely from year to year. Densities should be monitored and, as numbers rise to critical levels, steps should be taken to remove the carp, primarily through commercial exploitation.

Native animals in the area that have been classified as vermin include dingoes and wombats. The problems and control measures associated with the dingo are the same as those for the wild dog.

Wombats become a pest to some landholders by damaging wire-netting fences; they can also be a road hazard. In 1970 the bounty on wombat scalps was removed; the current policy followed by officers of the Vermin and Noxious Weeds Destruction Board is to catch or destroy the offending animal following complaints by a landholder.

A number of other native animals and birds have caused localized problems in the area, and in some cases the Fisheries and Wildlife Division has issued permits for the control of a specific population.

Eastern grey kangaroos are widespread through the area, sheltering in forested areas during the day and grazing on adjacent crops or pastures in the mornings and evenings. They cause physical damage to fences and crops as well as reduced productivity of farmland, particularly in the cooler months when pasture production is slow. Black-tailed wallabies and red-necked wallabies also damage fences, but the main problem arises when they browse young eucalypts or pine plantations.

Brush-tailed possums become a nuisance in urban areas, where they may damage gardens and nest in ceilings and wall cavities of houses. Occasionally they cause damage to plantations or orchards. Fruit bats have also caused orchard damage on rare occasions. On one occasion, in 1969, a permit was issued to control water rats that were eating fishing gear at Paynesville.

Native birds that have occasionally been a nuisance in the area are listed below.

Emus cause physical damage to fences and crops.

Black swans graze and foul pastures near large expanses of water, sometimes eating crops.

Coot and eastern swamp hen cause similar problems to the black swan, particularly in the Lindenow area.

Cormorants allegedly compete with sport fishermen for fish. They may cause a rise in the *Escherischia coli* level of domestic water storages if sufficient numbers roost there.

Sulphur-crested cockatoos damage grain crops.

Crimson rosella and king parrot sporadically damage grain crops and orchards. In the case of the latter, flocks of juvenile birds have been the cause.

Pied currawong damages orchards.

Weeds

A State-wide survey of proclaimed noxious weeds in 1970 indicated that 51 of Victoria's 93 species of noxious weeds were growing in the study area (see Appendix 7). Some are widespread throughout the area, others are more restricted in extent. Their importance is governed by the manner in which they affect the environment, the degree of infestation, and their ability to propagate and spread.

The blackberry (*Rubus* spp.) causes the most concern. It is widespread, infesting the banks of streams and encroaching onto tracks and clearings. On occasion, it may stabilize disturbed stream banks; but the brambles restrict access to streams for fishermen, bushwalkers, and campers, reduce the capability of land for grazing, and harbour rabbits.

Blackberry seed spreads in the droppings of birds and foxes that eat the ripe fruit. The plants reproduce readily, and the prickly canes discourage animals from eating the plant or from damaging it by trampling.

Blackberry can be suppressed by the application of certain herbicide sprays. However, direct spraying methods are not fully effective, are expensive to apply and require care in the handling and storage of chemicals. Restricted access makes spraying impossible over large

A small stream choked by blackberries

areas of mountainous country, and in the vegetable-growing areas the use of hormone weedicides would endanger the productivity of crops. There is also increasing public concern about the commonly used spray 2,4,5-T.

Efforts to find a mechanism for biological control of blackberry started in 1977. Two organisms, a stem borer and a rust, showed potential. However, subsequent specificity tests to ensure that these organisms would not harm any crops or native plants showed the stem borer to be unsuitable. Tests on the rust are to be completed in 1982.

St. John's wort (*Hypericum perforatum*) creates a considerable problem in the study area as, to a lesser extent, do great mullein (*Verbascum thapsus*) and horehound (*Marrubium vulgare*). Various species of thistle that are declared noxious weeds have importance on both public and private land and could spread rapidly, particularly on cleared and cultivated land, if controls were relaxed. Boneseed (*Chrysanthemoides monilifera*), which is scattered throughout the area, has serious potential and is closely monitored.

Destructive Insects

Leaf-eating insects have caused no serious defoliation in the foothill forests in recent years. In predominantly agricultural areas, however, the remaining eucalypts, such as forest red gum, have suffered severe dieback. The primary cause is probably extensive and periodic defoliation by various insects, including Scarabaeidae (Christmas beetles), Chrysomelidae (leaf beetles), Psyllidae (lerps), and various species of moth, such as the gum-leaf skeletonizer moth (*Uraba legens*) and the mottled cup moth (*Doratifera vulnerans*).

Wood-boring insects that attack eucalypts include the horizontal borer (*Austroplatypus incompertus*). This indigenous ambrosia beetle breeds in all eucalypts local to the study area except gums, red ironbark, and Gippsland grey box. It can cause substantial degrade by constructing extensive small-diameter galleries in the heartwood. The associated ambrosia fungi cause further degrade by staining the wood along the gallery walls.

In radiata pine plantations and shelter belts, the wood-boring Sirex wood wasp (*Sirex noctilio*) has been found, but population levels of the pest are low at present. The best control techniques are to maintain stands in a healthy condition by early felling of susceptible low-vigour and damaged trees, and to introduce nematodes and wasps. The former sterilize female Sirex adults, while the latter kill the larvae.

Fungal Disease

The cinnamon fungus (*Phytophthora cinnamomi*) is found in both agricultural and forest soils within the study area. It is widely distributed in farmland, where it causes disease to some horitcultural crops. Evidence suggests that the fungus has been carried into forest areas via soil adhering to vehicles used in agricultural areas.

It is widely scattered between Mount Taylor and Lake Tyers, as indicated by patches of dead and dying trees. It also occurs in the lower foothill forests west of the Mitchell River and has been isolated from soil samples taken beside a few diseased trees along the Nowa Nowa--Gillingall Road.

The fungus attacks trees and shrubs by producing rot in small (and sometimes larger) roots. Also, recent evidence suggests that the stem may be girdled by the fungus following damage to surface roots by heavy machinery.

Symptoms of the disease resemble those produced by drought - the affected eucalypts shed some of their foliage and the crowns die back; in severe cases, the tree may be killed. Understorey shrubs show varying symptoms but the more-susceptible plants may die suddenly.

Heavy summer rain, particularly in poorly drained areas, increases the incidence and severity of the disease.

The potential for injury by the fungus is related principally to soil type and drainage, climate, and plant species. High levels of soil moisture assist the development of the disease. Recent research shows that soils must be saturated for infection to occur. Such conditions are likely after heavy rain, in areas receiving additional drainage water, or on poorly drained sites. The fungus is also favoured by soil temperatures between 15°C and 30°C, with an optimum of about 26°C. Thus the risk of disease is greatest in warm climates or during prolonged periods of warm weather (especially when combined with high rainfall). Soil temperatures greater than 30°C, however, are injurious to it.

Soil organic matter harbours numerous fungal and bacterial micro-organisms that are antagonistic to *P. cinnamomi*. These organisms reduce the amount of fungus present and its level of activity, The hazard will therefore tend to be lower in soils rich in organic matter and higher in infertile sites.

Soils carrying the highest risk are thus those that are both poorly drained and infertile. The profile is usually a sandy silt overlying an impervious clay at about 50 cm depth and the topography is flat. Moderate-risk soils have a similar profile, but in undulating topography the impeding layer lies at about 50 cm, whereas for soils on flat land it lies between 50 cm and 150 cm.

Deep, moderately fertile, and well-drained soils on undulating topography have a low rating; while mountain forest

An area of forest devastated by a combination of Phytophthera cinnamomi *and fire*

All forestry vehicles have soil washed from them before leaving Phytophthera *- infested areas*

soils, which are characteristically deep, well-drained, and rich in organic matter, have very low risk.

Apart from environmental conditions, the incidence and severity of attack by cinnamon fungus is also related to the vegetation type, as plant species vary in their susceptibility to the disease.

Mountain ash and alpine ash are moderately sensitive to the fungus, but grow naturally in mountain areas where the cool climate and well-drained soils do not favour it. Other species, such as red gum and Gippsland grey box, may grow in areas with a higher hazard but are tolerant of the disease.

Of the eucalypt species typical of coastal and foothill forests, silvertop ash is the most sensitive. Messmate, brown stringybark, yertchuk, and white stringybark are susceptible, but appear capable of tolerating some degree of infection.

Research is continuing on methods of combating the fungus. One preventative measure applied in the study area is the application of quarantine regulations to ensure that heavy machinery used in infected coastal areas is thoroughly cleaned before entering mountain areas. Other practices such as modification of harvesting and regeneration operations may be used if research shows that these are effective and practicable.

Water-quality Problems

Water may be polluted from a number of sources - such as run-off from unsewered urban areas, discharges from industry or sewage plants, effluent releases from pleasure craft, drainage from agricultural land, and erosion caused by poor land management.

As outlined in chapter 7, the most polluted streams in the study area are the Latrobe and Macalister Rivers. The former drains the heavily industrialized Latrobe Valley; the latter drains the Macalister Irrigation District.

Developments being planned for the Latrobe Valley could only lead to further reduction in the quality of water in the Latrobe River. Policies to increase agricultural production could also adversely affect water quality in most of the study area's streams.

Increased utilization of the area's surface water resources, as described in chapter 7, will necessarily reduce stream flow, thus contributing to the increasing water-pollution problem. The effects on rivers of such reductions in flow include less flushing, higher biological oxygen demand, fluctuating dissolved oxygen, increased temperature range, increased pollutant concentrations, and ecological instability caused by the loss of sensitive species.

Increased irrigation may lead to greater nutrient and salinity concentrations, affecting flora and some fish. Building dams for irrigation and other purposes will increase total suspended solids and nutrient levels during construction.

The expected decrease in water quality from the catchment streams will obviously affect the lakes, as the receiving water bodies. The impact will be most significant on Lake Wellington, which will suffer the greatest reduction in fresh water inflow.

Three major problems arise from a decreased or altered pattern of flow to Lake Wellington:

* the risk of an increased salinity range - leading to a less diverse and less stable ecosystem

* insufficient inundation of the wetlands - resulting in a decrease in biota, particularly birds

* increased concentrations of nutrients, suspended solids, and other pollutants

Given current and projected inputs, Lake Victoria and Lake King are certain to remain as brackish--marine systems. Lake Wellington, on the other hand, will tend to an unstable brackish condition with wide seasonal variations. Such an environment is stressful to aquatic life and supports populations of only low diversity.

There is also a danger that the risks of flow diversion would be accentuated due to natural variations in flow, both year-to-year and seasonal. Although diversions may amount to a small percentage of average annual flow, they form a disproportionately large percentage of summer--autumn flow.

While the proposed Mitchell River dam at Tabberabbera will change the nature of one of Victoria s last undammed rivers, it will also assist in regulating the seasonality and volume of the major fresh-water input to Jones Bay and northern Lake King. Any diversions of Mitchell River water to cater for the needs of the Latrobe Valley, however, would have important implications for salinity levels and for the biota of the Jones Bay--northern Lake King arm of the lakes system.

The importance of wetlands as sinks for nutrients and suspended solids is well known. If lack of inundation were to result in permanent loss of portions of its surrounding swamps, nutrient and suspended solid loads in Lake Wellington would undoubtedly increase.

It has been claimed that developments in the Latrobe Valley will lead to the eutrophication of Lake Wellington. Such an outcome is far from certain, however.

Perhaps the most realistic scenario for the immediate future is a general increase in inputs to the lakes of total suspended solids and nutrients, and a slow increase in salinity levels through fresh-water diversion.

Since these developments have the conflicting effects of increasing tubidity and nutrients and at the same time increasing sedimentation rates, any attempt to predict the likely net change in trophic status is currently impossible.

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CONSERVATION

Conservation is concerned with man's relation to his environment. The need for conservation of economic resources is obvious, because society uses these for many of the material comforts 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 - protection of native species, natural features, and landscapes - and the preservation of archeological and historical features. In recent years, society has placed a greater emphasis on the need to protect these attributes. Such protection is important for many land uses, including reference, conservation of species, recreation, and education. None of these uses necessarily monopolizes the land; often conservation uses are compatible with each other or with commercially productive uses.

Use of Conservation Areas

Reference

The solution to problems in land use, such as soil instability or falling productivity, is often helped by reference to an undisturbed example of that land type. Here the soils, vegetation, and fauna, and the proceesses linking them, can be studied under natural conditions.

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

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

Although all land types should be represented in reference areas, the need is most urgent in those that have already been extensively developed for various other uses. Few, if any, areas suitable for reference remain for some land types in the study area. For instance, the forest red gum woodlands that were formerly widespread over the Gippsland plains west of Bairnsdale have almost disappeared. Conscious effort must be made to retain reference areas in suitable remnants to represent each land type.

Conservation of species

Each species of plant and animal is a unique assortment of biological characteristics, evolved over millions of years which makes a contribution to the richness and diversity of the environment. Each is part of man's natural heritage, potentially offering an enrichment of our knowledge; as such, many people feel a moral responsibility to ensure that none should knowingly be lost or endangered.

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

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

Threatened species and those endemic to the study area must receive high priority for preservation. Appendix 1 lists significant plant species in the study area. The status of the vertebrate animals recorded in the study area is noted in Appendices 2-6.

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

The range of different ecosystems in a region is often reflected in the vegetation. Plants express the various conditions of soil and climate, and they determine the types of food and shelter available for animals. Conservation of a representative area of each distinct vegetation formation therefore ensures the protection of most of the different ecosystems and most of the individual species.

Special natural values

Particular areas of land are often needed to preserve such natural values as distinctive geological features. Many of these have great scientific interest while others are valuable for education.

The more accessible and spectacular features also attract tourists; but, unlike historical or archeological sites, these geological features are not protected by any specific legislation in Victoria. It is therefore important that they be satisfactorily preserved in suitable reserves.

The Register established under the *Historic Buildings Act* 1974 does not include buildings or structures on Crown land or on land vested in any Minister. The National Trust of Australia (Victoria), however, records or classifies all buildings, landscapes, areas, objects, and sites that its expert groups consider worthy of preservation.

The study area also contains a number of Aboriginal relics, mainly around the lakes. Since many of these are culturally and scientifically important, some of the more significant sites on public land may need special protection.

Recreation

Most Australians live in the artificial environment of large cities and towns, and many find that their lives are enriched by contact with the natural world. The need for natural surroundings for certain forms of outdoor recreation is discussed in Chapter 14. Bird-watching, nature study, hunting, and bushwalking all require conservation of the native plants and animals; picnicking and pleasure driving simply re-

Anticline cave

quire a background of trees or shrubs in the recreation areas. These requirements can be filled in the study area.

Few parts of the study area are very far from the obvious hand of man. Taken alone, therefore, the Gippsland Lakes hinterland has little scope for true wilderness recreation. Some of its more isolated sections, however, adjoin large expanses of similarly remote public land in neighbouring study areas. In conjunction, these blocks of public land do exhibit many of the characteristics of wilderness. Smaller, more accessible

Picnic facilities behind the primary dune at Lake Bunga

areas are also valuable in providing some degree of solitude and contact with nature, and in reducing the pressures on places better suited for conservation of particular natural features or species.

Culture

The preservation of the profound beauty and regional diversity of the natural landscape should supplement our concern for the preservation and display of man's own finest creations - art, music, building, and writing. Thus we must preserve characteristic Australian scenery and wildlife, particularly as our economic system necessarily encourages the use of exotic plants and animals, often as monocultures.

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 natural land forms and observe, interpret, collect, and monitor biological 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.

Viability

Each natural community has evolved within its particular environment, with all the species forming a stable but slowly changing system. Undisturbed, the community represents the best combination and relative abundance of the plant and animal species that can continue to live and compete with each other in the prevailing soil, topographic, hydrological, and climatic conditions.

Different natural systems have different degrees of stability. In some of the most vulnerable, stability depends on some particular facet, such as specialized vegetation; others may have inherent topographic, soil, or hydrological weaknesses.

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

Large reserves have less perimeter relative to their area and so tend to be better buffered against intrusive factors. Generally, the conservation of birds and mammals will require areas larger than those required for the maintenance of plants, insects, or amphibians. Communities that exist in more variable climatic zones - regions prone to drought, floods, or fire - usually require large areas (or more examples set aside) to ensure survival.

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

Narrow strips of native vegetation are valuable for migratory and nomadic birds and as wildlife 'corridors' for small animals. This applies particularly in those parts of the study area that are predominantly agricultural.

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

In the past, many such areas have not been properly administered nor have they been well known to the public. Because of this, they have not been used as they might have been, nor have they been as secure from alienation or despoliation as they should have been.

Types of Reserve

Many of the uses discussed above are complementary, and this is reflected in the types of reserves into which 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 important landscapes and historical sites. There are different types of parks, and individual parks are zoned to reduce conflict between uses.

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

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

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RECREATION

Recreation can be defined as any activity (or planned inactivity) undertaken for personal pleasure during a person's leisure time. This chapter is concerned with outdoor recreation and, in particular, the wide range of activities carried out on public land. Recreational use of public land and the conservation of public land and of ecosystems are major reasons for the retention of natural areas.

Resources for outdoor recreation include both natural and Man-modified landscapes such as forested and cleared lands, water bodies, and air space. The recreation resource itself is a combination of physical and biological features and the ability and desire of Man to appreciate or use it.

Outdoor recreation in the study area is concentrated on public land, which includes some of Victoria's most outstanding recreational features. As well as providing for the recreational requirements of local residents, these features attract almost one million visitors to the area each year. Thus, the utilization of public land as a recreational resource not only gives enjoyment to the user, but also forms the basis of a vital component in the region's economy, with towns such as Lakes Entrance depending largely on tourism.

For decades the area has been a popular destination for holiday-makers. Pamphlets dating from early this century advertised tours involving travel by train from Melbourne, steamer cruises on the lakes, and trips by 'drag' (horse-drawn coach) to other points of interest. With subsequent increases in personal mobility, disposable income, and leisure time, the area has become progressively more important for tourism.

This in turn has led to the development of facilities to cater for this trade, especially accommodation and retail facilities in resorts such as Lakes Entrance, Metung, and Paynesville.

Public land in the study area provides a variety of natural and semi-natural environments well suited to cater for a wide range of activities. It supports activities ranging from canoeing to caving, and as disparate as horse-racing and bushwalking.

However, most outdoor recreation is water-based, with the Gippsland Lakes being far and away the most popular venue.

Other water-based attractions include the area's major rivers and streams, Lake Glenmaggie, and ocean beaches between Lakes Entrance and Lake Tyers.

A brief summary of the study area's recreational resources and activities is given below. Map 10 shows the main natural and historic features of the area and the locations of various recreational facilities.

Recreational Resources

The Gippsland Lakes

Renowned throughout Australia, the Gippsland Lakes offer excellent opportunities for almost all types of water sports, including fishing, swimming, boating, water-skiing, and yachting. The main lakes' broad expanses of shallow water, coupled with the much smaller and more sheltered Lakes Bunga and Tyers, provide a range of ideal environments for such water-based activities.

Boat ramps and jetties are located at a number of points around the lakes (see Map 10). Commercial operators offer cruises, hire-boats, and house-boats. Boats fitted with sleeping accommodation make up a significant proportion of the hire-boat trade. In order that pollution from recreation usage is kept to a minimum, the discharge of rubbish and sewage effluents from boats into the lakes is not permitted. However, the lack of adequate facilities for receiving sewage from boats has meant that the regulation prohibiting the discharge of such effluents is not strictly enforced.

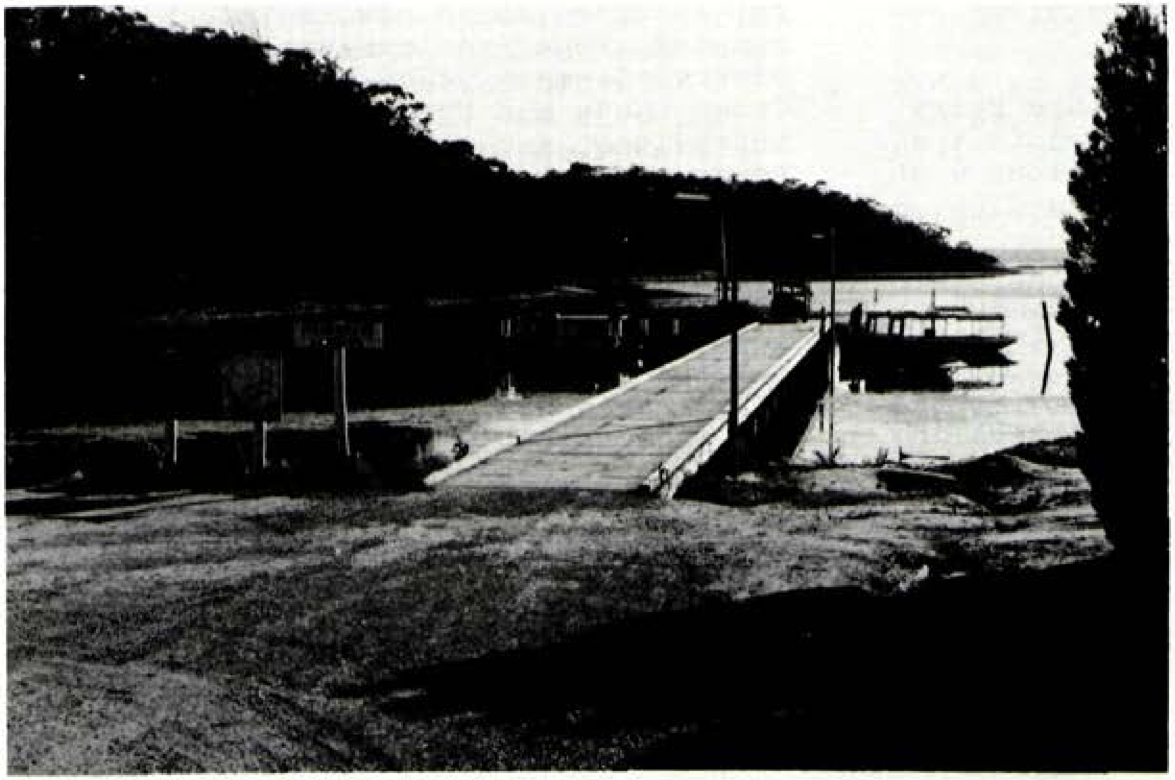
Yachtsmen rank the lakes system among the best inland areas for certain forms of sailing in Australia.

Flat-water canoeists can also find suitable waters, but use sheltered areas only, because the shallow waters of the larger lakes (coupled with strong winds) can quickly produce extremely rough boating conditions. The less-exposed Lake Tyers is therefore more favoured as a canoeing venue.

The combination of shallow depth and salinity variation in the lakes system has produced an extremely rich and varied fish resource. Many visitors come to the area for the fishing alone.

Wildlife on and around the lakes are also a major recreational attraction. The lakes and surrounding wetlands comprise one of Victoria's best duck-shooting areas. Stubble quail, Japanese snipe, and hog deer may also be hunted in season. The number and variety of birds, especially water birds, provide splendid opportunities for bird-watching.

These many attributes, ready access, and the development of nearby accommodation



The jetty at Fisherman's Landing on Lake Tyers

and commercial facilities have combined to make the Gippsland Lakes perhaps eastern Victoria's most important recreational resource.

Limestone caves

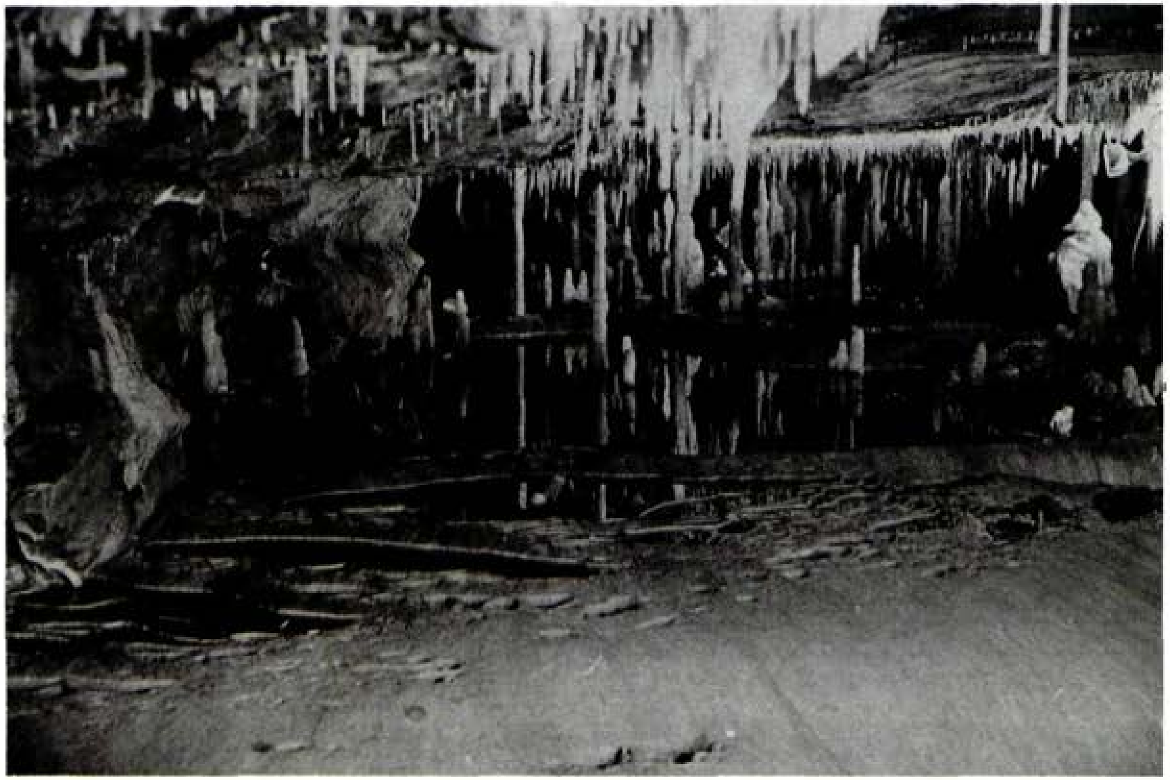
The series of limestone caves between Buchan and Murrindal are among the most spectacular and scientifically important caves of this type in Australia. The entrances to most of these are on public land, and nine separate areas are protected by reservation, including the major 285-ha Buchan Caves Reserve.

The presence of large caverns was established soon after the settlement of the Buchan district in 1837, but it was not until 1889 that a survey of any of the caves was undertaken by James Stirling, a Mines Department geologist. In 1890 another geologist from the Mines Department, A.E. Kitson, reported that many of the more accessible portions of the caves had been badly damaged by vandals, and he recommended that reservations be established to protect them.

In 1907 Frank Moon discovered the Fairy Cave. Royal Cave was discovered in the following year and these two, along with the nearby Federal Cave, are now displayed as the Buchan Caves. Under Moon's direction, new entrances were tunnelled, the caves illuminated, and the various natural features protected.

Subsequently the caves have been further developed and so have the facilities in the reserve, which now include a powered camping ground and caravan park. The reserve is managed by the Department of Crown Lands and Survey - with a resident supervisor, and staff who conduct guided tours through the caves. The Buchan Caves - now the most popular land-based recreation resource in the study area - attract about 80,000 visitors per year; the camping ground there accommodates 17,000--18,000 visitor-nights annually.

Other caves have not been developed to the same extent, although some at



Limestone formations in a cave at Buchan

Murrindal, which were open to the public in the 1920s and 1930s and subsequently closed, are being investigated with a view to re-opening them. In fact one such cave on private land has recently been opened for guided tours.

Speleologists consider the area between Buchan and Murrindal the most important caving area in the State. The Victorian Speleological Association has explored many of the caves on both public and private land in the area. The Association offers members accommodation in a former guest house at Buchan.

Lake Glenmaggie

Apart from being the main source of water for Gippsland irrigation schemes, Lake Glenmaggie is one of the most popular inland boating venues east of Melbourne. It provides for water-sport activities ranging from water-skiing and power-boat race meetings to sailing. Members of the Lake Glenmaggie Boat Club have use of certain facilities, while the general public may launch their boats from the three ramps provided.

Fresh-water angling is another popular pastime on the waters of this storage.

A narrow strip of public land surrounds the lake and is under the control of a committee of management. Camping is not permitted on this land outside of the three caravan parks situated on the western foreshore, which accommodate around 17,000 visitor-nights annually. Picnic areas are provided on the eastern shore at Sandy Point and also near the dam wall. Approximately 14,000 vehicles visit the latter site each year.

National and other parks

Glenaladale National Park lies 30 km north of the Princes Highway, off the Fernbank--Dargo Road, and is the only such park in the study area. The 143 ha comprising it were donated to the State in 1963 by Australian Paper Manufacturers Ltd. It contains important examples of temperate rainforest and outstanding geological features along the scenic Mitchell River gorge and its tributary, Woolshed Creek.

The main scenic feature of the park is the Den of Nargun - a cavern beneath an overhanging rock ledge in the gorge of Woolshed Creek. A waterfall usually masks the entrance to the cavern, falling to a pool below, and providing a scene of great beauty. A number of walking tracks have been developed in the park. Camping is restricted to a site beside the Mitchell River, which is for the use of canoeists and hikers in transit.

Although only small, Glenaladale National Park receives more than 16,000 visitors a year.

Even though the Lakes National Park and the Gippsland Lakes Coastal Park are

A picnic area in the forests north of Lakes Entrance

outside the study area, their location, south of Lake Victoria, obviously places them as part of this recreational resource. These parks contain walking tracks, picnic sites, camping grounds, and jetties, and provide ideal opportunities for nature study, especially birdwatching. They attract 110,000 visitors per year.

Surrounding Lake Tyers is the 5,315-ha Lake Tyers Forest Park, 3,720 ha of which lie within the study area. This constitutes the largest conservation reserve in the area. It is well served with access roads and walking tracks, and picnic and toilet facilities are provided at a number of places.

Its main feature is of course Lake Tyers itself - a drowned river valley that is often closed to the sea by a sand barrier. Its narrow, forest-lined inlets are picturesque and fishermen find the sheltered waters a contrast to the larger lakes.

The Forests Commission, which manages this park, estimates that between 20,000 and 25,000 people visit the area each year.

The Commission also manages the Moormurng forest park, south-west of Bairnsdale, and the Fairy Dell scenic reserve, west of Bruthen. The former protects a remnant of the Gippsland plains flora and has good access tracks but only one picnic site. The latter has picnic and toilet facilities and a walking track to the study area's largest patch of temperate rainforest. Neither area is intended to cater for large numbers of people.

Rivers and streams

Water bodies always provide a focus for recreational activity and the study area is well endowed in this respect, not only with lakes but with a number of major rivers and streams.

As well as being a significant scenic attraction, they provide opportunities for boating and estuarine fishing in their lower reaches and for white-water canoeing and fresh-water angling higher up.

Many of the major north--south roads in the study area follow river valleys, and wayside stops with picnic facilities have been developed at a number of spots to take advantage of the pleasant riverine environment. Examples include the Blue Pool reserve and the Quarries reserve on Freestone Creek, and one at Cheynes bridge on the Macalister River. Other more isolated picnic spots are at Angusvale on the Mitchell River, at the junction of the Buchan and Snowy Rivers, and at the Channels on the Avon River.

The Eastern Highlands

As well as incorporating specific features mentioned previously, the Eastern Highlands are extensively used for recreation by both visitors to, and residents of, the study area. The most popular pursuits are pleasure driving, fishing, white-water canoeing, bushwalking, and fossicking; others are picnicking, swimming, blackberrying, nature study, and horse-riding. In addition, a number of lookout points provide scenic vistas over the ranges and the Gippsland plains to the ocean.

A number of walking trails have been developed, of which the trail from the Golden Point Hut on Ben Cruachan Creek along Purgatory Spur towards Mount Wellington and Lake Tali Karng and the tracks along the Avon and Mitchell Rivers are the most popular. Sambar deer are hunted in the Glenmaggie Creek and Wentworth River catchments as well as in a number of other localities in the study area.

Ocean beaches

The study area contains only about 10 km of ocean beaches between Lakes Entrance and Lake Tyers. The most popularly used spots on this section of the Ninety Mile Beach are at Lakes Entrance (reached by a footbridge across the Cunningham Arm), Eastern Beach, Shelly Beach, and those at Lakes Bunga and Tyers. These beaches, the first of which is patrolled by a surf lifesaving club, provide venues for swimming and surfing. Lake Bunga beach has picnic and toilet facilities behind the dunes and a self-guided nature trail.

The entire 10-km stretch is suitable for surf-beach fishing.

Activities

Pleasure driving

A survey carried out in 1975 by McKenry, for the Department of Youth, Sport and Recreation, showed that 86% of the sampled Victorian adult population had been pleasure driving in the country at least once in the preceding 12 months. This does not mean that all of these people toured through public land in the Gippsland Lakes hinterland, but it does provide a measure of the popularity of pleasure driving, which was the most popular pastime recorded.

The study area offers a variety of tours over a well-maintained road system. The Heyfield--Licola road offers some of the best scenic driving in Gippsland, providing excellent views of the pastoral Macalister River valley and surrounding rugged hills. Further east, the Omeo Highway through the Tambo valley and roads in the Buchan area are commonly used by sightseers. Local pleasure driving is also common in the foothills north of Bairnsdale, especially towards Mount Taylor and Bullumwaal.

Popular locations for four-wheel-drive touring and trail-bike-riding include forest areas west of Seaton and north of Ben Cruachan. Trail-bike clubs in the area are based at Sale and Maffra. The Akademos Rally (run by Melbourne University Car Club) and other rallies in part use roads through public land.

The Maffra and District Car Club uses an area of public land near Boisdale as a hill-climb circuit.

Camping

Although informal camping takes place on public land throughout the study area, it is concentrated along accessible rivers such as the Macalister and Tambo.

Camping and caravan parks with full facilities, including powered sites, are located on public land behind Eastern Beach, at Paynesville, Eagle Point, and in the Buchan Caves reserve. Camping is also permitted at the Quarries reserve north of Briagolong, but facilities are less elaborate.

Most of the camping and other accommodation facilities, however, are on private land. The many caravan parks, motels, and holiday flats offer everything from a bush retreat atmosphere to a lakeside holiday.

A total of 20 holiday camps operate in the study area, of which 16 are school, youth, or family camps, mostly located close to the Gippsland Lakes. The four commercial camps are situated in locations ranging from the foothills of the Eastern Highlands at Briagolong and Glenmaggie to the Gippsland Lakes and Lake Tyers areas.

The commercially run camps distinguish themselves from the others by the range of additional activities they offer. For example, horse-riding safaris may be offered or a greater range of recreation facilities provided. In all cases, parties use camps as bases for recreation and for excursions to places of interest within the area. In most cases they also make use of nearby public land

Camping ground at the Buchan Caves reserve

for walking, nature study, swimming, and orienteering.

Hunting

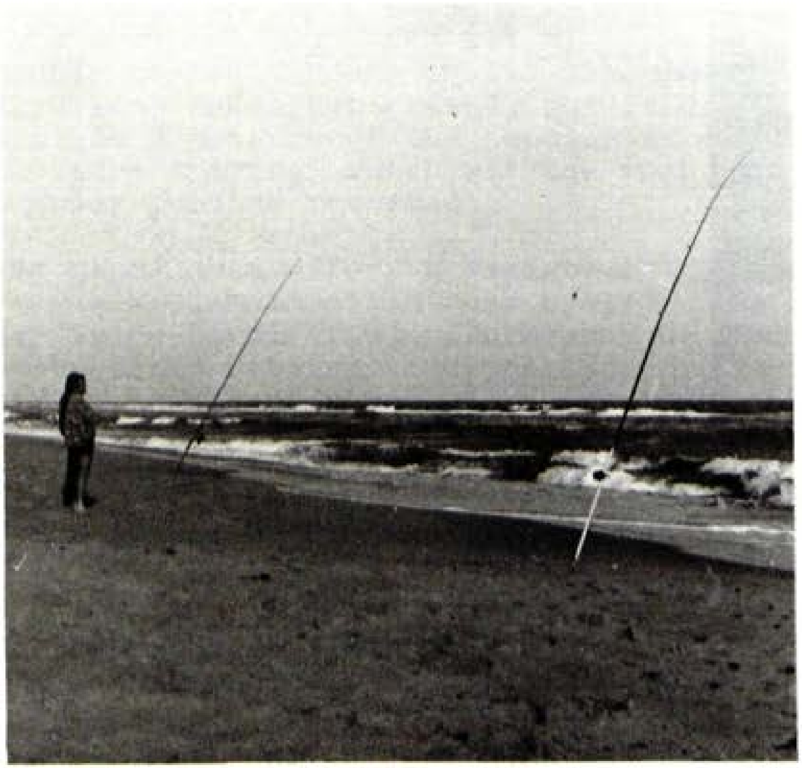
The Gippsland Lakes, along with associated swamps and marshes, are of State-wide importance to duck-shooters. Local concentrations of game birds also occur on rivers, swamps, billabongs, and dams throughout the study area. During open season, duck-shooting is permitted on five State game reserves near the lakes.

Japanese snipe, stubble quail, and hog deer are hunted on the Gippsland plains fringing the lakes. Sambar deer provide sport for deer stalkers at a number of places in the Eastern Highlands. The main hunting period for sambar deer is during the winter months, when trophy heads are at their best and hunting conditions generally most favourable.

Foxes and rabbits are hunted both for sport and for vermin control. On public land they are usually shot near the boundaries with agricultural areas.

Fishing

Recreational fishing is one of Victoria's most popular leisure activities: a public opinion poll has indicated that approximately one million (36%) of the State's population go fishing at least once a year. Of these, almost 150,000 fished the Gippsland Lakes, ranking them as second only to Port Phillip Bay as the single most popular fishing venue.



Surf fishing off the Ninety Mile Beach near Lakes Entrance

Bream is the major species fished for in the Lakes and the estuarine sections of their catchment rivers. Other species caught include mullet, flathead, flounder, garfish, and brown trout.

While all the major streams in the area contain fresh-water species, some are more heavily populated and more popular with anglers than others. Some of the most favoured of such streams include the Timbarra River, Haunted Stream, Macalister River (above and immediately below Lake Glenmaggie), and Wonnangatta River. Brown and rainbow trout make up the bulk of the catch in these streams; other species include tupong, blackfish, and redfin.

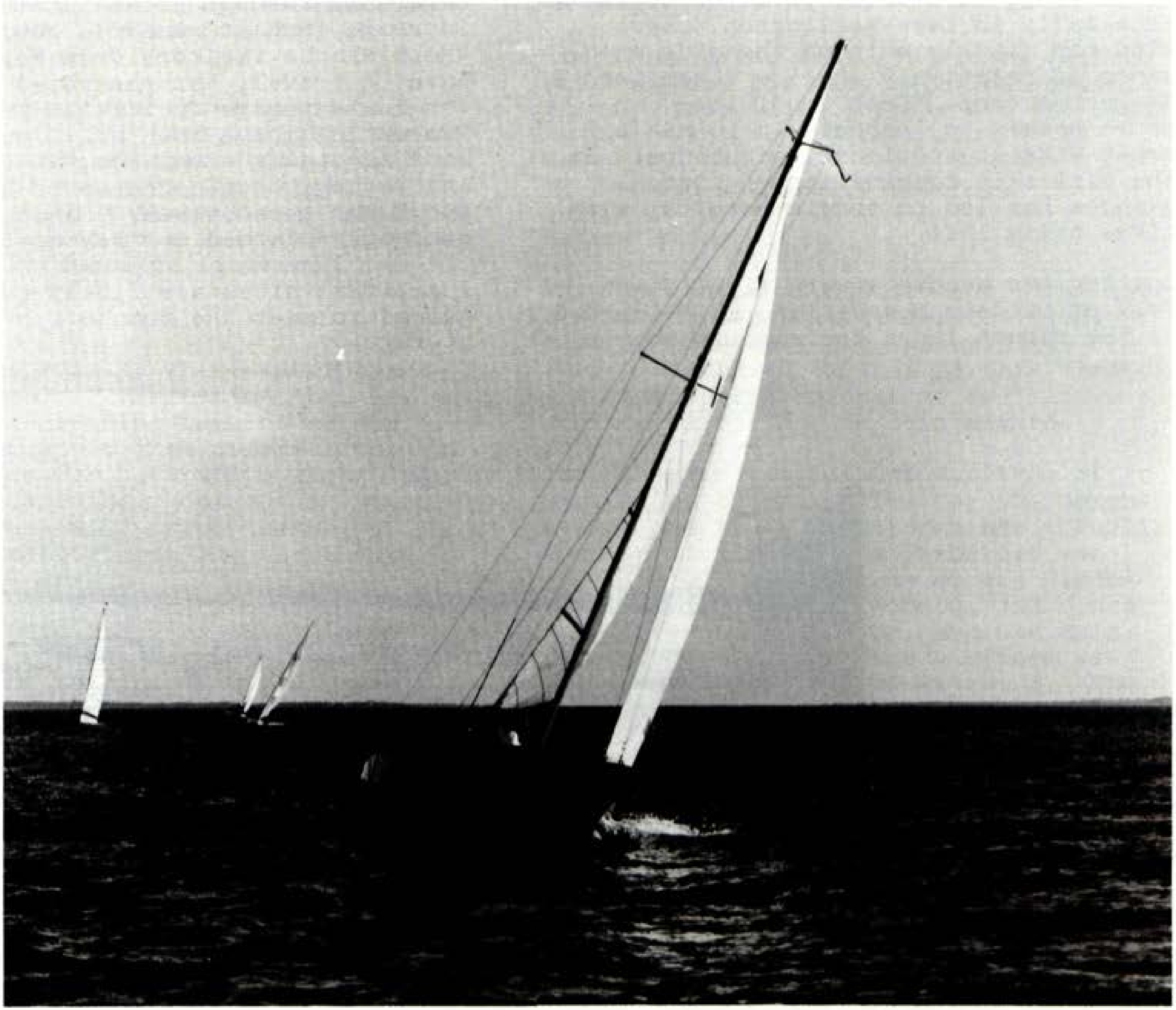
Lake Glenmaggie also provides good sport for fresh-water anglers, with redfin and trout being the most commonly caught species.

Most streams have not been stocked with trout since the late 1960s to early 1970s. There have, however, been more recent liberations of trout in Lake Glenmaggie and the Macalister River (1981) and the Snowy, Buchan, and Wonnangatta Rivers (1978). Fresh-water fishing has been assisted by the construction of various dams for water supply, but degraded by the introduction of European carp. Severe infestations of blackberries along many streams, which restrict or prevent access, are a further source of concern.

Boating

The Gippsland Lakes and Lake Glenmaggie provide the study area with some of the best and most popular boating waters in Victoria. Both sail-boat and power-boat enthusiasts are well catered for, with the provision of boat-launching facilities at various locations.

While for the most part these water bodies offer ideal conditions for all forms



Sail-boat racing on the Gippsland Lakes of boating, care needs to be exercised - especially in Lake Wellington, where wind can quickly whip up the wide expanse of relatively shallow water into a dangerous chop. Such conditions can prove hazardous, especially to small craft with inexperienced occupants. In the past this combination of circumstances has led to tragic results, with lives being lost.

Boating has become a very significant form of outdoor recreation, as evidenced by the recent large increase in boat ownership throughout the State. This increase in boat numbers, coupled with the distance visitors from Melbourne have to travel, has generated a demand for boat-storage facilities in the area. Two marinas have been built on public land adjoining the lakes, at Paynesville and Metung, by the Shires of Bairnsdale and Tambo respectively. Another is currently planned for Paynesville.

Additional sites are likely to be required to meet the demand for boat storage.

The marina at Metung

More than 180 private jetties are licenced on Crown land surrounding the lakes.

Commercial operators offer a wide variety of vessels for hire, ranging from large craft with accommodation - such as yachts, motor cruisers, and houseboats - to small aluminium dinghys. In addition regular cruises on the lakes are available for sightseers or fishermen.

Canoeing

Canoeing, especially white-water canoeing, is a form of recreation that is attracting increasing numbers of participants. The study area offers excellent opportunities for both white-water and flat-water canoeing. Commercial tour operators run 'wild river' canoe and raft expeditions along the Snowy and Mitchell Rivers.

Many of the area's major rivers have sections of various degrees of difficulty ranging up to exceedingly difficult (grade 5 in a grading from 1 to 6). The Mitchell, Snowy, Tambo, and Buchan Rivers are the most popular for white-water canoeing. The Mitchell River, below Angusvale, has been the venue for championship competition at the highest level.

Flat-water canoeing is pursued on the rivers' lower reaches and on sheltered sections of the Gippsland Lakes, especially Lake Tyers.

Swimming

The study area, with its rivers, lakes, and beaches, has many excellent swimming sites. Especially popular are the sandy beaches with road access around the lakes and the major ocean beaches such as Eastern and Shelly Beaches.

Nature study

Various tracts of public land offer interesting opportunities for the study of natural history. The conservation reserves discussed earlier in this chapter - some with interpretative facilities - are most important in this regard.

The lakes and associated wetlands offer unrivalled opportunities for the observation and study of water-birds. Public land controlled by the Fisheries and Wildlife Division - such as the Clydebank Morass, Macleod Morass, and Jones Bay State game reserves, and the Sale Common State game refuge - offers excellent venues for bird-watching. The Department of Crown Lands and Survey has developed a self-guided nature trail at Lake Bunga.

Nyerimilang Estate, a 178-ha grazing property, was purchased by the State government in 1976. The National Parks Service became the responsible management authority in 1980, and is currently preparing management plans to enable the property to be used for educational research and interpretative activities.

'Forestours' in the Colquhoun forest north of Lakes Entrance

In the forests around Lakes Entrance, the forests Commission runs guided self-drive 'Forestours' during school holidays.

These have proved highly successful, with as many as 1,200 people a year taking part in the escorted tours and about 3,000 taking the self-guided tours.

Orienteering

Popularity of orienteering is growing. Orienteering groups use areas in the Moormurng forest and on public land east of Briagolong and near Bruthen.

Bushwalking

While many people take short walks to points of interest, public land in the study area is not extensively used by bushwalkers. The major tracks are along the Mitchell and Avon Rivers and the popular track to Lake Tali Karng, in the adjacent alpine area, begins at the Golden Point hut north of Ben Cruachan.

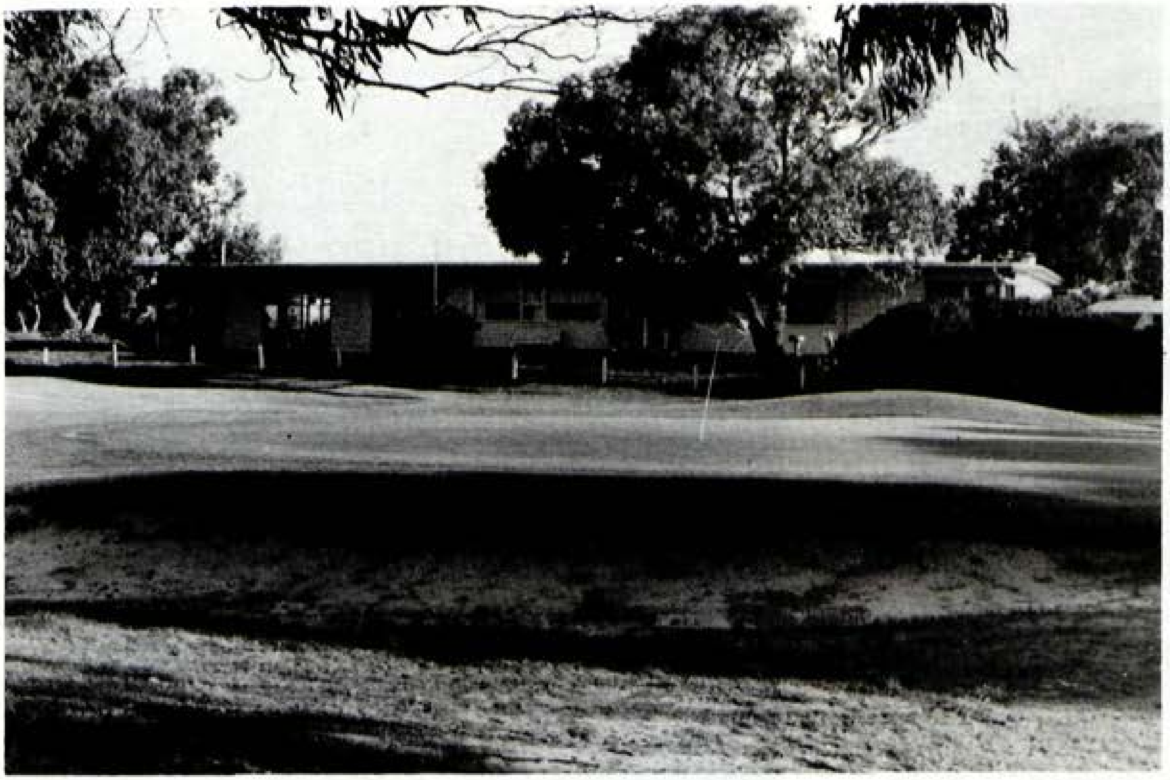
Organized sports

Throughout the study area, small blocks of public land are used for golf-courses, rifle ranges, football and cricket grounds, race-courses, hill-climb circuits, equestrian events, and the like.

Horse-riding and bicycle touring

For many residents (especially children) horse-riding is a popular hobby. From time to time many of these people take rides into nearby bushland. In addition, organized groups operating from Mount Taylor, Valencia Creek, and Briagolong conduct trial rides into adjoining forested public land.

Bicycle touring has returned to popularity in recent times, offering as it does the opportunity for physical exercise and leisurely contemplation of the surrounding countryside. A firm at Strat-



The Lakes Entrance Golf Club occupies public land at the eastern end of Cunningham Arm

ford organizes bicycle tours of the surrounding country.

Surfing

Of the narrow study area frontage to the ocean, between Lakes Entrance and Lake Tyers, Red Bluff is the most popular spot with surfers.

Fossicking

Gold fossicking takes place at a number of former gold-field sites in the Eastern Highlands, such as Donnellys Creek and Haunted Stream.

Gemstones are sought in the Gladstone Creek north of Stockdale, on the Avon River north of Stratford, and by the Boggy River north of Nowa Nowa. A caravan park proprietor at South Buchan also offers 'rock hound' tours for novice fossickers.

Bottle-collecting is also popular, especially around the sites of former mining settlements.

Guided tours of the limestone caves attract tens of thousands of visitors to the Buchan Caves reserve each year

Caving

The limestone caves in the Buchan--Murrindal area offer the best opportunities in the State for this specialist sport, which has a small but enthusiastic following.

Tourism and the Economy

Tourism has developed into a very important factor in the economy of the Gippsland Lakes hinterland - in terms of both money spent and employment.

The study area forms portion of the East Gippsland Tourist Region, one of 12 such

Negotiating a vertical pitch at Baby Berger cave south of Murrindal regions throughout the State. The Victorian Eastern Development Association, with headquarters in Bairnsdale, is responsible for tourist promotion within it.

A comparison with other parts of the State gives an insight into the economic significance of tourist activity in the area. Thus, the region's proportion of employed persons engaged in industries associated with tourist activity was among the highest of any in Victoria outside the Port Phillip District. Then too, few areas in the State have more guest rooms and bed spaces in hotels, motels, holiday flats, and guest houses, more caravan sites, or higher gross takings of caravan parks.

The limited data available suggest that tourist numbers and expenditure in the area have been increasing. However, the extent to which this apparent expansion has generated additional employment opportunities is uncertain, although it would appear that centres like Lakes Entrance have benefited in this way.

A report published by the government of Victoria in 1981, entitled 'Tourism, a Research and Information Paper', revealed that in 1979/80 the East Gippsland Region attracted more than a million visitors, who spent nearly four million visitor-nights (see Table 13).

Table 13

NUMBER AND ORIGIN OF TOURISTS TO EAST GIPPSLAND REGION

Tourist origin	Number	Visitor-nights
International	85,000	47,000
Domestic-interstate	66,000	413,000
Domestic-intrastate	864,000	3,524,000
Total	1,015,000	3,984,000

Expenditure figures of $30.15 per day by international visitors and $27.33 per day for domestic visitors, indicated in the report, are heavily qualified in terms of net benefit to the economy. Allowing for this fact, the report shows that the net benefit from tourism to the East Gippsland Region may be as much as $100 million per annum. The study area's economy is the major beneficiary of this expenditure, as approximately 80% of tourist business in the East Gippsland Region is conducted there.

Studies commissioned by the Ministry of Tourism indicate that, of the domestic visitors to the study area, 65% came from Melbourne and 28% from Victorian country towns. The major single purpose of visits to the region was holiday/pleasure.

The absence of any major historical park or museum confirms the important role that the natural features on the area's public land play in attracting visitors and making the study area one of Victoria's most important tourist destinations. Table 14 gives the visitor levels for the major attractions on public land in the study area.

Table 14

VISITOR LEVELS FOR MAJOR TOURIST ATTRACTIONS ON PUBLIC LAND

Gippsland Lakes	400,000
Buchan Caves	80,000
Lake Tyers Forest Park	20,000--25,000
Glenaladale National Park	16,000
Gippsland Lakes Parks	110,000

Future demand

In the late 1970s, it was expected that the rapid increases in fuel prices would result in a decline in the visitor rates to areas distant from capital cities. The East Gippsland Tourist Region was such an area - approximately 90% of visitors in 1979/80 came by car. In fact, the increased fuel prices induced people who would otherwise have gone interstate to select a destination within Victoria. This resulted in visitor numbers to East Gippsland increasing.

The large and increasing population of the Latrobe Valley is expected to be a significant factor in the future recreational demand placed on the area.

Provision of additional facilities for motorists in reasonable proximity to local attractions would reinforce the use of towns in the study area as bases from which day trips could be made.

Creation of highway parks (areas sufficiently large to allow travellers to be isolated from the road environment and to allow dispersion of picnickers) along the Princes Highway, would encourage visitors to make a more leisurely and thus safer journey to their destination. The recently completed Stratford highway park is a good example.

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Portion of the Stratford highway park

HARDWOOD PRODUCTION

The pattern of timber production in the area has generally been in response to fluctuating local requirements and to periods of high demand generated outside the region by the necessities of war and by periods of fast economic development.

History

The forests provided the Aborigines with shelter, implements, and food. European settlers, however, brought greater demands - initally for local building materials and fuelwood, but subsequently they cleared the forests for pasture and croplands, and cut trees for fencing and railway timbers and to supply the timber industry.

Gold-mining commenced in the area in 1854, but declined and came to a halt during World War I. While it lasted, it greatly intensified timber-cutting in the foothills, as miners sought mine props, heavy construction timbers, and fuelwood. Concurrently, durable timbers from the coastal plain forests were in great demand for the then-burgeoning pastoral industry.

Construction of the Latrobe Valley railway in the 1880s brought additional cutting in coastal forests. Apart from the durable timbers needed for the project itself, the rail link provided ready access to markets in Melbourne, which at that time was undergoing a building boom. Economic development was greatly assisted by timber supplies from Gippsland and by the advent of steam-powered mills, which supplanted the slow process of pit sawing. Products were used for bridge and harbour construction, railway sleepers, and street paving blocks, and for building materials such as cladding, framing, and sub-floor timbers. It is of interest to note that, in 1911, a sawmill at Briagolong supplied yellow stringybark flooring for use in Australia House, London.

Reduced production during the depression of the 1930s was succeeded in the 1940s by increased sawmilling occasioned by World War II and the completion of salvage operations in the ash forests closer to Melbourne, which were killed in the 1939 fires. Collins' sawmill at Brookville made an important contribution to timber supplies during the war years.

Moreover, the scarcity of petroleum fuel necessitated the widespread use of charcoal, which was burnt in gas-producers to fuel motorized transport. Charcoal-producing burners in the study area were located at various sites near Bruthen, Nowa Nowa, and Briagolong. At one site, adjacent to Colquhoun railway station, large volumes of wood from the surrounding forests were converted and railed to Melbourne.

Timber cutters late last century

The post-war building boom in Victoria, which continued into the early 1960s, created peak demands for timber for house construction. Several large sawmills were set up in the study area in response to that demand. These included mills at Swifts Creek, Nowa Nowa, Bruthen, and Buchan, which drew supplies wholly or substantially from the study area. During this period the township of Heyfield also expanded greatly, and a maximum of nine mills there directly employed some 300 persons. Sawlogs for these mills, however, came mainly from forests to the north of the study area. Production of railway sleepers was also at a peak during the 1950s, with gangs directly employed by the Victorian Railways working in foothill forests. The timber industry therefore made a vital contribution to employment and the reconstruction of post-war economies and social structures.

Production of sawn timber dropped during the economic recession of the early to mid 1960s. Since that time, the industry has improved, with the trend to fewer but larger mills and a greater degree of mechanization. Sleeper production, however, still depends largely on the swingsaw and chainsaw, and production levels remain low, in part because the hilly terrain and scrubby undergrowth of the area make mechanized operations difficult.

Firewood production declined markedly from the 1950s to an annual volume of less than 2,000 cu.m, but increasing supplies of pulpwood have been sought since 1965 for use in the pulp mill at Maryvale. Pulpwood produced as a by-product in sawlog operations has allowed economic operations to continue into largely defective or low-yielding areas, thus enabling their regeneration to produce more highly productive forests.

At present, timber production is more closely allied to long-term levels of supply, and levels of output and employment have stabilized.

The Forests

The responsibility for wood production from State forests rests with the Forests Commission, Victoria. Timber products supplied to industry from within the study area include sawlogs, pulpwood, poles, sleepers, fencing materials and firewood.

Timber productivity for the forests in the area varies. Table 15 provides a guide to the relation between the various structural vegetation types, the main timber species within them, and productivity.

In broader terms, stands greater than 40 metres tall are referred to as mountain forests, whereas stringybark, gum, and silvertop forests less than 40 metres tall are known as foothill or coastal forests, depending on their location. Stands containing ironbarks, boxes, or

Table 15

PRODUCTIVITY OF HARDWOOD FOREST

Structural class +	Main timber species	Potential productivity *(M.A.I., cubic metres per ha per year)**
Open forest IV (trees over 40m)	Alpine ash, mountain ash, messmate stringybark, mountain grey gum	M.A.I. range 7--21 depending on site; suitable for sawlogs and pulpwood
Open forest III (trees 27--40m)	Messmate stringybark, silvertop, white stringy-bark, blue gum (eurabb-ie), mountain grey gum, narrow-leaf peppermint, yellow stringybark	M.A.I. range 3--6; suitable for sawlogs, pulpwood, sleepers (some species), and other products
Open forest II (trees 15--27m)	Silvertop, white stringybark, red stringybark, yertchuk	M.A.I. range 1--3; suitable for sawlogs, pulpwood, sleepers (some species) and other products
Open forest II (trees 15--27m)	*red ironbark, forest red gum, Gippsland grey box, red box*	M.A.I. 1--2; *durable species main-ly suitable for sleepers, poles, piles, fencing and firewood*
Open forest I (trees 8--15m)	Red stringybark, red box	M.A.I. very low; mainly suitable for fencing materials and firewood

\+ Structural class of the forests, after the classification by R.L. Specht.

* *The potential productivity is that expected with improved utilization,* adequate stocking, and intensive management of forests.

** M.A.I. stands for mean annual increment and represents the total volume production of logs up to a small-end diameter of 10 cm under bark, divided by the age of the stand in years.

red gum are classed as durable-species forest.

Mountain forests

Alpine ash, mountain ash, messmate stringybark, and mountain grey gum are the predominant timber species. Their high volumes per hectare and fast growth rates, combined with excellent wood characteristics for a range of uses, make them extremely important. Ash species in particular have timber with an attractive appearance, a low incidence of defect, and relatively low density. The better-quality timber is used in flooring, internal joinery, and cabinet-making. Ash timber is also highly prized as a raw material for paper-making because of its favourable fibre properties, light colour, and low density.

In the mountain forests, the harvested areas are regenerated successfully by removing overhead shade, preparing a suitable seed-bed, and seeding or planting where necessary. Overhead shade is reduced by removing trees during harvesting operations. In some cases remaining trees are killed, except for those retained as habitat trees. A suitable seed-bed is provided by mineral soil exposed during logging, or is prepared by burning logging debris to produce an 'ash-bed'.

Seeding by hand or from the air with species endemic to the area is usually practised. Seed fall induced from trees remaining on the site sometimes provides a supplementary source.

Foothill and coastal forests

Both types of forest contain a similar range of timber species, but the dissected terrain of the foothills results in a complex pattern of forest ranging from low to high productivity. Coastal forests, on the other hand, occur mainly on undulating land and are more uniform in productivity. They are also more accessible.

The most important species include silvertop, messmate stringybark, white stringybark, and yellow stringybark. They produce sawn timber, used widely in house-framing and general construction. Pulpwood is also an important product from these forests. Others include poles, sleepers, and fencing materials.

Much of the productive forest has been selectively logged a number of times, with the result that regeneration has not occurred in some areas or, in others, has been suppressed by the remaining trees. Non-commercial operations have been used to kill or remove cull trees where finances permit.

Pulpwood harvesting in recent years has enabled the rehabilitation of degraded forests by allowing integrated sawlog and pulpwood harvesting in stands that it was previously uneconomic to utilize.

Mixed-species sawlogs at a log landing

Regeneration is then obtained by exposure of soil through mechanical means or by fire, and by sowing seed where necessary. An established system of primary roads has enabled the dispersal of successive cutting areas, or coupes, in these forests.

Durable-species forests

The main species are red ironbark, Gippsland grey box, red box, and forest red gum. Box--ironbark forests are mainly located south and west of Lake Glenmaggie. They have been utilized for many years on a single-tree selection basis and now essentially comprise young regrowth.

They are generally accessible, and supply fencing materials and firewood.

Regeneration of these forests is by copice on the stumps left after cutting. Special restrictions apply to the Flora and Fauna Reserve near Heyfield and the Moormurng Forest Park near Bairnsdale.

The Timber Industry

The Forests Commission, Victoria, supervises and controls the harvesting and removal of timber from State forests by a licensing system - with specified conditions of supply. It may also enter into agreements to supply wood of various grades and qualities, at specified prices and levels of supply, to industry and individuals.

Sawmilling

Sawmilling is an important industry in the area, providing employment at a number of centres in Gippsland. A total of 19 sawmills - located at Erica, Heyfield (5), Valencia Creek, Stratford, Bairnsdale, Mount Taylor, Bruthen (2), Swifts Creek, Ensay North, Buchan, Buchan South, and Nowa Nowa (3) - have licences to obtain timber from within the Gippsland Lakes hinterland area. Although the Erica sawmill has rights to timber from within the study area, it is located outside it.

Six of these mills - drawing supplies from Maffra and Bruthen forest districts - obtain all or most of their log supplies from the study area. Some obtain a smaller proportion of their total log intake from it, while a few have not taken supplies from the area in recent years.

As Table 16 shows, in 1979/80 sawmills operating within the study area directly employed 562 persons in log procurement and sawn-timber production. (It should be noted that considerably fewer people would be employed to process that proportion of the timber derived only from within the study area.) This employment makes an important contribution to the economic prosperity and social fabric of the centres concerned.

Compared with most sawmills of a decade ago, mills are now more mechanized, have a greater through-put of sawn timber, and require a smaller but more skilled labour force. Over the past 15 years, and in common with that in other rural

Table 16

EMPLOYMENT BY SAWMILLS LOCATED IN THE STUDY AREA - 1979/80

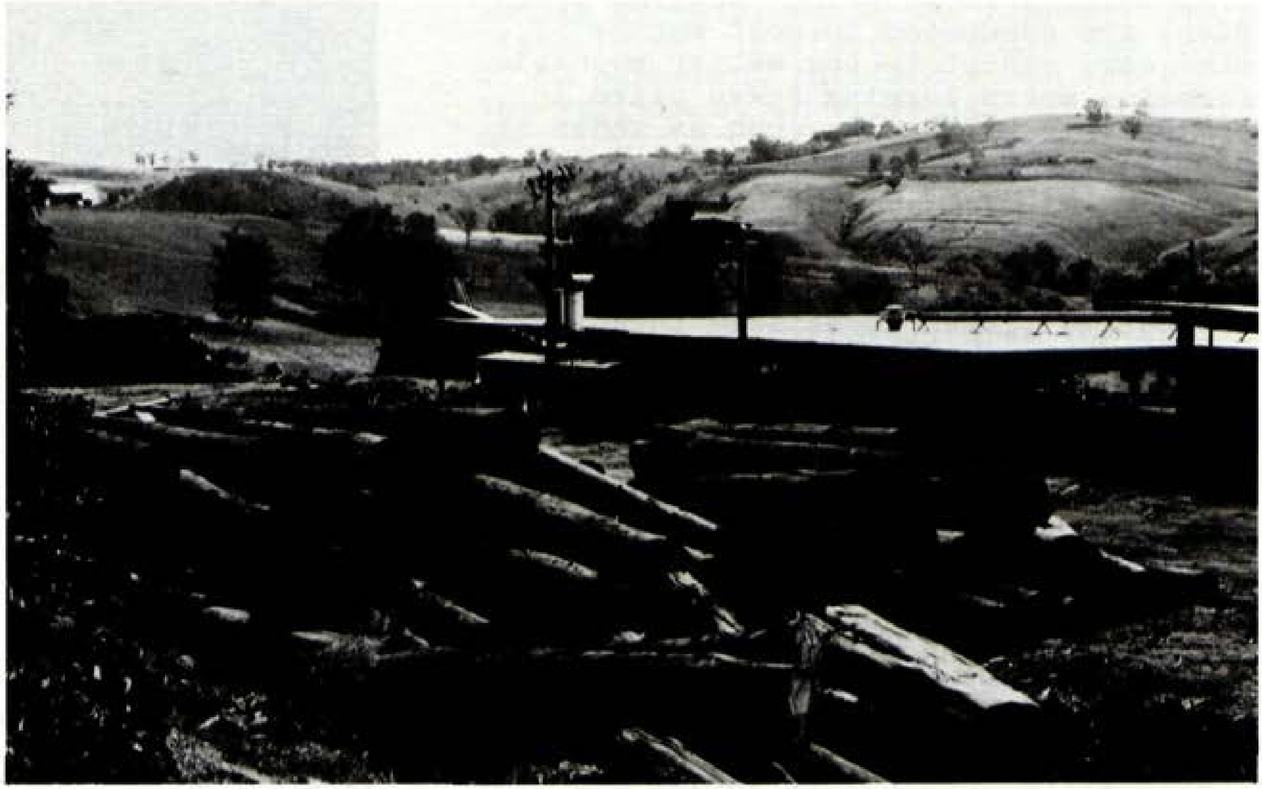
Supply area (Forest district)	No. of sawmills	No. of employees	
		Mill	Bush
Maffra	2	20	10
Bruthen	4	94	21
Nowa Nowa	5	114	33
Swifts Creek	2	39	8
Heyfield	5	169	54
Total	18	436	126

Source: Industry survey - Forests Commission, Victoria 1979/80

Notes: 1. Sawmills in the Heyfield forest district - and others at Ensay North, Buchan South, and Nowa Nowa - have drawn most of their supplies from outside the study area in recent years.

2. The sawmills listed are those that draw log supplies from State forest.

Sawmill at Buchan



industries such as agriculture, employment in the timber industry has steadily decreased, both in absolute terms and as a percentage of the total work force (see Table 3).

In recent years, however, with the encouragement of government decentralization programs, secondary processing and manufacturing timber industries have undergone some shift from metropolitan to country centres. One such relocation has resulted in the retention of more than 100 jobs in Heyfield.

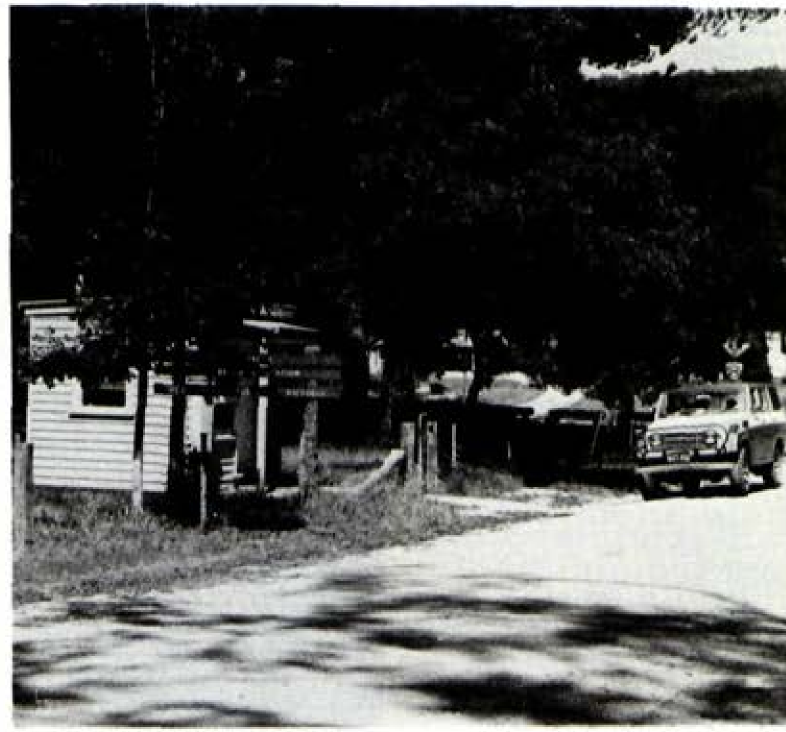
The industry supplies markets in the Latrobe Valley and the Melbourne metropolitan areas, as well as servicing the timber needs of local communities. The sawn timber is produced mainly for use in house construction. Other sawn products include fence palings, fork-lift pallets, formwork timbers used in construction projects, and a variety of miscellaneous structural timbers.

Logs supplied from the study area for conversion to various sawn products averaged around 46,000 cu.m annually from 1975/76 to 1979/80. Logging operations are conducted in most months of the year, except in the wetter mountain forests, where logging takes place in summer only. Sawmills such as those at Heyfield, Nowa Nowa, and Swifts Creek, which obtain most of their supplies from mountain forests, therefore require an alternative source in winter to supplement stockpiled logs. The availability of lower-altitude forests is thus very important to them in providing an extended logging season.

Pulpwood

On those areas of forest where management for production of sawlogs is the primary land use, the ability to harvest pulpwood as a residue from sawlog operations has both short- and long-term advantages. The forests of the study area have suffered from past wildfires that have caused defects in the trees and made many of them either wholly or partially unsuitable for sawn-timber production. The full potential of such forests can only be realized by the removal of stands of unproductive trees and their replacement with healthy and vigorous regrowth.

While the full potential will not be realized for many years, the immediate benefits of the controlled removal of pulpwood, as part of integrated forest management, are the increased efficiency of regeneration procedures following logging, a greater growth rate of the

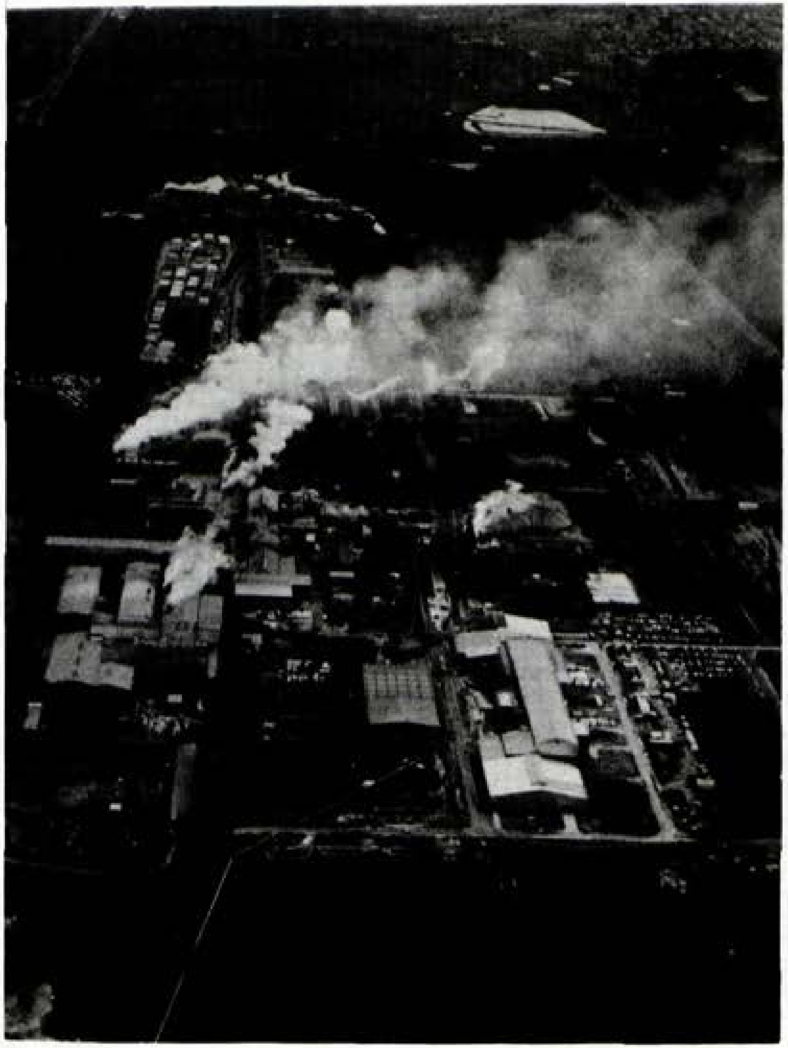


Mount Taylor log-checking station

resulting stand because of reduced competition from overwood, and increased levels of economic activity and of job opportunities within the forest and related industries.

Australian Paper Manufacturers Ltd receives part of its hardwood pulpwood requirement from State forests within the study area, and converts it to wood pulp and paper products at its Maryvale mill. The company is one of the two largest decentralized employers in manufacturing in Victoria, directly employing some

1,300 persons at Maryvale. A further 30 persons are employed in pulpwood procurement from the forests within the study area.



A.P.M.'s Maryvale mill

Supply of pulpwood to the company from State forest is effected under the terms of an Agreement ratified by an Act of the Parliament of Victoria. This Agreement incorporates a supply schedule that increases from the 1981/82 level of 525,000 cu.m to 765,000 cu.m towards the end of the agreed supply period in 2004.

The Gippsland Lakes hinterland is not currently a major supply area for the mill. (The actual volume during 1980/81 was about 34,000 cu.m). It will be more significant in future years, however, given the indicated planned increase in pulpwood supply. The pulpwood to be supplied then either is not being used at present or is wasted by being burnt in the necessary forest regeneration procedures following sawlogging.

The major expansion of the Maryvale mill recently announced by the government and A.P.M. Ltd, which will create a further 300 jobs at the mill, will utilize the additional supply already provided for in the Agreement as well as additional wood from company forests and plantations.

Railway sleepers

About 12 part-time sleeper-cutters operate in the area, mainly in foothill and coastal forests. The main species cut, which are known collectively as 'Gippsland whites', include white stringybark and yellow stringybark. Durable species such as red ironbark, Gippsland grey box, and forest red gum are much sought-after, but are in short supply. Annual production of sleepers in the 5 years 1975/76 to 1979/80 was about 23,000 pieces; the estimated production for 1980/81 is 34,000.

Other timber products

Piles and transmission poles are produced for use throughout Victoria. In recent years about 29,000 lineal metres have been supplied annually.

The forests, particularly those near the agricultural areas, supply the rural community with readily available wood for farm timbers and fuel.

Poles are used for equipment sheds, tank stands, hay sheds, and a variety of rough construction purposes. Fencing materials continue to find a steady market, with production averaging about 53,000 pieces annually. Firewood production has remained steady over the last few years at about 1,700 cu.m per annum.

Loading pulpwood billets

SOFTWOOD PRODUCTION

With the exception of a number of trial plots and small school plantations totalling 70 ha, no softwood plantations have been established on public land within the study area. The government has undertaken, however, that it will increase softwood supplies to Australian Paper Manufacturers Ltd, and that, where company freehold forest land is required for coal-based development, suitable other land will be made available to the company. As a result, it could be expected that public land would be considered for softwood production in the future.

Suitability criteria for radiata pine

Radiata pine *(Pinus radiata)* is the major softwood species grown in Victoria, and the following growth conditions are desirable:

* a minimum rainfall of 700 mm per year (sites with rainfall between 650 mm and 700 mm per year are generally considered marginal for pines; however, with appropriate site preparation they can be used successfully, if the rainfall is reliable and well distributed throughout the year)
* a neutral or slightly acid soil of at least moderate fertility
* good drainage
* a minimum of 0.5 m (but preferably 0.75 m or more) of soil over any root- or water-impeding layer
* freedom from heavy snowfalls (that is, elevations less than 950 m, and preferably less than 800 m)

It is possible to modify sites to make them more suitable for growing radiata pine, because it is a very hardy and adaptable species. Experience obtained in establishing plantations, and from trials, has led to some generalizations on modifying sites to achieve this. The following comments generally apply.

The gradational soils developed about the highlands support good growth, provided there is no impeded drainage.

Growth rates on heavy clays and shallow soils can be improved by deep ripping to facilitate root penetration. Ripping on the contour will conserve water in dry areas. In low-lying areas - where the problem is too much water - ripping down the slope will assist drainage.

Application of phosphate fertilizers on soils deficient in phosphorus (and/or on those with high phosphorus absorption) is often worth while.

Applications of 100--600 kg superphosphate per hectare have increased growth by 25--30% on young soils on granite in western Gippsland and on heavy clay soils in the central highlands (Ballarat Zone). A similar response has occurred on the light sands over clay subsoils in areas planted by A.P.M. in Gippsland, and in the south-west of the State.

Specific trace element deficiencies can be corrected where necessary by addition of the element or by appropriate site treatment.

Establishment of softwood plantations

Most softwood plantations in the study area have been established by A.P.M. Forests Pty Ltd, on freehold land. These A.P.M. plantings form part of more than 40,000 ha of softwood plantation that the company has established over the last 30 years to supply its processing plants in the Latrobe Valley.

The biggest of these plants, the pulp and paper mill at Maryvale, is the single largest decentralized plant in Victoria, directly employing 1,150 people. The company also operates a sawmill at Morwell, which utilizes pine logs and employs a work force of 140. A further 460 people are employed in forestry - both in the establishment and maintenance of plantations and in wood procurement through contractors.

A significant and increasing number of individuals and small companies have also planted softwoods on freehold land, especially following the introduction of a government loan scheme in 1966 designed to encourage and assist land-owners to establish farm wood-lots as a source for local forest industries.

Table 17 lists the areas of softwood plantation in the study area.

Table 17

SOFTWOOD PLANTATIONS IN GIPPSLAND LAKES HINTERLAND (1980)

Ownership	Area (ha)
Public land	
Forests Commission	0
Other (such as State school plantations)	70
Freehold land	
Farm forestry loan areas (11)	320
Other (mainly A.P.M. Forests Ltd)	6,430

The Bairnsdale High and Primary Schools' small pine plantation at Mount Taylor is the largest such plantation on public land anywhere in the study area

Industrial requirements

Conversion to wood pulp at Maryvale is the main industrial use for softwood currently grown within the study area. Where thinning of plantations to yield pulpwood has taken place, material from later thinnings and final fellings mainly provides sawlogs. A softwood preservation-treatment plant is located at Maffra.

Future plantation development

Under a government committment to A.P.M. Ltd. the Forests Commission will supply pulpwood volumes from Gippsland rising to 200,000 cu. m by the year 2000. In order to meet this commitment and provide for sawmilling and other associated industries in the Latrobe Valley, the Forests Commission has been directed to increase its rate of plantation establishment in the Latrobe Softwood Plantation Development Zone from 600 ha to 1,300 ha net per annum.

At this rate of planting, the plantation zone's target of 40,000 ha net, about a third of which has already been planted or for which land has been allocated, would be reached early next century.

The government has also agreed that, where A.P.M. forest land in the Latrobe Valley is required for coal extraction, power station, or other purposes, suitable other land will be made available to the company. Adopting the highest development scenario for both S.E.C. and non-S.E.C. coal-fields, it would appear that no more than about 2,000 ha (net) of A.P.M. plantations would be affected, and therefore subject to replacement, in the next 10 to 15 years. However, over a 50-year period some 12,000--13,000 ha (net) of A.P.M. plantations could be required for coal-based development.

Thus, the expanding wood requirement for the A.P.M. mill, together with the possible loss of A.P.M. freehold land over the next 10 to 15 years, could result in the need for some 28,000--29,000 ha net of softwood plantations to be established.

The present Latrobe Softwood Plantation Development Zone, which is outside the study area, does not contain sufficient suitable public land to cater for these extra plantations. Furthermore, because of strong demands on the Latrobe Valley land base for industrial, residential, and agricultural uses, the large-scale purchase of private land for plantation establishment may be neither possible nor desirable.

In the light of these factors, consideration may need to be given to the use of land in the Gippsland Lakes hinterland area to meet at least part of the requirements for additional softwood plantations.

Preliminary reconnaissance work, which the Forests Commission has carried out to determine the suitability of land for softwoods, indicates that approximately 27,000 ha of public land in the study area could meet the site requirements for softwood establishment. This land is located in the Stockdale, Providence Ponds, Lindenow--Sarsfield, and South Buchan areas indicated by cross-hatching

Public land near Stockdale supporting white stringybark open forest is typical of land the Forests Commission says meet the requirements for softwoods

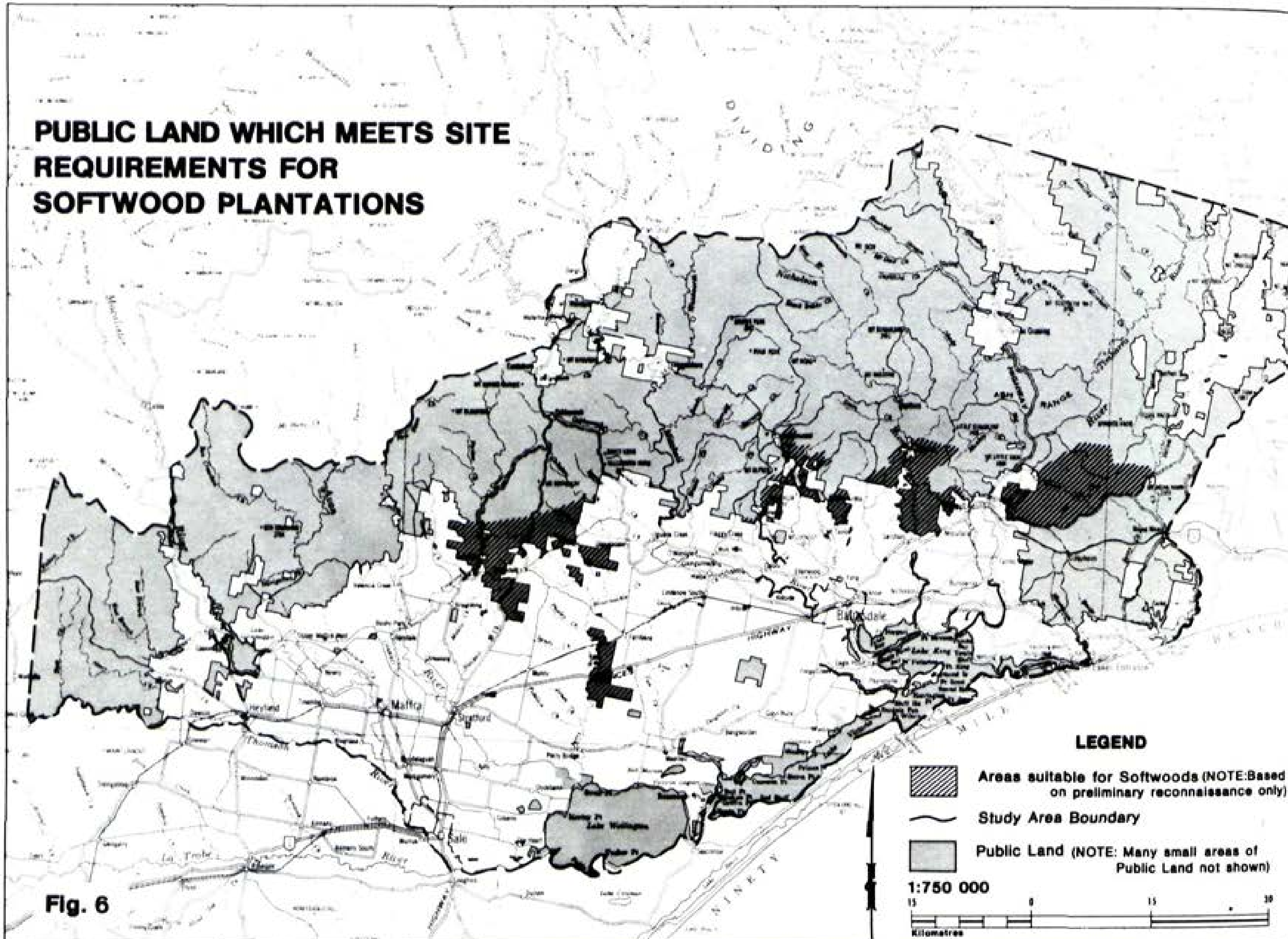

PUBLIC LAND WHICH MEETS SITE REQUIREMENTS FOR SOFTWOOD PLANTATIONS
LEGEND
Areas suitable for Softwoods (NOTE: Based on preliminary reconnaissance only)
Study Area Boundary
Public Land (NOTE: Many small areas of Public Land not shown)
1:750 000
Kilometres
DIVIDING
RANGE
HIGHWAY
Bairnsdale
Maffra
Stratford
Heyfield
Sale
Lake Wellington
NINETY
MILE
La Trobe
River
Fig. 6

Table 18

PREDICTED PRODUCTIVITY OF RADIATA PINE PLANTATIONS

Site treatment		Predicted MAI (m^3/ha/yr) at age 10	Site quality class*
Ordinary	- No weed control; 23 kg phosphorus per ha at age 0	7.5--9	V--V1
Medium	- Weed control; 23 kg phosphorus per ha at age 0	12--15	1V--V
Intensive	- Weed control; intensive fertilizer	19--20	111

* Site quality - described on a scale of 1 (very good) to V111(very poor) - is used quantitatively in South Australia and frequently applied descriptively in Victoria. The conversion from predicted MAI at age 10 to site quality class is approximate.

in Figure 6. It is important to note that these areas have as yet been identified only on the basis of broad-scale reconnaissance, and detailed assessment needs to be undertaken before finally deciding their suitablity.

The study area also contains large areas of privately owned land that meet the site requirements for softwood establishment. The extent to which purchase of such freehold land may be used to meet the plantation requirements will depend on factors such as the land's price, availability, and location, and the availability of government funds for its purchase.

Potential productivity

The productivity of a site can be measured in terms of the average annual growth of wood volume per unit area. It is expressed in cubic metres per hectare and is known as the mean annual increment (MAI). Mean annual growth rate typically increases steadily until the plantation reaches about 30 years of age and then remains more or less constant until about 40 years of age. A gradual decline follows, as the trees become older and less vigorous.

Detailed soil studies have not been carried out in the study area to date to confirm areas suitable for softwoods, but much of the potentially suitable land has apparently similar soils to the existing A.P.M. Forests Pty Ltd plantations in the Stockdale area. Growth data from these plantations suggest that the range of productivities shown in Table 18 would be achieved.

Productivity of an area can also be increased, by using genetically superior seed sources and through the application of capital-intensive establishment and tending techniques. These techniques include fertilizing at or shortly after planting, weed control, cultivation, deep ripping of sites with soil layers that impede the movement of soil water, and the addition of trace elements. They can lead to a considerable increase in productivity, as shown in Table 18.

Reference

Bureau of Agricultural Economic. 'The Australian Softwood Products Industry.' (AGPS: Canberra 1977.)

AGRICULTURE AND APICULTURE

Primary production throughout the Gippsland Lakes hinterland encompasses a wide range of activities - from timber milling to commercial fishing - and includes agricultural activities such as grazing, cropping, and vegetable production.

Map 9 indicates the locations of these various major primary industries. The fishing and timber industries are discussed in separate chapters.

Agriculture

The major agricultural enterprises in the study area produce wool, mutton, lamb, beef, milk, vegetables, and maize. Minor products include walnuts, orchard fruits, cereals, wine, and mohair.

Some 42% (approximately 375,000 ha) of the area is agricultural land containing about 1,500 separate holdings - chiefly on the flat to undulating land in the south. Most of it is cleared.

Agricultural environment

In the south, the agricultural lands comprise extensive plains of mainly duplex soils (being relatively infertile near the coast), deep fertile alluvium on the river flats, and the podzols and sand of the foothills.

In the north, they comprise river valleys and the less-steep slopes of the surrounding mountains, such as around Buchan.

On average, rainfall is evenly distributed throughout the year. Annual averages range from less than 600 mm around Maffra, which is under the influence of a rain-shadow caused by the mountains to the west, to more that 1,000 mm in the high country. Local rain-shadow effects are also evident in the mountain valleys such as at Dargo and Ensay.

Irrigation augments water supplies on the alluvial flats of the major streams and in the Macalister Irrigation District around Maffra.

Warm, calm days are common throughout winter, and summer temperatures are often moderated by easterly breezes. As would be expected, temperatures do not range as widely on the coast as they do further inland, and they are somewhat lower again in the mountains during winter, although in summer they can be higher.

Pasture growth can occur at any time of the year, but is usually slower in winter and often ceases in summer due to lack of moisture.

Pastures

In common with most of Victoria, this area has phosphorus-deficient soils, and superphosphate fertilizer is used widely. Potassium deficiency affects many of the lighter soils, and may develop in other soils under intensive cropping. Where necessary, the trace elements copper and molybdenum are also applied.

The main introduced grasses throughout are perennial ryegrass and cocksfoot, with some paspalum and phalaris. Native perennial and annual grasses and the annual clovers and medics also make substantial contributions to pasture production.

Subterranean clover, an annual, is the most productive clover on the dryland (unirrigated) pastures, although the perennial white clover can be prolific in some years, particularly after summer rain. Under irrigation, the pastures usually comprise perennial ryegrass, cocksfoot, and white clover.

Where lucerne is grown on the alluvial flats, it is used mainly as a source of hay. It may also be grown on other sites with good drainage, and in these situations is used for both hay production and grazing.

Dairying

Some 450 dairy farms (4% of the total for the State) operate in the area and produce whole milk with an annual gross value of about $19.7 million (1980 farm-gate prices). Most of this milk supplies two processing plants at Maffra.

The majority of the dairy farms are located in the Macalister Irrigation District, in the Shires of Maffra and Avon; the balance occupy the alluvial flats of the Mitchell River near Bairnsdale and the Tambo River near Bruthen.

The last decade has seen a 38% reduction in the number of dairy farms in the area and a reduction of 16% in the number of dairy cows; thus, the number of milking cows per farm has increased by 36% over the same period.

Table 19 indicates these changes in each of the relevant municipalities.

Farms that have ceased dairying have, in the main, been on the dry (unirrigated) country. The industry has now concentrated on irrigated land, where pasture production is more reliable.

To ensure the supply of fresh milk throughout the year, price incentives are offered to farmers to compensate for the higher cost of production during the winter. Normally the calving season is concentrated into the August--September period, in order to match the lactation

Table 19

DAIRY FARM STATISTICS 1979/80 (1969/70)

Shire	Dairy farms	Milking cows ('000)	Average herd size
Avon	110 (153)	11.9 (11.9)	108 (78)
Bairnsdale	55 (132)	4.7 (8.6)	85 (65)
Maffra	252 (346)	30.1 (32.7)	119 (95)
Tambo	36 (98)	2.6 (5.3)	72 (54)
	453 (729)	49.3 (58.5)	109 (80)

Source: Department of Agriculture

pattern of the cattle to the ready availability of pasture, thereby maximizing production.

Beef cattle

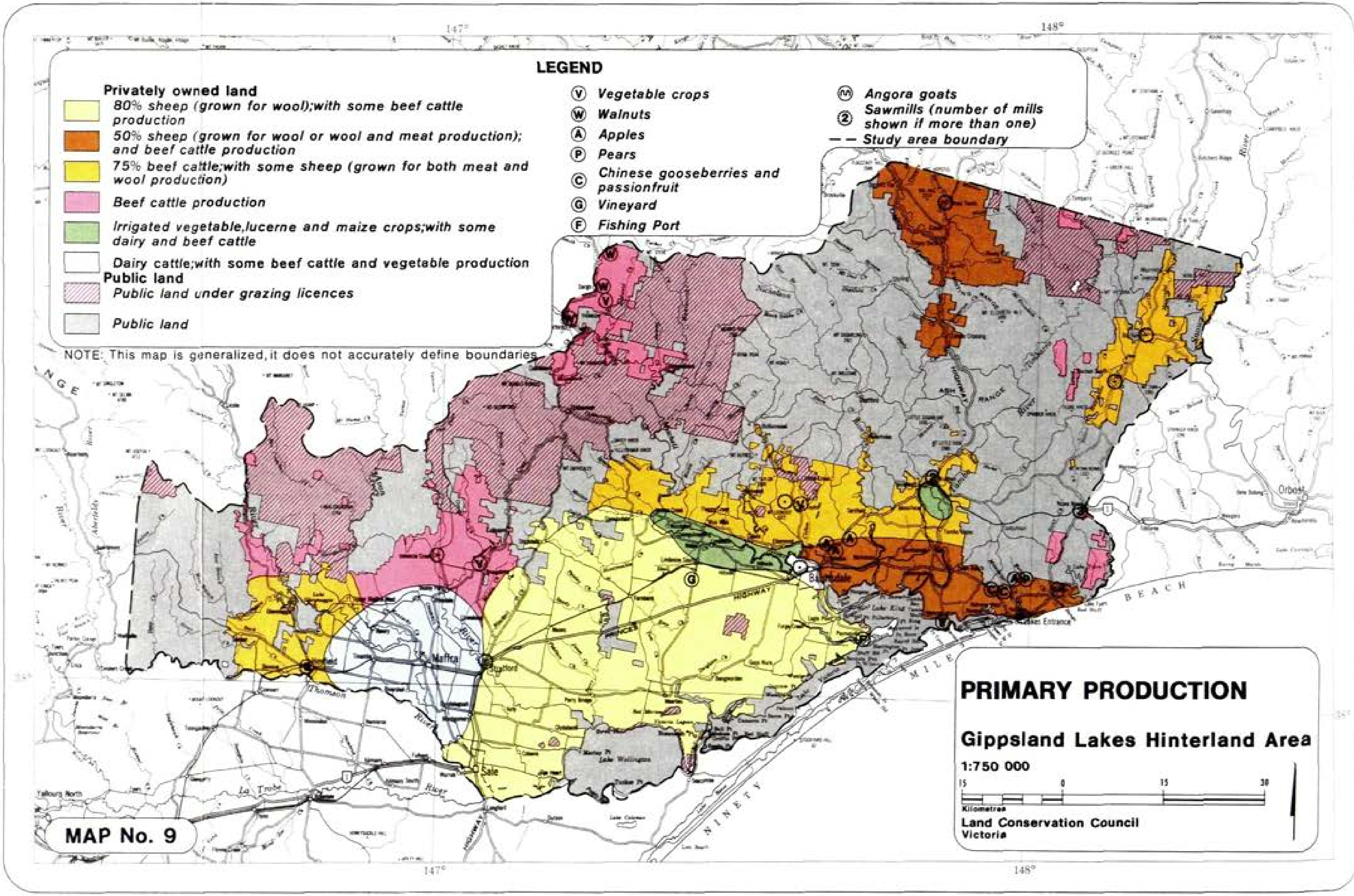
From a peak in the mid 1970's, the numbers of beef cattle in the area declined steadily to about 112,000 head (4.3% of State total) in March 1979. This reduction has been due to a combination of the lower profitability of beef compared with sheep and the unfavourable seasonal conditions.

Map 9 indicates the proportional usage of freehold land for beef or sheep production. (These proportions are based on the dry-sheep-equivalent capacity of the areas - using the ratio of one beast being equivalent to one beef animal or 10 dry sheep.)

On the irrigated pastures in the south of the study area, the few beef cattle enterprises mainly fatten stock for market and vealer production. Elsewhere, the proportion of beef cattle to sheep varies: from about 20% cattle, on the plains in the south, to all cattle on the pasture lands in the mountain valleys. Here, the industry is based on breeding herds (primarily Herefords) producing weaner calves for the autumn sales.

Forest grazing

More than 25% of public land in the area is held under some form of grazing


LEGEND
Privately owned land
80% sheep (grown for wool);with some beef cattle production
50% sheep (grown for wool or wool and meat production); and beef cattle production
75% beef cattle;with some sheep (grown for both meat and wool production)
Beef cattle production
Irrigated vegetable,lucerne and maize crops;with some dairy and beef cattle
Dairy cattle;with some beef cattle and vegetable production
Public land
Public land under grazing licences
Public land
Ⓥ Vegetable crops
Ⓦ Walnuts
Ⓐ Apples
Ⓟ Pears
Ⓒ Chinese gooseberries and passionfruit
Ⓖ Vineyard
Ⓕ Fishing Port
Ⓜ Angora goats
② Sawmills (number of mills shown if more than one)
Study area boundary
NOTE: This map is generalized, it does not accurately define boundaries
147°
148°
Maffra
Stratford
Sale
Bairnsdale
Lakes Entrance
Orbost
Thomson
La Trobe
River
HIGHWAY
PRINCES
NINETY
MILE
BEACH
PRIMARY PRODUCTION
Gippsland Lakes Hinterland Area
1:750 000
15
0
15
30
Kilometres
Land Conservation Council
Victoria
MAP No. 9

right. Map 9 shows the larger areas of public land subject to such grazing right. Many other areas are too small to show at this scale of mapping but are nonetheless important for such things as horse paddocks close to towns.

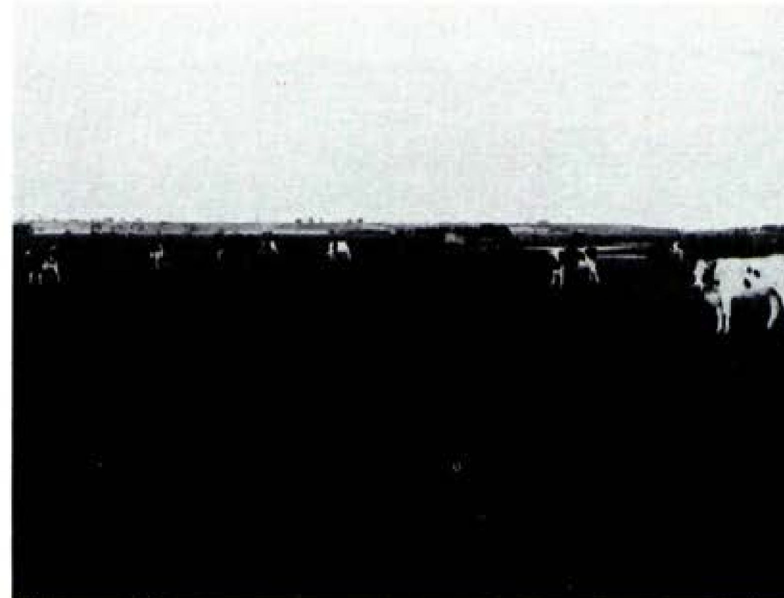
Three major systems of granting grazing rights apply:

* grazing licences granted by the Department of Crown Lands and Survey for a period of 1 year (although they can be issued for a 21-year period), with or without restrictions on cattle numbers and usually renewed annually (this applies to about 80% of the grazing rights)

* annual grazing licences granted by the Forests Commission for blocks on reserved forest, with or without restriction on numbers

* agistment granted by the Forests Commission on reserved forest, generally for a shorter term, with fees set on a per-head basis (the Lands Department can also issue agistment permits)

In most cases, the licensee, on application, is usually granted the same grazing block year after year. The numbers of cattle run on a grazing block each year may vary - depending on market conditions, feed conditions on the licensee's freehold, and the condition of the blocks. Some blocks may not be used for several years; in others, grazing conditions may deteriorate due to the growth of scrub species.



Cattle grazing irrigated pasture near Stratford

For the majority of the licensed blocks in mountainous areas, the topography and vegetation restrict grazing to the flatter ridge-tops or the flats and lower slopes in valleys.

The Fisheries and Wildlife Division may allow seasonal grazing of certain areas under its control in order to reduce fire-hazard conditions. The Nyerimilang Estate, now under the control of the National Parks Service, is a long-established grazing property that a local

Beans grown for processing

grazier continues to use, by arrangement with the Service. Similarly, a property belonging to the Gas and Fuel Corporation, adjoining Lake Victoria, is farmed by an adjoining landholder. Land owned by the State Rivers and Water Supply Commission at Tabberabbera is also held under grazing licence.

Sheep

The number of sheep throughout the State reached a peak in the early 1970's, but declined to about 22 million towards the end of the decade. This tendency was reflected in the study area, where some 423,000 head (2% of the State's total) were recorded in March 1979.

Wool production from Merino sheep is the main industry on the drier plains between Stratford and Bairnsdale. In the foothills, the proportion of sheep to cattle falls, and around Ensay farmers run sheep and cattle in almost equal proportions.

A significant contribution is made to farm income by the sale of surplus sheep, and some properties produce prime lambs for the market.

Pasture improvement, with the introduction of subterranean clover and application of superphosphate, has lifted the carrying capacity of the southern plains area from about two sheep per hectare in its native state to ten sheep per hectare. Productivity per sheep has also increased, due to better nutrition and breeding.

Vegetable production

From an industry that, 20 years ago, was based almost entirely on beans, vegetable production in the study area has expanded and diversified and is likely to continue to do so, provided suitable markets can be found.

Mild climatic conditions and the availability of irrigation water make the fertile alluvial river flats prime vegetable-growing sites. Some thousand hectares of such land on the Mitchell River flats, near Lindenow, are devoted to vegetable production, and in 1980/81 yielded a gross income of approximately $2.6 million. A smaller area is located on the Tambo River at Bruthen, and some vegetables are also grown in the Macalister Irrigation District, at Briagolong and Dargo, and in a few frost-free areas near the coast.

Victoria's main area for the growing of beans for processing is on the Mitchell River flats. Other summer crops grown here and elsewhere in the study area are beans for seed (at Dargo) and vegetables such as sweet corn, capsicums, tomatoes, and gherkins. In the cool season, the brassicas (cabbages, cauliflowers, broccoli, and brussel sprouts) are grown.

Most vegetable production is under contract to food processors based in Melbourne; no processing industry exists in the study area itself.

Cropping

Of some 2,000 tonnes of maize harvested in the State during 1978/79, 95% came from within the study area. The crop is usually grown on the river flats under irrigation and is used for stock feed locally or for processing. The area sown to maize has increased over the last few years and further expansion is expected.

Availability of improved cultivars and reasonably good prices for grain have led to an increasing interest in the growing of cereal crops (wheat and barley)in the area. About 2,000 ha are at present being sown to cereals each year.

The summer rains that prevail in eastern Gippsland make the area ideally suited to the growing of lucerne; some 1,200 ha were planted in 1979. The lucerne may be grazed, or cut for hay production for subsequent on-farm use or to be sold as a cash crop.

Orchards east of Bairnsdale and near Lakes Entrance produce apples, pears, passionfruit, and Chinese gooseberries, and also fruit-tree nursery stock for orchard supplies. Near Dargo, walnuts are grown commercially in orchards,

Gherkin cucumbers being graded and packed while those collected from the trees scattered throughout the township are sold on a community basis. Many of the walnut trees grow on public land water frontages.

Small vineyards near Lindenow South and Lakes Entrance are at present the only commercial wine-producers in the region.

Sweet corn on the Mitchell River flats

Apiculture

The apiculture industry depends on the introduced honey-bee *Apis mellifera*. This social insect collects and stores quantities of plant nectar as a carbohydrate food source. The excess is harvested as honey. In the process, the bees also collect pollen on specially adapted hairs on their rear legs. Pollen is a protein food that they store, along with the nectar, for feeding. The pollination activity of honey-bees, particularly in relation to agriculture and horticultural crops, is probably more important than their commercial value as producers of honey.

Commercial bee-keeping is a 'migratory' industry. Operators truck their hives to areas of high nectar yield, following the honey flow of different eucalypts. They also travel to over-wintering areas where the bees can build up their stocks of pollen.

While 45 apiarists regularly operate in the study area, this number could increase greatly in seasons when prospects are much better there than in other parts of the State.

The bulk of Victorian honey is sold to large processors, who clarify and pack it for export and for the home market. Most bee-keepers also maintain a small local trade in their own areas. About half the annual Australian production is exported, mainly to the United Kingdom, but popular honeys such as yellow box are almost entirely consumed by the home market.

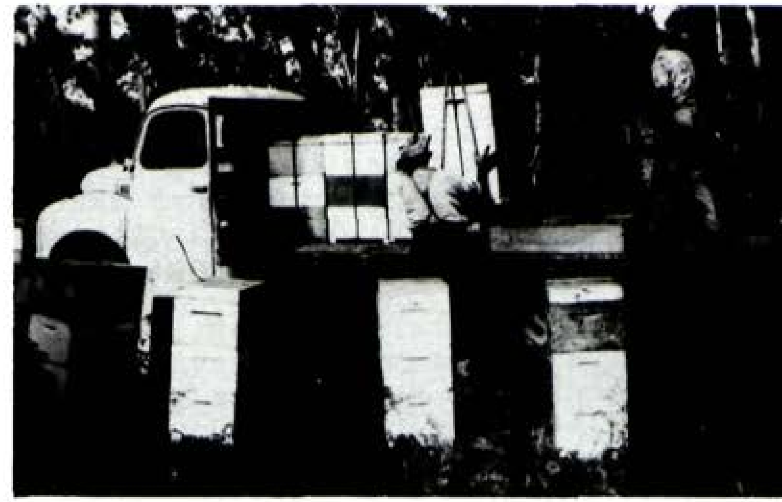
Apiarists also harvest quantities of beeswax, a product with many uses, including cosmetic and polish manufacture.

Honey valued at almost half a million dollars and beeswax worth around $10,000 are produced here annually. This is the value of direct production within the area and does not take account of production elsewhere following build up and preparation of bees in the study area. It is estimated that about 5% of Victoria's honey products come from the study area. However, this proportion is extremely variable and could range up to 90% of the State's annual production in years when heavy flowering occurs in the forests of this area but poor honey flows are found elsewhere.

Important plant species

Eucalypts are the most important honey-producing species, but others - which do not produce high nectar yields or on their own produce a poor-quality honey - can be particularly important for brood rearing. These include wattles, hop bush, banksias, tea trees, bottlebrush, and sweet bursaria. The following species are the main eucalypt honey flora.

Yellow box regularly yields nectar to produce the best-quality honey in Australia. Bees do not collect its pollen,



Loading hives in the coastal forest

however, and would deteriorate without access to an alternative source.

Red ironbark yields copious quantities of nectar to produce first-grade honey but, like yellow box, produces little pollen.

Red box produces a good-quality honey, but nectar flows are unreliable. Virtually no pollen is yielded.

Fuzzy box is a valuable species supporting an average production of 50 kg of choice honey per hive in an average to good season.

Gippsland grey box yields moderate quantities of nectar that produces a light-coloured, mild honey. Pollen yields are poor.

Mountain grey gum produces abundant pollen and occasionally gives a honey crop of medium grade.

Forest red gum is usually a poor source of nectar, yet at times it can produce a reasonable yield of material that makes a good-quality honey. Good quantities of pollen are produced in spring.

Messmate is most useful for building up bee colonies in autumn and providing winter stores from the copious yields of pollen in late summer and autumn. Nectar flows are unreliable, but can give good honey crops at intervals of 7-8 years.

Blue gum produces a medium- to good-quality honey as well as good supplies of pollen.

Silvertop produces a poor-quality thin honey, but yields abundant supplies of pollen.

White stringybark produces good-quality honey and prolific amounts of pollen.

Bee hives placed on private land adjoining forested public land

Red stringybark is variable in its productivity of both nectar and pollen. It produces a medium-grade honey.

On agricultural and horticultural land, lucerne and seed crops and various clovers are important sources of nectar and pollen. Declared noxious weeds, such as blackberry and thistles, are also important sources. A potential disadvantage in utilizing any of these plants lies in the application of pesticides - to protect the former group and kill the latter - that can rapidly decimate a whole apiary.

Licensed bee-keeping on public land

On private forested and agricultural land, siting of hives is by arrangement with the land-owner. On reserved forest the Forests Commission issues bee-farm and range licences. A licence covers an area with a 1.6-km radius, which has good access, satisfactory vegetation, and a supply of water. Temporary bee sites may also be licenced.

The Department of Crown Lands and Survey operates a similar system of licences on unreserved Crown land.

The study area currently contains 19 bee-farm and range licences plus a large number of temporary sites. However, the numbers do not accurately reflect the use of public land for honey production, as many sites on private property work the adjacent public land. It has been estimated that, for every site on public land, up to a dozen bee-keepers could be using this land from private property.

COMMERCIAL FISHERIES

Gippsland Lakes

The Gippsland Lakes have always been a source of fish for both food and recreation. Gippsland's original inhabitants - the Aboriginal people of the Kurnai tribe - were skilful fishers, using spears, nets, and fish pens. The concentration of their camps around the lakes indicates that they came to rely upon this plentiful food supply. In fact the lakes fisheries were so prolific and dependable that the Kurnai rarely needed to move far afield in search of food.

The first white settlers fished both for the table and for relaxation. It was not long, however, before they realized the potential of the lakes' fisheries and began to utilize them in a more intensive fashion. Thus began, more than 100 years ago, commercial fishing in the region.

Commercial fishing received a boost when a rail-head was established at Sale, in 1879. From that time fish caught in the lakes were transported by steamer (from as far east as Lakes Entrance) to Sale, whence they were railed to Melbourne.

With the establishment and upgrading of the Princes Highway, the importance of the Gippsland Lakes as a supplier to the Melbourne fish market increased markedly.

By 1919, commercial fishermen had an annual catch of 434,000 kg of black bream - then and now the most important species harvested from the Gippsland Lakes - as well as a variety of other species such as mullet, flathead, salmon, and garfish. From then on, the commercial catch declined steadily until by 1940 it had decreased to 19,500 kg, a decrease of 95% in 21 years.

This decrease resulted when the lakebeds lost the water plant known commonly as eel grass (*Zostera* sp.). The *Zostera* beds are important to the bream fishery, because they act as a nursery area for immature fish and provide habitat for the shellfish and other species important as food for the bream.

Not until the late 1950s did *Zostera* again become established over much of the floor of the lakes - the reason or reasons for this regeneration are the subject of some conjecture.

With the return of the *Zostera* beds, the bream catch increased to the point where, in 1973-74, commercial production exceeded 486,000 kg.

The Gippsland Lakes currently form Victoria's second-largest estuarine fishery, with about 35 full-time fishermen, based in Lakes Entrance, Paynesville and Met-

Fishing from bark canoes on Lake Tyers (c. 1886)

Packing fish for delivery to Melbourne (late 1800's)

ung, producing about 500 tonnes of fish annually. This catch represents something less than 10% of the State's total fish production.

In this multi-species estuarine fishery, methods, fishing gear, and boats have not altered greatly over the last 20 years. The major methods used are gill netting, seining, and stake netting. Of the species caught, black bream, yellow-eye mullet, luderick, tailer, and European carp predominate. Fish are boxed and then sent in either iced or refrigerated containers to the Melbourne fish market. Transport and sale are arranged by either fishermen's co-operatives or the individual fishermen.

The Fisheries & Wildlife Division, which is responsible for the management of this and all other Victorian fisheries, considers that the current level of commercial fishing does not significantly deplete fish numbers. It further believes that this level of commercial fishing, involving fewer professional fishermen than previously licensed, coupled with regulations as to where and when they may operate (the lakes are closed to commercial fishing from 10.00 a.m. Friday to sunrise Sundays) ensures that an adequate share of the fish stock is available to recreational anglers.

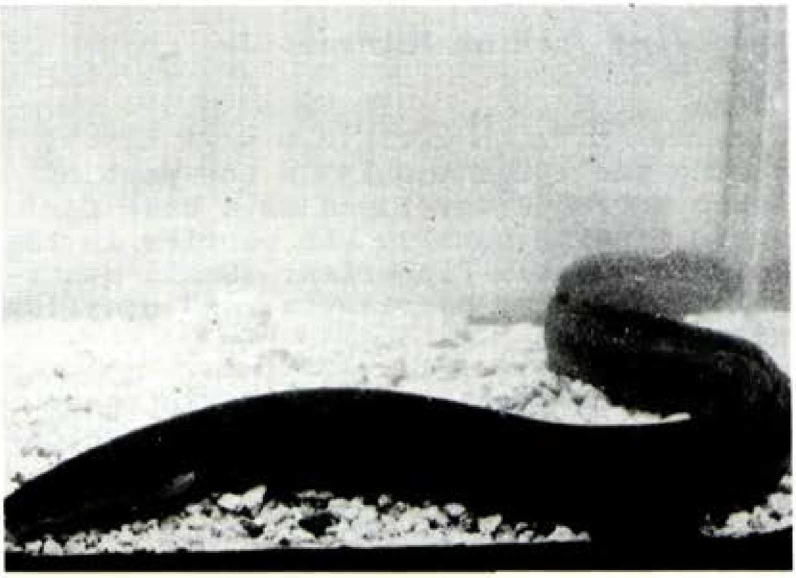
A number of licensed bait fishermen also operate in the lakes, collecting sandworm, shrimp, crab, prawns, and shellfish for sale as fishing bait to anglers. This small industry may employ up to 12 operators at any one time.

Over the years, there have been a number of attempts at farming Sydney rock oysters in the Gippsland Lakes, and a group of Lakes Entrance fishermen is currently using a number if sites east of Metung for experimental farming. It is too early at this stage to accurately assess the success or otherwise of the venture.

Fresh water

The area supports only a relatively small fresh-water fishery, with short- and long-finned eels as the major commercial species. These species have been commercially exploited since the early 1960s, but usually only two or three fishermen operate in the area at one time. In 1975 the value of the annual catch was approximately $35,000. Short-finned eels are the most valuable; they are snap frozen and smoked, and mostly exported to Europe. The long-finned eel is sold to local commercial fishermen for bait.

Fisheries regulations allow eel-fishermen to operate in all lakes, dams, swamps, etc. south of the Great Dividing Range, but do not allow them to work in streams flowing into the lakes system. They may work in the lakes themselves, but do so only occasionally, because the eels are only rarely concentrated in commercial quantities.



The long-finned eel

Unloading fish at Paynesville

Ocean

During the 1920s and 1930s the port of Lakes Entrance developed as a base for boats fishing outside the barrier in the inshore coastal fisheries. Small quantities of shark, barracouta, and crayfish were landed.

After World War 11, the Lakes Entrance fleet expanded further with the development of the Danish seine trawl fishery, which exploited the sizeable trawl grounds found on the continental shelf at the eastern entrance to Bass Strait. By 1980 this fishery was producing between 2,500 and 3,000 tonnes of demersal fish - mainly school whiting, flathead, morwong , and gemfish. Most of the school whiting is exported to Japan: the remainder is sold as fresh or processed fish in Victoria and New South Wales.

In 1968 Australia's only fish-meal plant was established on Bullock Island at Lakes Entrance. This plant is based on purse-seining for anchovies and pilchards in inshore waters within 3 to 5 kilometres of the coast. The industry supplies up to 20% of Australia's fish-meal needs.

Although Lakes Entrance fishermen had for many years been aware of the presence of scallops along the Ninety Mile Beach, it wasn't until the decline of Port Phillip Bay scallop-beds that any serious attempt was made to exploit this fishery. During the mid 1960s, commercial scallop-beds were located in the ocean waters adjacent to Lakes Entrance. These and more-recently discovered beds have supported a profitable scallop industry.

A sandbar seaward of the entrance restricts the vessels using Lakes Entrance: the depth of water and wave size limit the draught and thus the size and operating range.

Dredging is carried out by the Ports and Harbours Division with the aim of making the port safe for the present fishing fleet. Even with this restriction.

Lakes Entrance is currently Victoria's largest fishing port, and on occasions has been the largest fishing port in Australia on the basis of weight of fish landed.

Reference

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MINING AND QUARRYING

This chapter should be read in conjunction with Map 11 (Mining and Quarrying).

Minerals

The search for minerals played an important role in the early settlement of Gippsland, although the amounts won from the area covered by this report were relatively small.

Since 1965, 40 mineral exploration licences have been granted over both public and private land, either wholly or partly within the study area. Of these 13, covering a total area of 3,794 sq km, remained current in November, 1981. In addition, 13 applications for licences covering a further 6,790 sq km are pending.

Recent mining within the study area has been restricted primarily to the production of small quantities of iron ore and kaolin; most of the current mining tenements (Table 20) are located on public land.

Gold

Payable quantities of gold were taken from most of the rivers of the area and from many reefs during the gold-mining era - between 1854 and World War 1.

The greater proportion of reef gold in the study area has been found in rocks of Ordovician age; although some has been found in reefs in the Snowy River volcanics, in thin quartz or kaolin seams intruded in joints in the lower Avon River Group of shales and sandstones (north of Briagolong), and in reefs associated with the Woods Point Dyke Swarm.

A gold mine on Yahoo Creek - a tributary of the Nicholson River - is managed as a tourist attraction.

Silver and lead

These minerals are associated with barite (a barium mineral) in the basal part of the Buchan Caves limestones, and with the Snowy River volcanics and subsequent intrusive rocks from the early Devonian period.

There are no known large concentrations of the minerals; they have been found only as small veins and in the crystalline linings of small cavities in the country rock.

Table 20

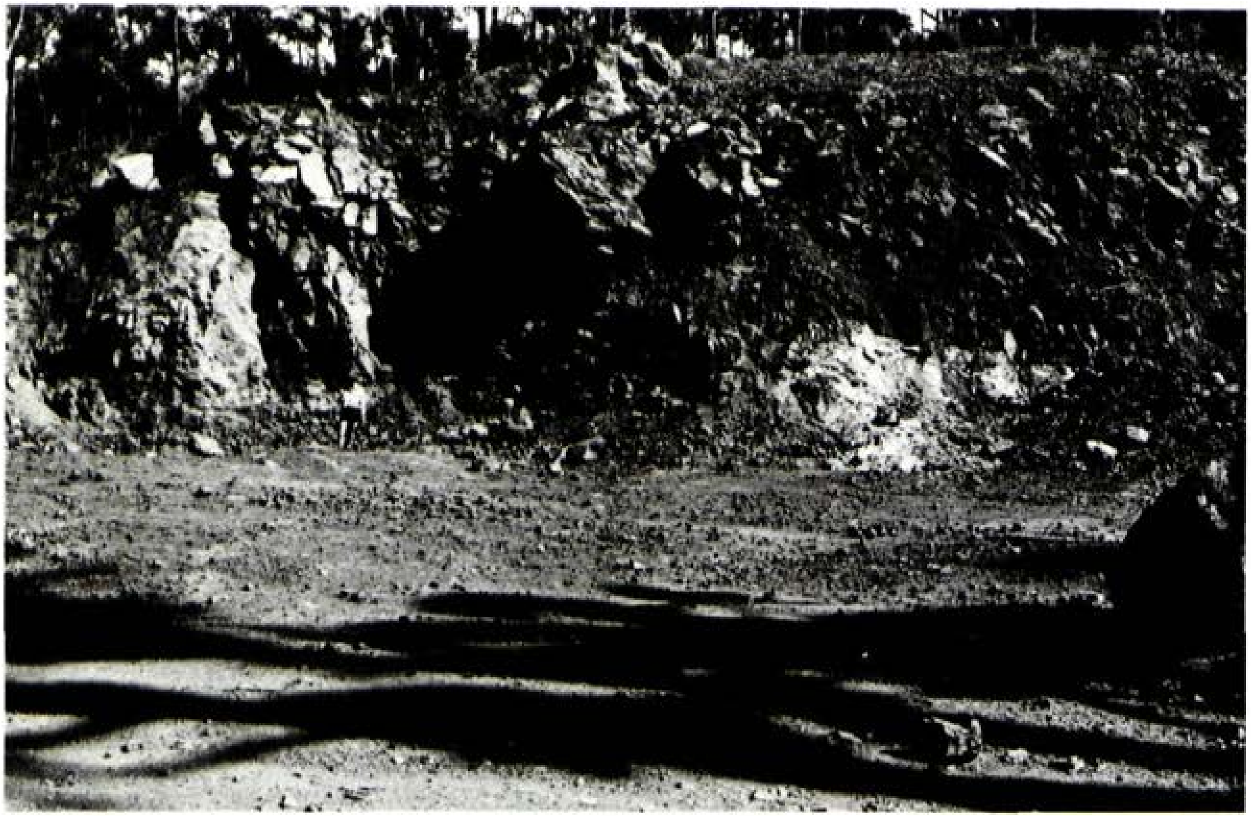
MINING TENEMENTS, NOVEMBER 1981

Tenement type	No.	Parish	Area (ha)	Mineral	Expires
Mining lease	149	Kooroon	28.4	gold	28/7/88
" "	411-1	Nowa Nowa South	8.7	iron	renewal application
" "	494	Kooroon	2.3	gold	28/7/88
" "	536-1	Nowa Nowa South	15.9	iron	9/10/82
" "	614	Tinamba	3.0	kaolin	3/6/86
Gold-mining lease	5650	Quag-munjie	30.9	gold	6/9/86
Mineral lease	8788	Buchan	7.6	iron	29/5/83
Miner's Right Claim	271	Butgulla	1	gold	11/10/82
"	792	Butgulla	1	gold	11/10/82
"	858	Butgulla	1	gold	20/7/82
Mineral search licence	1954	Bullumwaal	40	nickel, cobalt, gold	13/8/82
" "	1955	Bullumwaal	40	silver, bismuth molybdenum, platinum	13/8/82
" "	2028	Bullumwaal	40	gold	Nov.'82
" "	2118	Moornapa	40	gold	Nov.'82
" "	2241	Butgulla	40	gold	4/10/82

Active exploration for silver and lead is continuing in the Buchan area, although earlier mining here has met with little success.

Iron

A number of bodies of magnetite and haematite iron ore and manganese ore



Iron ore open-cut mine north of Nowa Nowa

have been found, both separately and together , in the Buchan-Nowa Nowa area. They occur, together with jasper and quartz, along major shear zones in the Buchan Caves limestones and in the Snowy River volcanics.

Occurrences of iron in the Nowa Nowa area have been known since 1876, but their extent remained unknown until after aero-magnetic mapping of the area in 1951, and subsequent ground magnetic surveys and drilling. The largest deposit, 8 km north of Nowa Nowa, contains some six million tonnes of high-grade magnetite--haematite ore. However, it lies beneath an overburden of hard rhyodacite between 25 and 80 metres thick.

Several attempts to develop the deposits have been made. The current lessee has been operating since 1961, and had extracted a total of 23,500 tonnes of ore up to 1980. The ore has been used both for heavyweight concrete and as a flux in the recycling of steel. It is currently under investigation to test its suitability for use in black-coal washing plants - to separate impurities from the coal.

Between 1955 and 1960, almost 11,000 tonnes of limonite was extracted from a quarry at Buchan. The deposit had formed within the Buchan limestones from a leached and weathered pyrite ore body. Limonite was used for cleaning coal gas, but the operation ceased in about 1959 when black coal was no longer used for gas production.

Copper

Intermittent mining of a copper-nickel sulfide ore body has taken place at Coopers Creek - just outside the western boundary of the study area. The host rock is a dyke of the Woods Point Dyke Swarm; a similar dyke swarm that may also contain copper sulfides occurs to the north of the study area - around Tabberabbera.

Copper has been found in some quartz reefs around Buchan, but the known values are low; and to date the red beds of the Avon River Group of sediments have also shown only low values, although the environment appears suitable for the formation of copper ore bodies.

Tin

Alluvial tin is found as cassiterite in the alluvium along tributaries of Dead Horse Creek, east of Bruthen. The surrounding granite pluton is the likely source of this mineral, but it is not known whether the ore is dispersed throughout the alluvium or is restricted to buried channels. Two shafts were sunk into the area late last century and the grade of tin from the samples varied from 0.7 to 2.7 kg per cu m of tin ore. No tin production from this area has been recorded, however. A lack of adequate water has proved a major impediment to development of the field.

Other metallic minerals

Lenses of manganese ore have been found in tuffs of the Snowy River volcanics. It is thought that these deposits might have been precipitated in small lakes (bog ore). They average some 45% of manganese, but the sizes of the deposits do not justify exploitation.

Small amounts of molybdenum and tungsten (occuring respectively as molybdenite and wolframite) were mined near the Tambo River early this century.

Minor deposits of platinum and antimony (occuring as jamesonite and stibnite respectively) are found around Buchan, while arsenic, bismuth, cobalt, mercury, and nickel occur near Bullumwaal.

Prior to 1978, no modern techniques of mineral exploration were undertaken in areas away from the then-known occurrences. At present, however, substantial work is being carried out by exploration companies in the search for base metals (copper, lead, and zinc) and for deposits of copper--molybdenum.

Oil and Gas

The Gippsland sedimentary basin, part of which lies across the southern lowlands of the study area, is rich in oil and gas. Great amounts of land-derived organic matter were preserved within these Gippsland basin sediments, providing the source material for oil formation.

Between 1925 and 1950, a small onshore reservoir of oil tapped near Lakes Entrance produced some 8,000 barrels of heavy crude oil. Subsequent onshore exploration for commercial hydrocarbons has to date been unsuccessful, although it is highly probably that other accumulations of oil and gas do occur.

The most productive oil-fields of the Gippsland basin and those with the greatest potential are located offshore. In 1979, Australia was producing almost two-thirds of her crude oil requirements and 94% of this came from the Gippsland basin. At the same time, the basin was supplying 48% of Australia's natural gas usage.

Within the basin's rock strata, three distinct sequences of sedimentation, described below in order of deposition, have been identified, each with its own sedimentation and structural history and each with a potential to contain hydrocarbons.

Strzelecki Group

This Group extends, below the surface, as far north into the study area as Stratford and Lakes Entrance. Although 35 petroleum exploration wells have been drilled into the Group, it has only been partly prospected, as it has yielded no significant hydrocarbon and shows no indications of reservoir rock.

Latrobe Valley Group

This Group occurs below the surface and has approximately the same distribution in the southern part of the study area as the Strzelecki Group, which it overlies. Excellent reservoirs of oil and gas exist in fields in the sandstones at the top of this formation, and smaller fields and pools exist throughout the Group.

Marine shales of the Lakes Entrance Formation of the Seaspray Group provide the seal for the reservoirs at the top of the Latrobe Valley Group. The smaller fields throughout the Group are sealed by coal and shale beds.

The major fields occur offshore - possibly because fresh water entered the margins of the basin along the onshore intake areas and flushed most of the hydrocarbons eastwards into their present locations.

Probably though, dry gas and even heavy tarry oils (under tight sand deposits) may exist in shallow accumulations towards the margins of the Gippsland basin - particularly within the Latrobe Valley Group and where the reservoirs have been protected from fresh-water flushing.

Seaspray Group

The lower levels of the Seaspray Group of sediments - the Lakes Entrance Formation of marine shales - provide the seal over the top of the extensive oil and gas fields of the Latrobe Valley Group.

The Seaspray Group extends across the lowlands of the study area (see Map 11). Except for near Lakes Entrance, however, no significant quantities of hydrocarbons have been encountered to date, either onshore or offshore, to warrant immediate commercial exploitation.

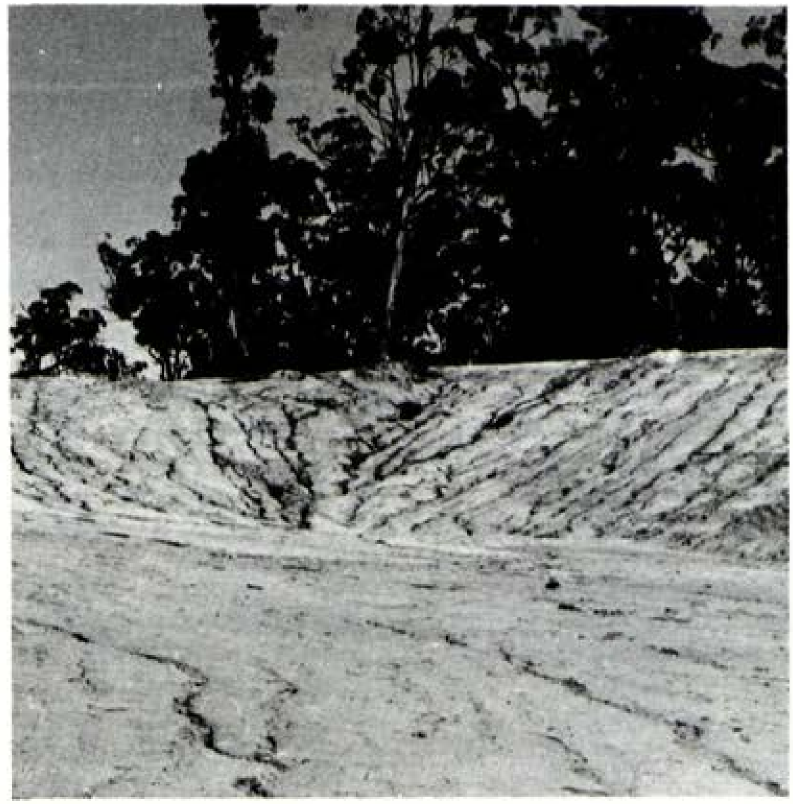
Coal

Applications for exploration licences have been lodged with the Department of Minerals and Energy by groups interested in assessing the coal-production potential of the coastal hinterland.

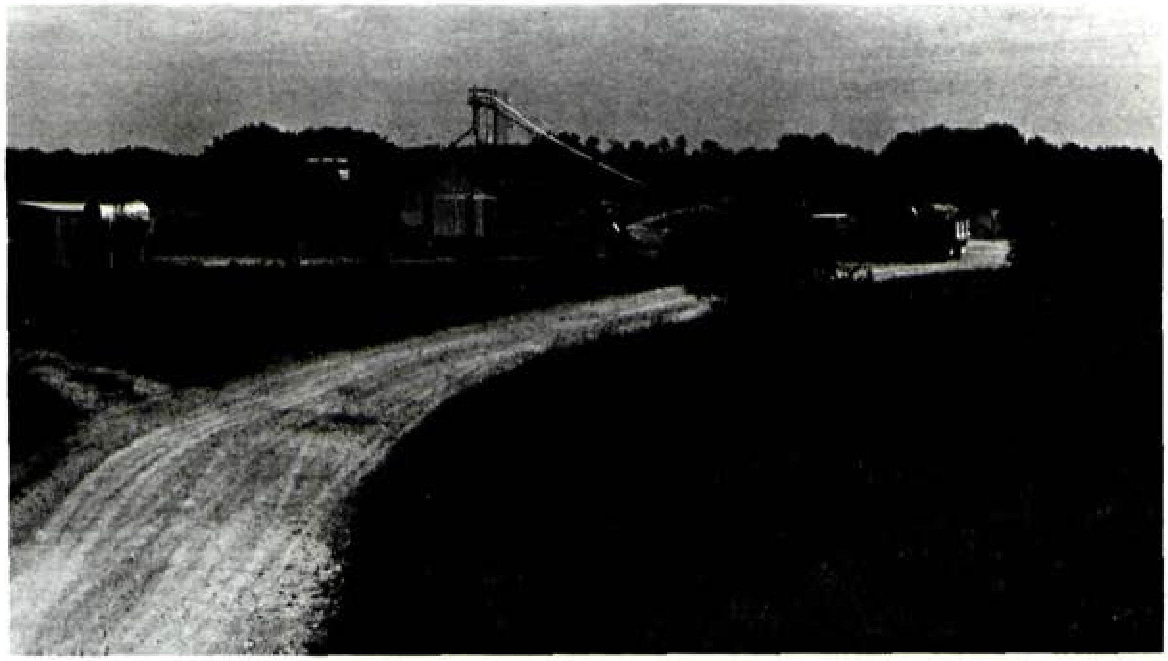
Stone and Extractive Industries

Extractive industries on Crown Land and private land are subject ot the provisions of the *Extractive Industries Act* 1966, and those in reserved forest are subject to the provisions of the *Forests Act* 1958.

Permits to search for 'stone' - the definition of which under the *Extractive Industries Act* 1966 includes building stone, rock of any kind, quartz, slate, gravel, sand, earth, or other similar materials - are issued by the Department of Minerals and Energy. For the purposes of commercial extraction, the Department issues leases on Crown land or licences on private land.



This gravel pit north of Bairnsdale is one of many small ones located on public land throughout the study area



At times of low flow, gravel is extracted from the bed of the Avon River

Municipal authorities and the Country Roads Board are non-commercial bodies, hence their stone-extraction activities are not subject to leases or licences under the *Act*. They are, however, subject to licensing under the *Forests Act* 1958 if the quarry is in reserved forest. Both the *Soil Conservation and Land Utilization Act* 1958 and the *Land Act* 1958 regulate extractions of less than 2 m depth.

Most of the stone extracted in the Gippsland Lakes hinterland comes from private land and is used primarily by the Country Roads Board and municipalities for the construction and maintenance of roads - although there is some

Table 21

MINERAL AND STONE PRODUCTION

Material	Quantity (tonnes)	
	1978/79	1979/80
Iron ore	8,409	1,791
Kaolin(unrefined)	291	604
Limestone	15,699	16,941
Crushed and broken rock	65,384	79,000
Gravel	93,490	129,000
Sand	23,494	45,000
Earth and Soil	1,170	-

usage by the constuction industries in the main urban centres.

Table 21 indicates the types and quantities of mineral and stone that were extracted in the study area during the periods 1978--79 and 1979--80.

Sand, gravel, and crushed rock for roadworks form the bulk of material extracted and most is utilized within the area. (Minor quantities are transported to East Gippsland, the Latrobe Valley, and Melbourne.)

The major stone quarries are located on private land within relatively short distance of the major population centres in the south.

Municipal authorities - as a group - use the largest quantity of stone in the area. Table 22 shows the quantities of stone that the shires and towns throughout the Gippsland Lakes hinterland required for the year ended June 1980.

Figures in the table only indicate the level of dependence on public land - the quantities vary from year to year with the locations of the work and finance.

The City of Sale extracts most of its gravel from a site in the Shire of Rosedale (outside the study area).

To some extent, distances to the work sites determine the location of many of the quarries used by shires. Quarrying of stone is a small proportion of the cost of roadworks; transport to the work site is a major consideration. In late 1981, the transport of stone cost 10¢ per tonne per km.

Table 22

MUNICIPAL GRAVEL AND STONE REQUIREMENTS 1979/80

Municipality	Quantity (m^3)	Percentage supplied from public land
Bairnsdale Shire	73,000	31
Bairnsdale Town	30,000	0
Tambo Shire	37,000	40
Avon Shire	16,000	4
Maffra Shire	40,000	31
Omeo Shire (in part)	7,000	14
Total	203,000	

In the north, the area contains a large number of small gravel pits - primarily on public land. These are used by the Forests Commission, shires, and logging contractors for roadworks throughout the area; many are 'one-off' pits used for a particular portion of a road.

The larger quarries are primarily in the south of the study area, may be located on either private of public land, and

Table 23

MAJOR STONE QUARRIES

Location	Private or public land	Nature of stone	Usage
Tom Creek	public	sand	private contractors - construction
Yellowmans Knob	public	rhyolite (crushed)	Shire of Bairnsdale and Country Roads Board - roadwork
Flaggy Creek	public	sandstone (crushed or broken)	Mitchell River Improvement Trust - stabilization work on Mitchell River and Clifton Creek
Sandhills	public	sand	Shire of Bairnsdale and private contractors - roadwork and construction
Nowa Nowa	public	rhyodacite (crushed or broken)	Ports and Harbors Division - stabilization and construction Victorian Railways - ballast General roadwork in the vicinity and to the east
Mississippi Creek	public	pink granite (broken)	Breakwater and groyne construction at Lakes Entrance
Granite Rock	public and private	granite (crushed or broken)	Ports and Harbors Division - stabilization and construction
Beds of the Avon and Mitchell Rivers	private	river gravel (coarse or crushed)	Three quarries supplying roading and general-purpose aggregate and river stone
Glenmaggie	private	basalt (crushed)	Aggregate to Loy Yang
Valencia Creek	private	sandstone (broken)	Macalister River Improvement Trust - stabilization work

supply a variety of products. Table 23 lists the major quarries in the area and indicates their usage.

Limestone

Devonian limestones outcrop in the Gippsland Lakes hinterland at Buchan, at Tabberabbera, and in the south-west of the area near Toongabbie. Tertiary limestone outcrops are worked in the south-east of the area at Hillside and Toorloo Arm.

Devonian limestones

In the Buchan area, a linear outcrop of Devonian limestones extends 26 km from Buchan South to north of Murrindal, chiefly on private land. Marble, with a range of colours from golden vein and various greys to black, was quarried from this outcrop over many years and has been used in numerous buildings. Up to 1948, Buchan marble had been used in 28 buildings in Melbourne, including the Melbourne Town Hall, Shrine of Remembrance, State Library, and National Museum.

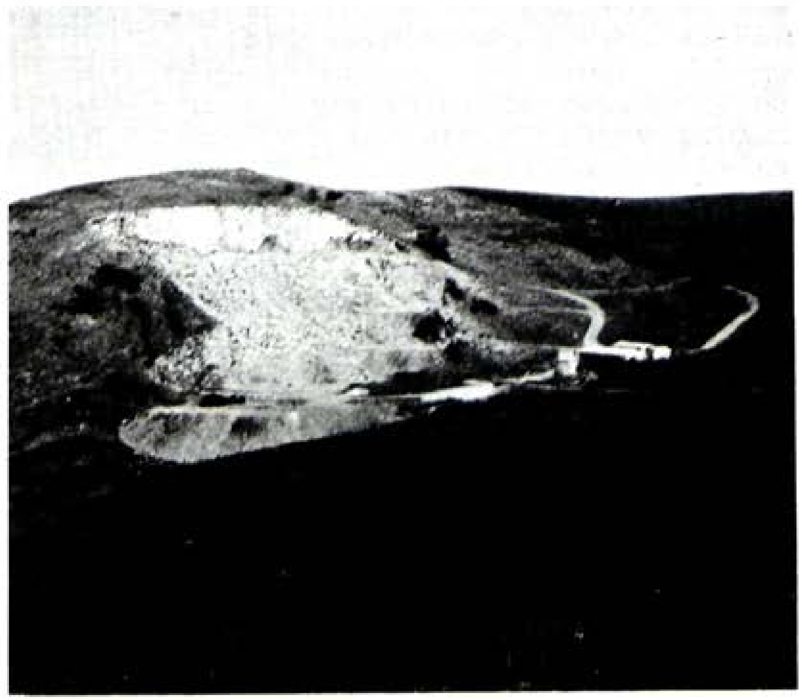
The Buchan Group limestones may be divided into three formations, two of which (described below) have commercial value.

The lower Buchan Caves limestone consists of dolomite, dolomitic limestone, and limestone, free of interbedded mudstones. Available reserves are of the order of 200 million tonnes of high-economic-grade limestone (up to 96%, but averaging 75% of calcium carbonate).

The younger Murrindal limestone contains thick beds of high-grade limestone interbedded by mudstone. Available reserves are of the order of 35 million tonnes.

Besides producing building stones, these Buchan deposits are suitable for most lime--consuming industries. Agricultural lime, from crushed limestone, has been supplied from sites south and east of Buchan.

A quarry in the Murrindal limestones, on private land (Rocky Camp), is the only



Limestone from this quarry north of Buchan is crushed and burnt into lime for use in the paper-making process

one operating at present in the Buchan area. The crushed limestone is roaded to Nowa Nowa, then railed to the Australian Paper Manufacturers Ltd mill at Maryvale, where it is burnt into lime for use in the paper-making process.

Another quarry at Buchan South (Camerons) has also supplied the same material and both have yielded building stone.

In the Toongabbie area, limestone outcrops in public land on Deep Creek, in the south-west corner of the study area, but it has not been quarried.

This outcrop is an extension of a fossiliferous grey limestone formation (Boola Formation of Lower Devonian origin), which has been quarried for ornamental stone near Toongabbie, outside the study area. The reserve here totals 17,000 tonnes, and similar formations have been quarried at Coopers Creek and Tyers River to the west.

In the Tabberabbera area, Lower Devonian marine limestones (Tabberabbera Formation) - interbedded with siltstones and sandstones - outcrop in a north--south belt. This Formation has little economic potential.

Tertiary limestones

Gippsland limestone outcrops along many streams and lakes between Bairnsdale and Orbost. It consists of fossiliferous marl (a calcareous mudstone) and limestone containing about 67% calcium carbonate. Outcrops of this formation are quarried at Hillside and Toorloo Arm, on a relatively small scale, to produce agricultural lime.

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WATER UTILIZATION

The study area is relatively well endowed with good-quality surface water, most of which is generated to the north of the area in the highlands. Only a small proportion of this is actually used for either urban or irrigation purposes.

Although stream flows are more uniform here than in many other parts of the State, usage is still constrained by their seasonal nature. Thus, if acceptable river flows are to be maintained, scope for increasing utilization of surface water resources will remain only limited without construction of additional storages.

The area also has a significant groundwater resource, which varies in quality and accessibility. Notwithstanding its potential for a number of uses, with a few notable exceptions this resource remains substantially under-utilized.

Current Water Use

Water use in the study area currently totals approximately 210,500 megalitres per annum, of which 200,000 ML is used for irrigation purposes and only 10,500 ML for urban supplies.

Urban water supplies

The need for a satisfactory water supply for Bairnsdale and surrounding districts was recognized late last century. In 1890 the Bairnsdale Irrigation and Water Supply Trust was constituted. This Trust planned to construct a weir on the Mitchell River immediately below its junction with Stony Creek and to transport water via a system of channels, flumes, and bridges. Although considerable problems arose during construction work, the scheme was eventually completed in 1893. It never operated, however, because of repeated flood damage to the weir.

In 1913, the Maffra Waterworks Trust - one of the first of such bodies - commenced activities. Today, 11 Waterworks Trusts and a Local Governing Body provide reticulated water supplies to more than 40,000 people in urban centres throughout the study area. Table 24 sets out details of the various domestic supplies. The State Rivers and Water Supply Commission is responsible for the financial and technical supervision of the activities of these water supply authorities.

Table 24

URBAN WATER SUPPLY

Water Trust or supply authority	Towns supplied	Source	Population served	Annual (1979) consumption (ML)	Treatment
Bairnsdale W.T.	Bairnsdale Lucknow Wy-yung	Mitchell R.	10,100	2,519	Clarification and chlorination
Briagolong W.T.	Briagolong Boisdale	Groundwater	550	47	None
Bruthen W.T.	Bruthen Wiseleigh Mossiface	Tambo R.	800	73	Sedimentation and iron removal
Buchan W.T.	Buchan	Buchan R.	280	39	None
Heyfield W.T.	Heyfield	Thomson R. and Macalister R. ex S.R. & W.S.C. channel	2,000	565	Chlorination
Lakes Entrance W.T.	Lakes Entrance Kalimna	Nicholson R.	4,600	857	None
Lindenow W.T.	Lindenow Lindenow South Walpa	Mitchell R.	365	55	None
Maffra W.T.	Maffra	Macalister R.	4,850	800	Clarification, filtration, and chlorination
Metung W.T.	Metung	Bulk supply from Lakes Entrance W.T.	500	115	None
Paynesville W.T.	Paynesville Eagle Point Raymond Island	Bulk supply from Bairnsdale W.T.	1,900	240	Clarification and chlorination by Bairnsdale W.T.
Sale Local Governing Body	Sale	Groundwater	14,250	5,000	Aeration, clarification, filtration, & chlorination
Stratford W.T.	Stratford	Macalister R. ex S.R. & W.S.C. channel	1,050	130	Clarification and chlorination

A rock barrage across the Mitchell River is designed to prevent the salt water from Lake King reaching the point where water is taken off for domestic use in Bairnsdale

Surface waters provide the source of supply for 10 of the Waterworks Trusts. On the whole this water is of good quality, requiring little or no treatment prior to reticulation. Groundwater is used to supply the towns of Sale, Briagolong, and Boisdale. Drawn from the Boisdale Formation aquifer system, it can be used without treatment at Briagolong and Boisdale, but the water at Sale has high turbidity and iron content, which necessitate its treatment by settlement, aeration, and neutralization prior to reticulation.

The Bairnsdale Waterworks Trust supplies a population of 10,000 (as well as selling water to the Paynesville Waterworks Trust) from an off-take located close to the town on the Mitchell River. Downstream of this off-take is a barrage across the river, designed to prevent the ingress of salt water from Lake King to the pump installations. The barrage is not completely watertight, however, and consequently it is difficult to maintain water quality during periods of low flow in the river. The Trust now intends to replace the existing pumping plant with a pipeline offtaking from a low diversion weir to be constructed upstream near Glenaladale. This would avoid both the salinity problems and the present risks of pollution of the town water supply by agricultural drainage from the Mitchell River flats.

Irrigation

Irrigation also commenced in the early years of this century. At first farmers

Bruthen Waterworks Trust facilities next to the Tambo River

Concrete irrigation channel in the Macalister Irrigation District

pumped direct from the rivers, but droughts, particularly that of 1914, led to demands for construction of storages to provide a more reliable supply. This pressure came mainly from land-owners along the Macalister and Avon Rivers, where subdivision had resulted in small holdings.

Construction of a concrete dam on the Macalister River, which has a larger and more reliable flow than the Avon, commenced at Glenmaggie in 1919. Completed in 1926, this has a capacity of 130,750 ML.

Meanwhile, the Main Northern Channel running east from Glenmaggie was constructed to serve properties in the

Newry area, and a tunnel through a ridge delivered water to land on the western bank of the Avon River. The first irrigation delivery was made in the Boisdale area in 1925. Within the next few years this system was extended southwards to properties near Sale.

The Main Southern Channel system, also built during this period, supplied irrigation water to land north of Tinamba, and in 1939 it was extended to the Riverslea area.

Irrigation was extended after World War II, with the establishment in 1948 of the Central Gippsland Irrigation Area, immediately south of the Thomson River. This included the Nambrok--Denison Soldier Settlement Area.

During the 1950s, extensions of the irrigation systems supplied the Newry North, West Boisdale, Nuntin, The Heart, and other small areas now incorporated in the Maffra--Sale Irrigation Area.

In an exceptional flood in 1952, the Thomson River formed a breakaway course through a series of meander depressions - beginning at a point where the river emerges from the foothills onto the river plain and continuing eastwards for about 10 km, to rejoin the original course near the town of Heyfield. To control flow in the breakaway course (known as Rainbow Creek) and also to enable diversion of water for irrigation in the Nambrok--Denison area via the

Spray irrigation of bean crops on the Mitchell River flats

Cowwarr Channel, the controlling authorities built the Cowwarr Weir at the point where the breakaway course began.

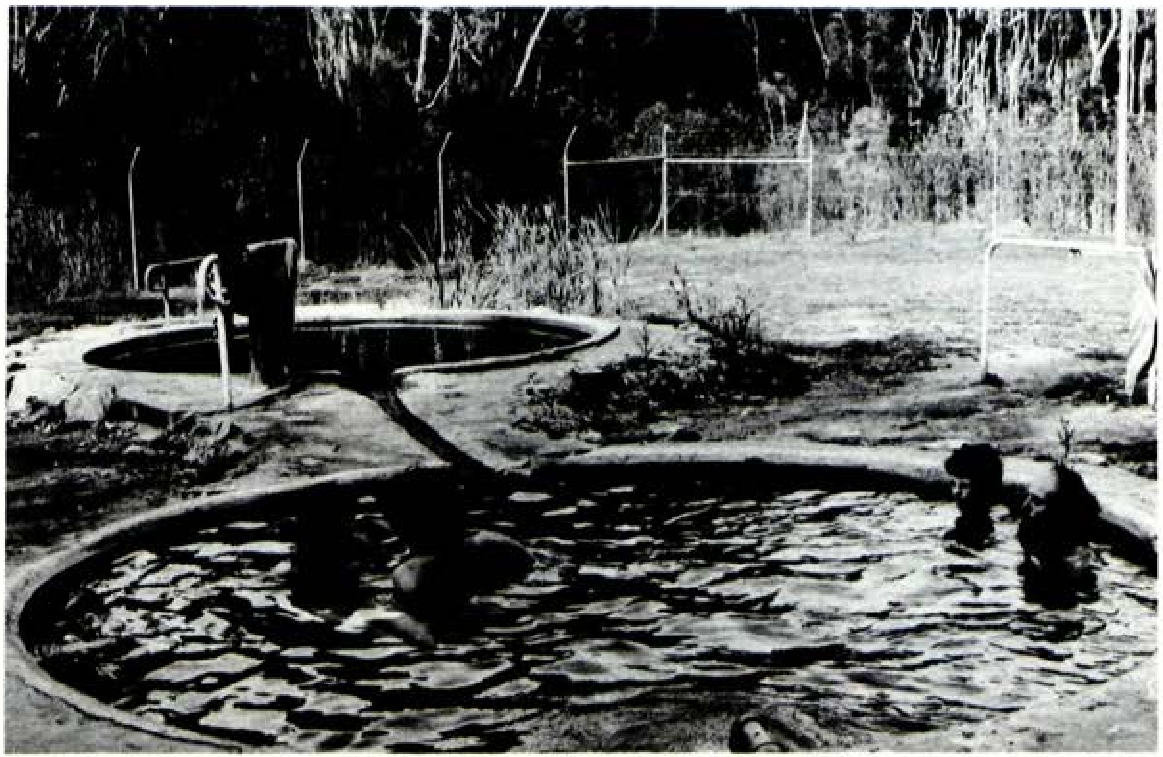
Provision of control gates on the spillway, in 1957, increased the capacity of Lake Glenmaggie to 190,300 ML to meet the additional water demand from the irrigation district.

In the early days of irrigation in the Macalister District the water was used for sugar beet, maize, lucerne, and fodder crops. From the mid thirties, a gradual change to perennial improved pasture (ryegrass and clover) took place and at present 90% of the irrigation supports this type of pasture. The rest supplies native and annual pasture, fodder crops, lucerne, cereal crops, and some vegetables. The perennial pasture is used almost entirely for the grazing of dairy cattle.

Demand for water in the Macalister Irrigation District is subject to wide fluctuations, but normal seasonal requirements are approximately 190,000 ML, of which the Maffra--Sale Irrigation Area uses 130,000 ML and the Central Gippsland Irrigation Area 60,000 ML. This water is distributed via more than 650 km of channels and 10 km of pipeline. Most channels are earthen, the exception being about 37 km of concrete-lined channels on the permeable soils of the Avon River flats near Boisdale.

The irrigation season extends from August to May each year, although in exceptionally dry years it has started as early as June.

Diversion for irrigation by pumping direct from streams has increased over the



Hot groundwater feeds these baths near Metung (the water is drawn from an oil exploration bore put down in the late 1920s) years, and at present all streams in the study area (with the exception of the Snowy River) are committed to the extent of available summer flows, other than for domestic and stock purposes. Further diversions would be available on the condition that on- or off-stream storage is provided, to store excess winter stream flows.

Rostering of pumping from the streams is generally required during low flows in the summer months. The degree of severity increases in accordance with a scale of restrictions ranging from Stage 1 to Stage 5. (Stage 1 represents pumping under a roster system, without restriction to the normal allocation, Stage 2 a roster system with 75% of normal allocation, and so on down to Stage 5 when there is no water available for diversion.)

Appendix 8 gives details of authorized diversions for irrigation, domestic and stock, and industrial use for the major stream systems within the study area.

With the exception of the Mitchell River and to a lesser extent the Avon River, where vegetable crops are irrigated, most of the diversion is to pasture.

Of the 200,000 ML of irrigation water used in the study area each year, about 30,000 ML is groundwater. While the great majority of authorized extractions from groundwater (see Appendix 9) are on the coastal plain between Sale and Bairnsdale, the most significant use occurs along the Mitchell River flats. Here, approximately 3,000 ha of vegetable crops and pasture are irrigated - 2,000 ha under licensed diversion from the river and 1,000 ha from underlying shallow aquifers. Some overlap of the areas irrigated occurs between the two sources of supply.

Future Water Use

As stated above, present commitments are such that without the construction of additional storages no significant increase in utilization of surface water could be contemplated. The Mitchell River dam at Tabberabbera is the only additional storage approved for the study area, and its purpose is essentially to safeguard existing irrigation development on the Mitchell River flats rather than to allow expansion of such development. It will also provide a regional storage for future urban and industrial development.

Many parts of the study area, however, have scope for increased utilization of the groundwater resource. Depending on the properties of water from particular aquifers, groundwater could be used for a variety of purposes - ranging from domestic consumption to the provision of hot spas for recreational or 'health farm' developments.

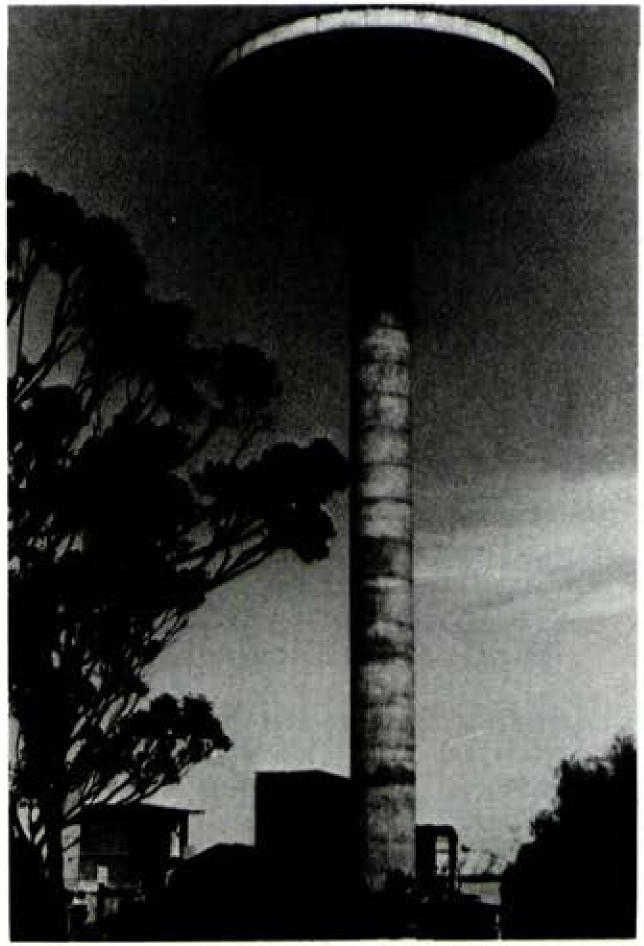
It has been suggested that further utilization of the shallow aquifers along the Mitchell River flats, associated with their artificial recharge during periods of high river flows, would achieve the same results as the impoundment of surface water in the proposed Mitchell River dam. This proposal is currently under investigation.

The major potential for future additional utilization of the surface water resources of the study area lies in the proposed coal-based industrial expansion in the Latrobe Valley. All industries using brown coal require moderate to substantial quantities of water, not all of which can be provided from the Latrobe River system.

Under the high development scenarios, and assuming present or planned water-use technologies and adopting existing environment protection policy standards, the water resources of the Latrobe catchment become virtually committed by the year 2000. Lower rates of development will defer this date, but it seems inevitable that, at some time in the future, additional water will need to be obtained from outside the Latrobe catchment.

Some of the options being canvassed for the provision of that additional supply for the Latrobe Valley involve the use of water from the study area. They include the possibility of allocations from the Thomson, Macalister, Avon, and Mitchell Rivers, and an embankment on McLennans Strait to produce a controlled storage with a higher level and greater storage capacity than the natural Lake Wellington.

It must be emphasized that these options are still in their conceptual stages and would need to undergo rigorous investi-



Groundwater pumping station and water tower at Sale gation before they could be implemented. Any such inter-basin transfer of water, however, would involve decreases in the fresh-water inflows to the Gippsland Lakes system and would be likely to impose major ecological changes, especially on Lake Wellington. Unless further water storages were constructed it would also conflict with the existing commitments to irrigation and other uses.

River Improvement

The *River Improvement Act* 1958 provides for river improvement and maintenance works to be carried out and enables the constitution of river improvement districts under the control of an authority. Apart from such works, it also makes provision for carrying out drainage works and for rating lands within the district that such works benefit.

River Improvement Trusts have been formed for reaches of the Latrobe, Thomson, Macalister, Avon, Mitchell, and Tambo Rivers (see Figure 5), to carry out works to reduce the frequency and extent of nuisance flooding along these reaches.

UTILITIES

Often, the utilities and services essential to modern community living are located on public land. They may include facilites for transport, communications, navigation, power supply, waste disposal, or airstrips. This chapter describes the major utilities in the study area and attempts to assess future requirements in certain fields.

At present, no major easement for pipelines or power-lines traverse the study area. A television transmitter station occupies public land at Lakes Entrance and another is under construction on private land at Forge Creek. National and commercial radio services are broadcast from Sale.

Water supply is an important land use in its own right. This topic is fully discussed in Chapter 20.

Electricity supply

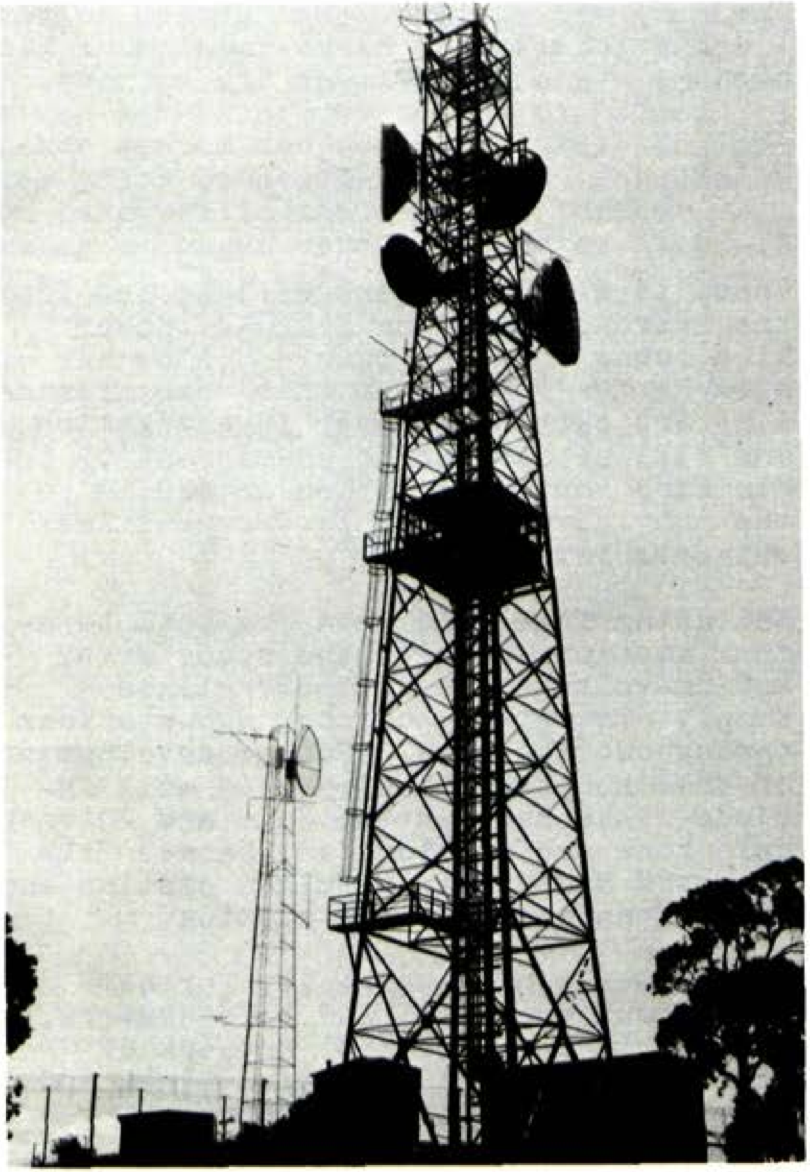
Although at present no high-tension (220-kV and higher) power lines cross the study area, the State Electricity Commission expects to locate new regional terminal stations near Bairnsdale and Montgomery.

These terminal stations will be fed from the Latrobe Valley by a 220-kV power line swung on steel towers. A number of alternative routes for this transmission line are currently under investigation and will be subject to assessment by the Ministry for Conservation according to the provisions of the *Environment Assessments Act*.

Radiating in a grid from regional terminal stations outside the study area, medium-voltage (66-kV) power lines supply electricity to zone sub-stations throughout the area. Future development of this sub-transmission grid will include links between the Sale and Bairnsdale zone sub-stations and between the proposed Bairnsdale terminal station and the Bairnsdale zone sub-station.

Distribution of electricity further throughout the area, and to consumers, occurs via a substantial network of 22-kV wood-pole distribution lines and 127-kV single wire-earth-return (S.W.E.R.) lines.

The great majority of the sub-transmission and distribution lines run in road reserves, although some of these and the



Telecommunication facilities on Mount Nowa Nowa; a fire lookout has been built into the main tower

majority of the S.W.E.R. lines are in easements - usually on private land.

The construction of power lines along the easements of existing road reserves ensures ready access for maintenance vehicles. In some cases, however, it may require the destruction of some roadside vegetation to meet the easement widths desired by the State Electricity Commission (see Table 25).

Table 25

AVERAGE EASEMENT WIDTHS FOR POWER LINES

Main transmission lines	40--70 m
Sub-transmission lines	15--25 m
Distribution lines	10--25 m

(In tall-forested areas, the respective easements may need to be wider.)

Railways and roads

The Victorian Railways Boards' Gippsland rail line passes through the study area. It transports goods and passengers as far east as Bairnsdale, and goods only between Bairnsdale and the railhead at Orbost. Another goods line, linking with the Gippsland rail line at Traralgon and Stratford, passes through Heyfield and Maffra.

The Country Roads Board (C.R.B.) has the responsiblity for constructing and maintaining the State's major road systems, including the Princes Highway, which traverses the southern portion of the study area, and the Omeo Highway linking Gippsland with the north-east of the State. Other main roads and forest roads also under the control of the C.R.B. link the settlements north of Buchan (and through Licola to Jamieson) with the highways to the south.

Some routes, declared as 'roads' by the C.R.B. and forming further links between settlements, come under the control of the respective municipalities. Other roads throughout the region are the responsibility of the Forests Commission and the municipalities - within their respective areas of control.

Apart from some improvements to existing alignments, there are no major highway projects planned in the forseeable future within the study area.

Road and railway reserves often contain significant remnants of the original vegetation, particularly where they pass through agricultural country, and often make an important contribution to the local landscape.

Airports.

The Commonwealth Department of Defence maintains the Royal Australian Air Force base at East Sale.

A major public aerodrome licensed by the Commonwealth Department of Transport and under municipal control is located near Bairnsdale. A similar facility is located just outside the study area, near Sale.

A number of authorised landing strips, including two near Lakes Entrance, are scattered throughout the area and are used by both agricultural and private aircraft.

Waste disposal

Disposal of the waste produced by urban communities is an increasing problem for municipalities and managers of public land. The selection of new sites can be difficult, as in many cases little public land remains near towns, and conflicts arise between waste disposal and the recreational and conservation pressures for the same areas.

The illegal dumping of rubbish on public land is of widespread concern, and even the licensed tips have caused problems with fire risk, windblown material, and unsightliness.

Throughout the study area, the disposal of solid waste is generally by the landfill method - using natural depressions, old excavations, or the trench-and-fill process.

Generally, the tips serving the major towns of the area are located on freehold land or on land specifically reserved for waste disposal. Both Buchan

Table 26

SEWERAGE AUTHORITIES

Sewerage authority	Population sewered	Method of treatment	Disposal of effluent
Bairnsdale	10,000	Existing: Screens, grit removal, primary sedimentation, secondary settling, sludge digestion; maturation of effluent in 0.6-ha pond on Macleod Morass Proposed: Further sedimentation tanks, trickling filters, sludge digesters, and additional maturation lagoons	Discharged to Macleod Morass
Heyfield	1,200	Two aerobic oxidation lagoons	Irrigation mainly in summer, with a ground-level storage to carry the winter effluent
Lakes Entrance	4,100	Sedimentation & sludge digestion in an Imhoff tank, followed by two trickling filters and sedimentation tanks in series and a polishing lagoon; digested sludge is disposed of in a liquefaction lagoon	Irrigation of golf course
Maffra -domestic	4,850	Two treatment plants: Plant A has two parallel streams: one is an Imhoff Tank; in the other, wastes undergo primary sedimentation followed by a trickling filter then to lagoons for irrigation	Irrigation of pasture
-industrial		Plant B treats milk wastes from two milk-product factories by sedimentation and trickling filter (in peak periods, this is supplemented by aeration with floating aerators on a lagoon).	Stored in lagoons, then irrigation of pasture
Paynesville	1,500 (plus high visitor influx)	Proposed works will consist of oxidation lagoons	Irrigation of pasture
Rosedale	1,500	Wastes pumped to L.V.W. & S.B. outfall, approx. 2 km south of town	By L.V.W. & S.B. (see below)
Sale	13,850	Wastes from Sale (including Wurruk) pumped to the L.V.W. & S.B. outfall sewer, approx. 8 km south-east of Sale	By L.V.W. & S.B. (see below)
Latrobe Valley Water & Sewerage Board		Wastes collected from several towns in the Latrobe Valley are treated in lagoons on Dutson Downs property	Disposal by irrigation and evaporation in Lake Coleman

Table 26 (continued)

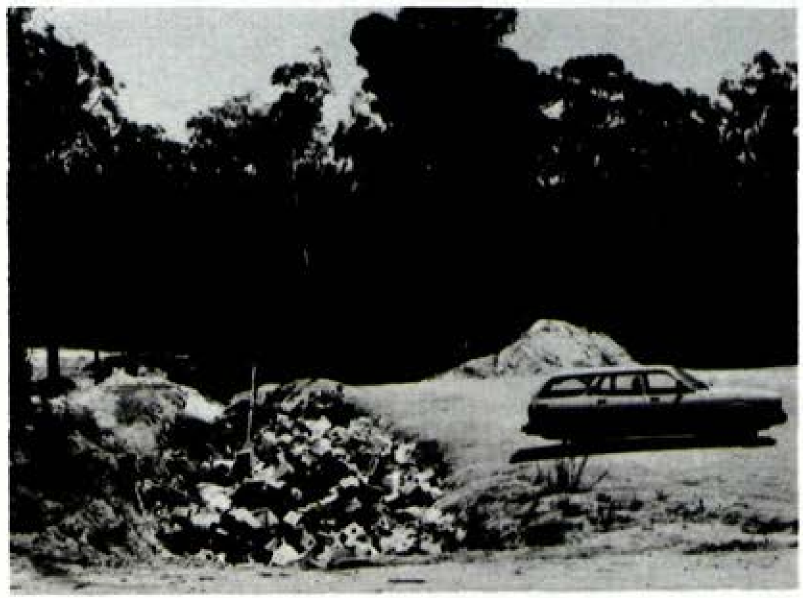
Sewerage authority	Population sewered	Method of treatment	Disposal of effluent
Proposed future works			
Lindenow		Proposals are for oxidation lagoons and disposal to a morass	
Metung		Proposals are for oxidation lagoons and disposal by irrigation/evaporation	
Stratford		Proposals are for oxidation lagoons and disposal by irrigation of pasture	

Source: State Rivers and Water Supply Commission, Local Authorities Branch.

and Bruthen townships, however, use licensed tips on public land. The City of Sale compacts refuse at a transfer station for subsequent transport to the tip some 10 km distant.

Sewage-treatment works processing both domestic and industrial waste operate for seven of the major population centres of the study area; a further three sewerage systems have been proposed. Disposal of the effluent from these systems is generally through irrigation works, although the Bairnsdale Sewerage Authority discharges effluent into swamplands near the town.

Land vested in sewerage authorities is not 'public land', according to the *Land Conservation Act* 1970. Further details on the sewerage authorities are set out in Table 26.



The Buchan rubbish tip located on public land south of the township

This slipway at Lakes Entrance is used for the maintenance of both commercial and recreational craft

Ports

The port of Gippsland Lakes (as gazetted under the *Marine Act*) includes the major Gippsland Lakes, which meet the ocean at Lakes Entrance, and the navigable rivers flowing into these waters.

As the port authority, the Ports and Harbors Division of the Public Works Department is reponsible for the design, maintenance, construction, and operation of all public harbour facilities on the port. These facilities include wharves, jetties, breakwaters, slipways, navigation lights, buoys, and other navigation aids. The Division also has responsibility for dredging and the construction and maintenance of foreshore protective works.

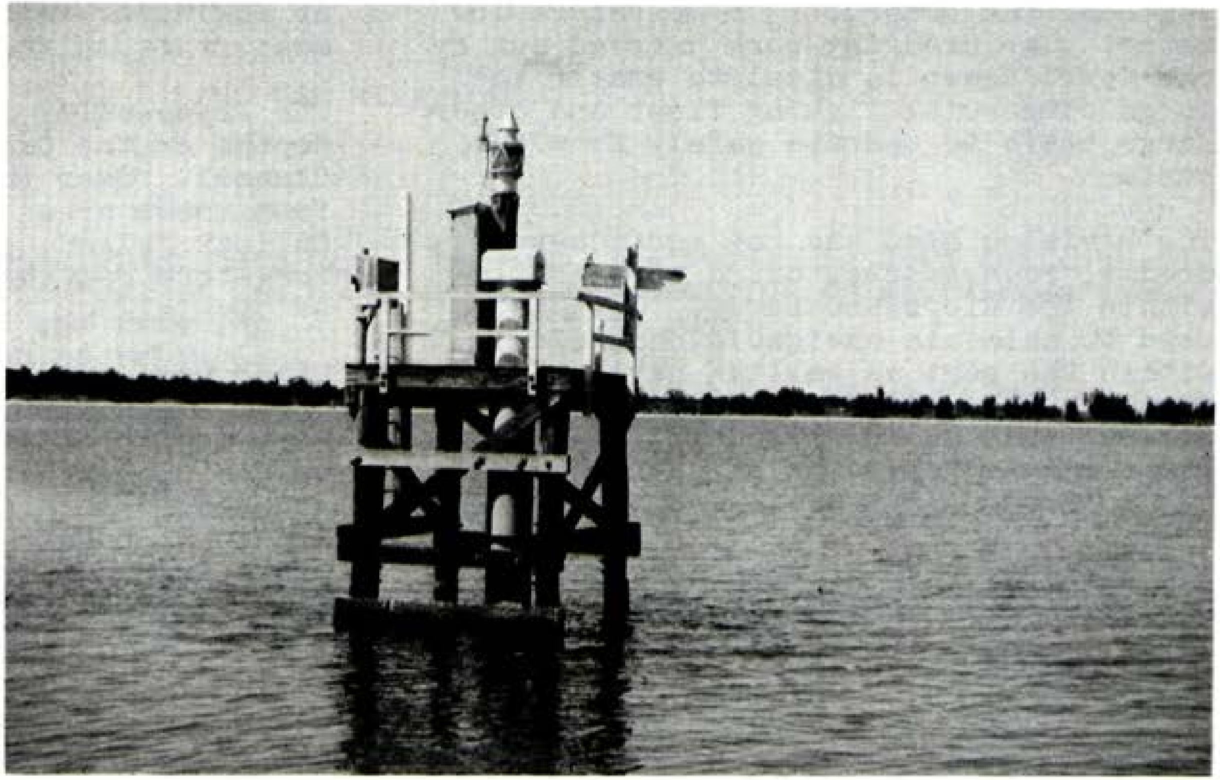
The Division maintains some 46 public jetties and wharves throughout the Gippsland Lakes and Lake Tyers, together with boat harbours at Lakes Entrance and Paynesville. These wharves and jetties have been largely provided for the fishing industry and for public landing purposes; boat harbours, which accommodate a large number of fishing craft, are also used by pleasure boats.

Three slipways are maintained at Lakes Entrance and four at Paynesville. The Lakes Entrance twin slipways accommodate craft up to 130 tonnes dead weight, while the large slipway at Paynesville accommodates craft up to 150 tonnes dead weight. All slipways are used by both commercial fishermen and the owners of pleasure craft.

A system of navigation lights is maintained throughout the Gippsland Lakes and this is supplemented by numerous jetty lights, beacon posts, buoys, and direction boards where required.

While most such navigation lights, beacons, and markers are located on water, several structures are based on land. The most important of these are listed below.

Old-style navigation light in McLennans Strait



* Mt. Barkly navigation light, situated on a lighthouse reserve at Jemmy's Point, is used by mariners in either making for Lakes Entrance or fixing position of the Entrance.

* The Entrance lead lights - situated on the east entrance pier and on the flagstaff or lookout on the dune between Cunningham Arm and Ninety Mile Beach - are the main guidance lights for mariners entering the Lakes from Bass Strait through and over the Entrance sand bar.

* The light-tower structure located at Hollands Landing, at the eastern end of McLennans Strait, supports a sectored light that enables safe navigation through the entrance channel to the Strait.

The sea-going dredge *April Hamer* which was especially designed and constructed for working on the Lakes Entrance Bar, spends approximately 6--8 months of each year at the bar in order to maintain adequate channel depths and widths. The aim is to maintain a minimum bar channel depth of the order of 3.6 metres at low water. Thr dredging work carried out by the *April Hamer* is vital to enable the large commercial fishing fleet and other large craft to operate safely from the port.

The Division also has one suction-type dredge, *Paynesville*, based permanently within the Gippsland Lakes. This is used to maintain navigable channels within the port as well as navigable depths at the entrances to the major rivers (such as the Mitchell, Nicholson, Tambo and Latrobe) and at both entrances to McLennans Strait.

All the more popular waterways are now provided with minimum depths of 2 metres at low water which is sufficient for most craft on the Lakes.

The *Paynesville* also maintains navigable depths in the Cunningham Arm and Reeve Channel. Over the years, dredge spoil from these areas has been pumped onto Bullock Island, enabling a programme of long-term reclamation and development of the island.

Other uses

Many public utilities and institutions occupy public land for such purposes as schools, cemeteries, trigonometrical stations, public halls, and depots. Small areas of public land are continually required for such uses.

LAND USE RELATIONS

Preceding chapters of this report have described the natural resources of the study area and discussed the existing and potential utilization of resources on public land. Hazards associated with these uses have also been considered.

Groups with a wide range of interests are making growing demands for resources on public land. In this situation the interaction of various uses becomes an important issue that must be considered before decisions can be made on the allocation of that land. This chapter examines the nature of the interactions.

Land use compatibility

Each type of land use requires a certain set of resources for its operation, and these have been discussed in relevant chapters. In many cases the resources required overlap in both time and space, thus providing a source of potential conflict. Moreover, the operation of each will have a series of direct and indirect effects on most other uses. These effects may be considered as:

* beneficial - resulting in an increase in another activity or activities (complementary uses)
* harmful - resulting in a decrease in another activity or activities (competitive uses)
* negligible - having no effect in either direction (supplementary uses)

The nature of these effects will determine the degree of compatibility between two or more land uses, and hence their ability to be combined in order to obtain the best combination of uses on a land management unit. In practice, there are several ameliorating factors, which include the following.

* Activities occur at different levels of intensity. (Incompatibility between two activities at a high intensity may be reduced if the operations of one become less intensive.)
* Some activities occur for a short period, thus restricting their effects and allowing other activities to continue in intervening periods.
* Often an activity only occurs in a small part of a wider area, thus localizing its effect. (This enables other activities to continue in the general area.)

* Compatibility between uses in an area changes over time as the once-harmful effects of one activity are lessened.

* Prevailing social attitudes towards the tolerance of harmful intereffects may change. (In some cases improved technology helps change these attitudes.)

* Skilful management techniques can reduce possible competitive effects of an activity on others.

Land use flexibility refers to the degree to which any one activity precludes (by its operation) other activities' utilization of a given resource. Flexible uses include those having either negligible or beneficial effects on others.

The following sections give a general outline of relations between broad land use categories in the study area. This report does not deal with relations between various activities or aspects within each major category of use, although the same principles would apply. Those between various forms of recreation, however, are briefly considered.

Agriculture

Clearing of land for agricultural production has benefitted some native animals by increasing the area of grassland and forest margins, while farm dams may have extended the range of some amphibians, reptiles, and birds. Nevertheless, agriculture is normally incompatible with most aspects of nature conservation, since most species are severly reduced in number or even eliminated by the removal of their habitat and the introduction of alien plants and animals.

On the other hand, agricultural activities have in many cases added visual variety to the landscape; for example, the cleared rolling hills and river flats at Dargo provide a contrast with the adjoining forested mountains.

Agriculture can affect water production, as the conversion from forest to grassland can alter the volume and timing of run-off, which in turn may lead to inreases in total water yield, turbidity, and salinity, as well as a reduction in summer stream flow. Pollution may also result from injudicious use of fertilizers and pesticides or from the concentration of stock near watercourses.

Forest grazing can conflict with nature conservation because of the disturbance to the environment caused by stock grazing and watering, and the introduction of alien plants.

It is also competitive with some forms of recreation that require natural environments and, by reducing the ground flora, which provides an important protein source for honey bees, it can compete with apiculture. With careful management, however, it may be compatible with catchment protection and water production in most environments.

Apiculture

Apiculture may complement agriculture, since the bees serve the useful function of cross-pollination.

Apiculture relies largely on the native flora and so is supplementary to timber production , recreation, water production, and some aspects of nature conservation. Bees do compete with native fauna for nectar and pollen, but the significance of this competition and its ecological effects remain largely unknown.

Hardwood timber production

This is a relatively flexible land use, particularly when carried out at only a low intensity. It is compatible with forest grazing, honey production, and all but the strictest forms of nature conservation. It can benefit some forms of outdoor recreation by providing access tracks for walking and pleasure driving.

Harvesting operations can immediately degrade vegetation, fauna, and landscape values. Most effects are temporary, but some could be long-term. Tree-felling becomes more noticeable as the size of the area increases and when most or all of the trees in a stand are cut. In mountainous terrain, harvesting may be visible some distance from the actual operation and so, at least temporarily, affects scenic values.

Increasing the levels of hardwood production decreases its compatibility with other uses, such as nature conservation, apiculture, and many forms of recreation. Intensive practices may favour certain commercially valuable species, remove trees containing sites for animal nesting (as these trees are often unmerchantable), limit the size to which trees are allowed to grow intensify harvesting activities, and require the increased use of fire.

Hardwood timber production in certain parts of the study area competes with recreational activities requiring solitude. It could also be considered to be in competition with agricultural production on those areas of forested public land that have potential for agricultural development.

Softwood timber production

Production of softwood timber in plantations is an inflexible land use. It is competitive with hardwood timber production, agriculture, nature conservation, apiculture, and some types of recreational activity. It can also compete with water production, as pine plantations may decrease water yields.

On the other hand, softwood plantations can add visual diversity to an area.

Also, because of their relatively open understorey, they provide good opportunities for picnicking and activities such as orienteering and camping.

Water production and conservation

The production of water is an important use of public land. To some extent it is competitive with agriculture, timber production, mining, and recreation (depending on the intensity of these uses, the management techniques employed, and the intended use for the water).

Activities such as logging, road-making, quarrying, clearing, and grazing can cause soil disturbance and reduce absorption by the soil, leading to increases in surface run-off, stream turbidity, peak flows, siltation, and erosion.

As well as contributing to stream flows, public land, particularly in the highlands of the Macalister, Avon, and Mitchell blocks, is an important source of groundwater - a valuable although underutilized resource in the Gippsland plains. Recharge of underground water supplies can be decreased if run-off is increased by clearing vegetation.

In many cases, activities using parts of catchments away from storage areas do not pose a substantial threat to either water quality or yield. The use of the land as a catchment is therefore normally complementary with nature conservation and , to varying degrees, with other activities.

Water storages increase the opportunities for some forms of recreation, such as lakeside picnicking and water-based activities.

Storages, however, can have adverse effects on nature conservation. Inundation by water obviously destroys the original habitat, and the storage may alter flow regimes, affect water temperature and oxygen content, and consequently aquatic and riparian vegetation and wildlife habitats downstream.

On the other hand, storages also create an aquatic habitat, supporting fish and waterfowl.

Compatibility between water utilization and nature conservation can be enhanced be design of structures and operation procedures.

Nature conservation

Nature conservation is generally compatible with a wide range of uses, such as water production, apiculture, and low-intensity recreation. It tends to compete with any activities that radically change the natural vegetation, such as mining, agriculture, urban development, or intensive forestry.

Excessive use for recreation is a problem in some areas of value for nature conservation, because these areas are often fixed in the public mind primarily as leisure resources. The other aims of parks and reserves (biological conservation, landscape preservation, research opportunities) can therefore be threatened. Areas set aside specifically for reference must be managed to exclude activities other than limited scientific study. This use is complementary with nature conservation and water production only.

Outdoor recreation

Outdoor recreation encompasses a wide range of activities. Their relations with other uses vary according to their type and intensity.

Some sports such as golf, horse-racing, and rifle-shooting require their own specialized areas and are therefore incompatible with most other uses.

Wilderness recreation is also incompatible with most other uses, as it requires both land where man's activities are minimal and also a low density of visitors, but is compatible with water production and nature conservation.

Most recreational activities are relatively flexible, however, and can be accommodated in areas managed primarily for other uses.

A single land use in a particular area may conflict with one type of recreation and yet complement another. For example an abandoned quarry may mar a panoramic view yet provide an ideal site for gem fossicking or riding trail bikes. Similarly, forestry tracks may reduce the value of an area for bushwalkers seeking natural surroundings, but make it more accessible for picnicking and pleasure driving.

Some pursuits such as adventure driving, fishing, and bushwalking can become self-competitive, especially at high usage rates.

Certain water-based activities such as swimming and water-skiing may be incompatible. Such conflict is to some extent alleviated by the zoning of certain sections of the Gippsland Lakes and Lake Glenmaggie for water-skiing.

Competition between recreational and commercial fishing in the Gippsland Lakes has long been a contentious issue. It has often been claimed, but never proved, that professional fishermen are depopulating the Lakes' fish

Urban and industrial uses

Urban areas contain a multitude of different activities that collectively are competitive in space with most non-urban uses, including agriculture, timber production, apiculture, water conservation, mining, and many forms of outdoor recreation. Moreover, the presence of urban areas - by intensifying the utilization of, or requirement for, most resources)- undoubtedly compounds the competition between many activities in adjacent areas of public land.

Extractive industries

Mining, quarrying, and shallow gravel extraction can be competitive with most forms of land use through site disturbance, roading, and pollution. Competition is usually localized, however, and its degree depends on the type and scale of operation. Underground mining does not usually involve as much site disturbance as open-cut mining or surface stripping, but dumping of waste material such as mine tailings may still conflict with other uses.

Many conflicts between extractive industries and landscape are localized, but they may be serious where values are high or the operations obvious.

On the other hand, some quarries provide the opportunity to study the local natural history, and open sites for the collection of fossils and gemstones.

Exhausted quarries and open-cut mines are often useful for water supply or rubbish disposal, or as sites for such recreation as trail-bike riding.

Public utilities and transport

Generally the provision of these services requires allocation of small areas of land only, but in most cases this represents an inflexible use.

Due to growing recreational pressures and more interest in nature conservation at a local level, waste-disposal problems are increasing. Most disposal sites are generally regarded as unsightly, sometimes produce offensive odours, and, if not carefully managed, may have detrimental effects on other uses such as water production.

Cleared easements for transmission lines or gas or water pipes compete with vegetation and some wildlife habitats, and may be unattractive; likewise the measures taken to reduce the risk of fire along transmission lines. Again, telecommunication facilities on peaks or ridges can conflict with scenic and other values, especially when constructed in attractive or remote landscapes.

These services and most others are generally considered essential. However, measures of compatibility with other land uses can be achieved by careful siting, location, and design to minimize the conflicts.

PART IV

BLOCK DESCRIPTIONS

BLOCK DESCRIPTIONS

In this part of the report, the study area has been divided into eight blocks. For each block, the location and land tenure, the nature of the land, present uses, capabilities for various uses, the present condition of the land, and likely land-use hazards are described.

A consistent format of headings and subheadings has been used to help the reader compare specific information for various blocks. Some sections deal only with the public land. These include vegetation, recreation, and wood production.

A key diagram at the beginning of each description gives the approximate location of that block in the study area, while Map 3 shows greater detail for all blocks.

'Capability' refers to the value of the land for the particular use to which it may be put. Present levels of use are described, where possible, to give some indication of capability. The potential productivity of land is important, particularly in the long term. For some uses (such as nature conservation) it is based primarily on inherent characteristics of the land. For others it also depends on inputs (such as fertilizer applications) that raise productivity.

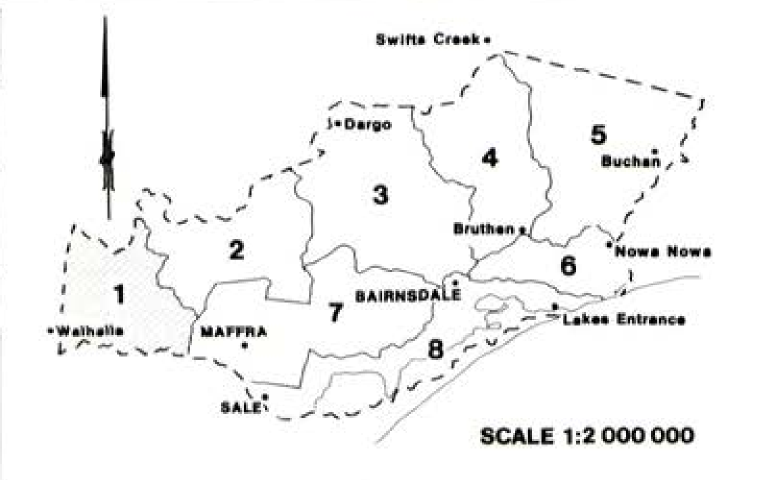
Capabilities are given in general terms only, because the amount of information available has varied from block to block and because some of the values have been difficult to quantify. In assessing capability, comparisons have been made with other blocks and with other parts of the State.

1. MACALISTER

A. General

1. Land tenure and location

Macalister block covers just over 80,000 ha. Public land occupies approximately 57,000 ha, the bulk of it is unreserved Crown land. Reserved forest accounts for around 22,000 ha, including the 160-ha Glenmaggie flora and fauna reserve north of Heyfield, which is reserved under section 50 of the *Forests Act*.



1. MACALISTER

Lake Glenmaggie covers an area of about 1,800 ha; all of this is public land, being owned by the State Rivers and Water Supply Commission. The Commission also owns approximately 250 ha surrounding the lake, which is under the control of a committee of management.

Many small Crown land reserves are scattered throughout the southern portion of the block. These - used for various public purposes - include gravel reserves, recreation reserves, and cemetery reserves.

B. Nature of the Land

1. Climate

This part of the study area exhibits the greatest degree of climatic variation, as the key parameters of rainfall and temperature show a marked gradient from the mountains in the west to the plains in the east.

The relatively high country between Walhalla and Mount Useful receives a mean annual rainfall of 1,200 mm, the highest in the study area. Rainfall decreases sharply as you move east to lower elevations, until at Heyfield, on the Gippsland plains, it totals only 619 mm. The Heyfield--Maffra--Sale area lies in a pronounced rain shadow, caused by the interception of rain by the mountains to the west.

Temperature variation is also related to altitude, with the lowest temperatures being experienced at higher elevations. Snow often falls in winter at elevations above 600 m, and at the highest point - on the slopes of Mount Useful - it could be expected to lie on the ground for up to a month. Average temperatures are considerably higher in the Heyfield--Glenmaggie area than in the mountains, especially during the summer; and unlike the coastal areas, this region has no tempering sea breeze.

2. Geology and geomorphology

Most of the block consists of Palaeozoic sedimentary rocks forming the dissected highlands to the north and west of Lake Glenmaggie. Remnants of Tertiary basalt flows occur as flat-topped ridges west of the Macalister River, and outcrops of Devonian rhyolite are located in the eastern part of the block. The residual of a prior landscape surface occurs as an elevated plateau situated in the north-western corner of the block.

Tertiary sediments, consisting mainly of sands and gravels, form a series of alluvial fans (piedmont downs) flanking the southern margin of the highlands. Terrace and flood-plain deposits of Quaternary age occur in the Heyfield district.

3. Soils

The highlands are characterized by uniform and gradational soils of various textures, with brownish loams and sandy clay loams being the most common. These soils can contain considerable amounts of gravel and on steeper slopes may be quite shallow. Gradational soils are more common on stable slopes. The Tertiary sediments bordering the highlands support podzolic soils while, on the Quaternary terrace and flood-plain deposits, uniform fine-textured clays, medium-textured loams, coarse sands, and a range of duplex soils have developed.

4. Vegetation

This block contains examples of some of the wettest and some of the driest forest types found in the study area.

In the north-west corner of the block, below Mount Useful, are the area's only alpine ash forests. At high altitudes, this vicinity also contains other examples of tall open forest, including stands of mountain ash.

Occupying one of the lowest-rainfall zones in the study area, the distinctive red box--red ironbark low open forests of the Glenmaggie--Seaton area are unique to this block and provide a stark

Pastoral Macalister River flats, flanked by steep forested hills north of Lake Glenmaggie

contrast to the wetter forests described above.

Between these two extremes are the forests that cover the greater part of the steeply dissected public land. These are in the open forest II--III structural range and are combined in a characteristic pattern: the more protected slopes (southern and eastern aspects) generally support open forest III of mountain grey gum and messmate, while the exposed slopes (western and northern aspects) support generally open forest II of silvertop, red stringybark, and red box. On the poorest sites east of the Macalister River, the red stringybark and red box forests do not exceed 15 m.

Understorey composition also reflects the site conditions. Thus the taller forests at high elevations usually have understoreys typical of wet sclerophyll forests, with an intermediate stratum of wattles and a dense stratum of shrubs. In the open forest III communities on sheltered aspects, understoreys can vary considerably; they may be dominated by bracken, or contain shrubs with a ground layer of herbs, or be of the wet-gully type. On the exposed aspects, understoreys of the drier forests are usually sparse and dominated by low shrubs and grasses. Indeed, in the open forest I community, bare gound can be exposed over more than 50% of the site.

5. Fauna

The forest environments represented on public land include small areas of tall open forest (below Mount Useful) and riverine forest, and much larger areas of open forest and foothill woodland. Examples of the farmland environment occur on cleared public land adjacent to Lake Glenmaggie. The lake itself is considered part of the inland wetlands environment.

The fauna can be generally predicted from the nature of these environments, and for details the reader should refer to Chapter 10 and Appendices 2-6.

Sambar deer, which prefer rugged terrain covered in open forest, are more numerous in this block than elsewhere in the study area.

Because of the copious quantities of nectar secreted when in flower, the red ironbark forests north and west of Heyfield are particularly valuable for honeyeaters and parrots. Indeed, it has been claimed that, because of the number of birds that congregate on them, red ironbark trees can be heard before they are seen.

Lake Glenmaggie provides refuge for many species of water birds. Only the margins are suitable for dabbling and wading species, but others, such as cormorants and musk duck, forage throughout the deeper areas. Bats inhabit State Rivers and Water Supply Commission tunnels downstream of the lake.

C. Present Use and Capabilities

1. Nature conservation

While all the forested public land has at least a moderate capability for nature conservation, some areas are more important than others. For instance the box--ironbark forests in this block represent the major occurrence of this vegetation type in the study area. Indeed, the association of these two tree species as dominants occurs in very few other locations in eastern Victoria. In general, the understorey in the box--ironbark forests has a greater floristic diversity than many other forest types and provides colourful displays of wildflowers. The importance of these forests has been recognized, by creation of a flora and fauna reserve north of Heyfield.

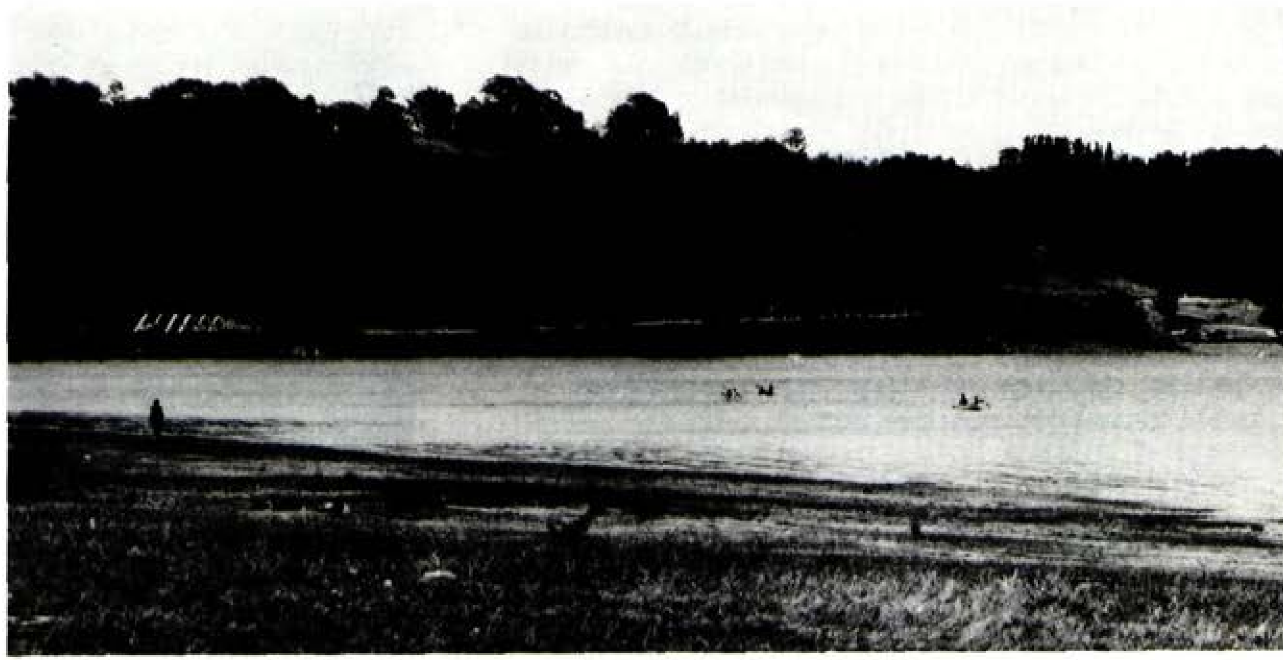
The block contains seven significant plant species, including *Goodenia grandiflora*, a rare shrub found only in rocky habitats in the Macalister and Upper Snowy River catchments.

Lake Glenmaggie has a high value for water-birds and provides a refuge for many species. The dry open forests around the lake have yielded the only recent Gippsland recording of speckled warbler.

2. Recreation

The single most important recreation resource is Lake Glenmaggie, which is one of the most popular inland venues for water sports east of Melbourne. Activities include water-skiing, sailing, power-boat racing, and swimming. Camping, picnicking, and boat-launching facilities are provided on public land surrounding the lake.

Fresh-water angling is a further popular pastime on the waters of this storage, as it is in the Macalister River upstream from Lake Glenmaggie. Canoeists also use this stretch of the river and, to a lesser extent, the lake itself.



Canoeists on Lake Glenmaggie

Cowwarr weir is another body of water formed primarily for irrigation purposes that has subsequently proved popular as a site for swimming and picnicking.

The Thomson River, upstream from Cowwarr weir, is highly regarded by canoeists. The Heyfield--Licola road offers some of the best scenic driving in Gippsland, providing excellent views of the pastoral Macalister River valley and surrounding rugged hills. Another pleasant drive can be had along the main forest road north of Seaton. This features the sites of numerous early settlements.

The rugged and remote hill country west of the Macalister River is a favourite area for deer-shooters. It also contains the sites of old gold mines at Donnelly Creek and Murderers Hill, which may be of interest to fossickers.

A rifle range occupies public land between Heyfield and Seaton.

Popular areas for four-wheel-drive touring and trail-bike-riding include rough, forested areas west of Seaton and north of Ben Cruachan.

3. Wood production

A high proportion of the forests covering this block are of the dry, low open forest type with low growth rates and hence low capability for most types of hardwood production.

Small stands of tall open forest, below Mount Useful, have a high potential productivity. Principal species in these stands are alpine ash and messmate, both of which provide excellent sawlogs. The moist foothill forests, on the more protected aspects, have a moderate capability for sawlogs and pulpwood.

Pulpwood is supplied to the A.P.M. mill at Maryvale and the quantities taken will increase in the future because of the planned expansions of this mill.

Although the box--ironbark forests north of Heyfield have a very low growth rate, they are important inasmuch as the durable timber of red ironbark is highly prized for fence posts and sleepers.

No public land meets the site requirements for softwood plantations.

4. Agriculture

Agricultural production is concentrated on the flat to undulating land in the Lake Glenmaggie--Heyfield--Seaton area and on the Macalister River flats. This is entirely pastoral land, which supports primarily beef cattle and to a lesser extent sheep grown for both wool and meat.

Public land below Mount Useful and east of the Macalister River is grazed by cattle. Four annual grazing licences involve three graziers. Most of this land is used only between the months of November and May. Only in the lower country does grazing continue year-round. A very small block of Crown land west of Seaton is also licensed.

For the most part, public land has a low capability for forest grazing.

The gently undulating public land, covered mainly in red stringybark--red ironbark forests, between Heyfield and Seaton has low to moderate potential for agricultural production. The rest of the public land is very steep and quite unsuitable for agricultural development.

5. Water production

The Thomson River, which forms the block's southern boundary, and the Macalister River are the major streams. The bulk of these rivers' catchments is outside the study area in the upper reaches of the Eastern Highlands. Water from both rivers is used for stock and domestic purposes and for irrigation, which in terms of volume is the major use.

The waters of the Macalister River are impounded by Lake Glenmaggie, at which point the river has a mean annual discharge of 497,000 ML. This storage has a capacity of 190,300 ML and is the major source of water for the Macalister Irrigation District. The extent of this district (within the study area) is shown on Map 7.

The Macalister River catchment down to Lake Glenmaggie has been proclaimed according to the provisions of the *Land Conservation Act* 1970 and the *Soil Conservation and Land Utilization Act* 1958.

At Cowwarr weir, the Thomson River has a mean annual discharge of 409,000 ML. This weir, located upstream from Cowwarr, enables diversion of water for irrigation in the Nambrok--Denison area and ensures a flow through the old course of the Thomson River.

Heyfield Waterworks Trust supplies Heyfield with water drawn from the Thomson and Macalister Rivers ex State Rivers and Water Supply Commission channel.

In addition to the irrigation water drawn from the Cowwarr weir and Lake Glenmaggie, many licences and permits have been issued for diversion of water for irrigation, domestic and stock, and industrial purposes. Such diversion (by direct pumping from streams) has reached a point where all streams are committed to the extent of available summer flows, other than for domestic and stock purposes. Further diversions would only be available on the condition that on- or off-stream storage is provided to store excess winter stream flows.

Only tiny quantities of groundwater are used, by a few people. Total authorized annual extraction at present is less than 50 ML.

While there are no immediate plans for additional storages or for significant increases in water use, the planned industrial expansion in the Latrobe Valley may require allocations of water from the Thomson and/or Macalister Rivers.

6. Mining and quarrying

Gravel is extracted for road-making purposes from public land south of Seaton and north-east of Lake Glenmaggie.

The north-western section of the block comprises portion of the Jordan goldfield. Currently, three Miner's Right claims cover part of this area.

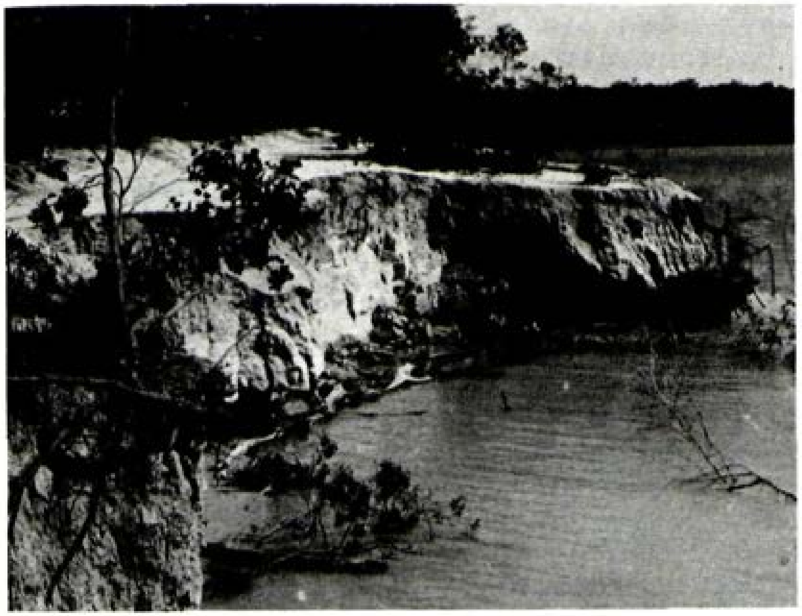
7. Utilities

A tip west of Heyfield and a cemetery north of that town are both located on public land.

D. Hazards and Conflicts

The major potential hazard is wildfire. This is an ever-present danger in the dry foothill forests growing on the public land. The steep and broken topography assists the spread of fire and handicaps attemps to suppress it.

Limited soil erosion occurs in the forested public land. Bank erosion can be a problem on Lake Glenmaggie and (after floods) on the major streams, the Thomson and Macalister Rivers and Rainbow Creek.



Bank erosion on exposed eastern shore of Lake Glenmaggie

While both vermin and noxious weeds are present on public land, neither constitutes a significant hazard at present.

The impact of increased levels of timber-harvesting, in particular that associated with an expansion of pulpwood production, constitutes a significant potential conflict. Concern has been expressed that, if employed over a relatively short rotation time, the clear-felling harvesting technique could lead to alterations in the forests' floristic structure, both short- and long-term destruction of wildlife habitat, increases in soil erosion and stream turbidity, and decreases in honey flows.

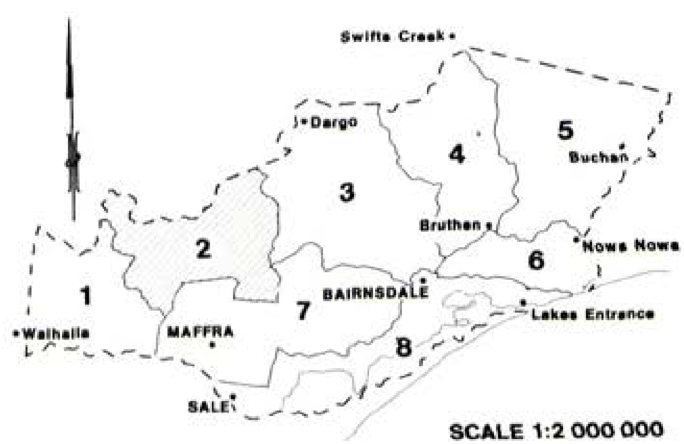
Another important conflict could arise if water from the Macalister and/or the Thomson Rivers was to be diverted to the Latrobe Valley. This could only be achieved at the expense of Gippsland irrigators.

2. AVON

A. General

1. Land tenure and location

Avon block covers a little more than 100,000 ha, including approximately 80,000 ha of public land. Although mainly unreserved Crown land, about 33,000 ha comprise reserved forest and a number of small Crown land reserves, most of which are located in the southern agricultural portion of the block.



2. AVON

One such reserve is The Quarries recreation reserve north of Briagolong.

B. Nature of the Land

1. Climate

In common with other parts of the study area, the Avon block has climatic conditions considerably influenced by altitude. Its mean annual rainfall varies from 1,000 mm in the headwaters of the Freestone Creek to 640 mm at Briagolong.

Most public land in this block is at elevations between 200m and 600 m, where rainfall varies between 650 mm and 800 mm.

Average temperatures are inversely related to altitude, rising as altitude decreases. Thus, while this block does not contain any weather stations that record temperatures, there is no doubt that Briagolong is consistently warmer than, for instance, Mount Blomford.

As few locations rise above 600 m, snow falls only rarely and even then it seldom lies on the ground for more than a few days.

2. Geology and geomorphology

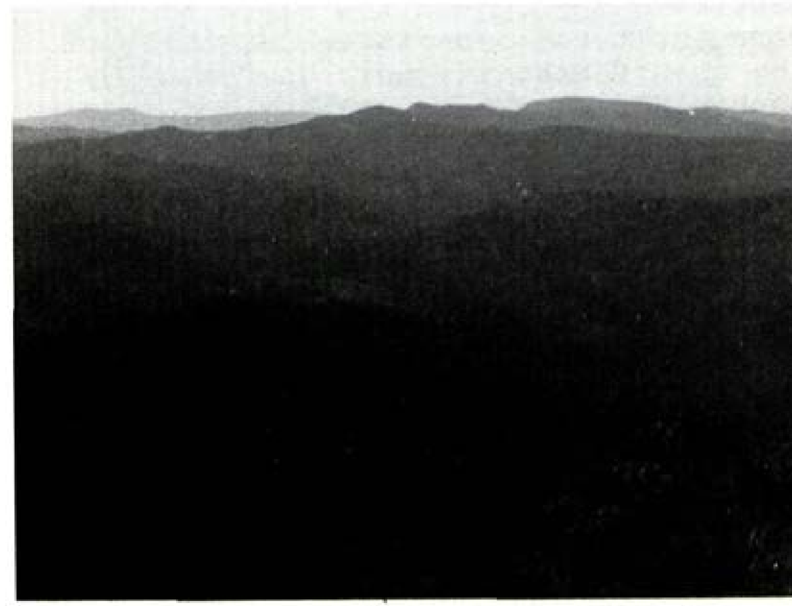
The block is dominated by a broad depositional basin known as the Avon synclinorium, which contains a sequence of gently folded non-marine sediments of Carboniferous age. Outcrops of Devonian rhyolite occur at the eastern and western extremities of the basin.

Sedimentary rocks of Ordovician and Silurian age are exposed in the north-eastern and north-western sections of the block respectively, and a granitic intrusion is centred around Mount Blomford. Together these Palaeozoic rocks form the highland portion of the block, which is characterized by moderately dissected mountainous terrain. An isolated intermontane basin has developed on granitic bedrock at Mount Blomford; it is the only basin of this type in the study area that remains as public land.

The southern portion of the block includes the dissected remnants of alluvial fans bordering the highlands and a sequence of Quaternary alluvial deposits associated with the Avon River and its tributaries.

3. Soils

The relatively low rainfall in the highland areas of the block have resulted in generally poor soil development. As a consequence, most soils tend to be stony and skeletal. Uniform sandy loams have



Looking north towards the Avon wilderness from Ben Cruachan summit

been derived from the granitic bedrock at Mount Blomford while podzolic soils are a common feature of the Tertiary deposits flanking the highlands. Flood-plain areas support a range of uniform and duplex soils.

4. Vegetation

The only significant examples of tall open forest IV are the forests dominated by messmate and mountain grey gum that occur at the higher altitudes north of Mount Blomford and in the headwaters of McColl Creek. Understorey can vary from a wet-gully type to one dominated by bracken.

Scattered throughout the block on the more sheltered aspects are examples of the open forest III unit dominated by mountain grey gum and either messmate (at higher elevations) or white stringybark, which replaces messmate at lower altitudes. Understorey composition varies with aspect, soils, elevation, and fire history, and can range from bracken through to dense stands of shrub species.

Other open forest III units comprise the yellow stringybark forests distributed in patches on both sides of the Avon River, and the white stringybark forests that occupy the low, sandy Stockdale hills.

Open forest II is the single most common structural form, with representatives of four separate units. Of these four, the red stringybark--red box and yellow stringybark units are the least widespread - the former being restricted to the Culloden and McDonald Gap areas, the latter to around and north of Lloyd Knob. The silvertop unit occupies the steep hill country in the north-west of the block, and the yertchuk unit is located in the south-west and central eastern portions.

Examples of red box--red stringybark open forest I occur throughout the block, especially in the upper reaches of the Ben Cruachan Creek. This forest type occupies the driest, steepest, most exposed sites.

One of the study area's few significant stands of forest red gum is located just south of Briagolong.

5. Fauna

The forest environments represented on public land include small areas of tall open forest and riverine forest, with the vast bulk being either open forest or foothill woodland.

The fauna can be generally predicted from the nature of these environments, and for details the reader should refer to Chapter 10 and Appendices 2-6.

C. Present Use and Capabilities

1. Nature conservation

While all the forested public land has at the least a moderate capability for nature conservation, some areas are more important than others. For instance, with the exception of outlying stands on Wilsons Promontory, the pocket of warm-temperate rainforest below Mount Moornapa represents the western limit in Victoria of this rare vegetation type. Also, public land south of Briagolong contains one of the few remaining significant stands of the once-widespread forest red gum.

In spring, fine displays of wildflowers can be seen on Ben Cruachan, on the rocky banks of the Avon River, and along the Freestone Creek valley.

The block contains II significant plant species, including the rare mint bush *Prostanthera saxicola*.

Geological formations of significance include the type section of fresh-water sediments and intercalated volcanics of the Avon River Group, which is exposed on the Freestone Creek above Culloden. A gorge known as the Channels, which the Avon River has excavated in Carboniferous siltstones and sandstones, is also of geological interest.

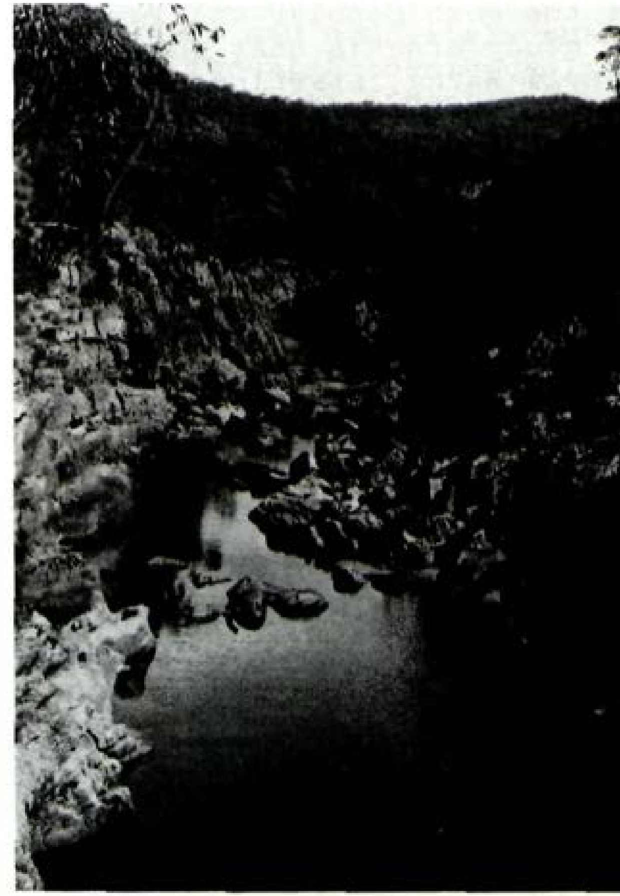
The area north of Ben Cruachan, in the upper Avon River catchment, contains few vehicular tracks and has not been substantially altered by Man. The relatively undisturbed nature of this locality enhances its conservation significance.

2. Recreation

As is so often the case, both in this study area and elsewhere in the State, rivers and streams form the major recreational focus in this block.

A signposted walking track follows a stretch of the Avon River above Valencia Creek. This popular track passes the Channels and has a number of picnic areas along its route.

A splendid scenic drive can be enjoyed by taking the road that follows the Freestone Creek and ultimately comes out at Cobbannah. Of a number of picnic



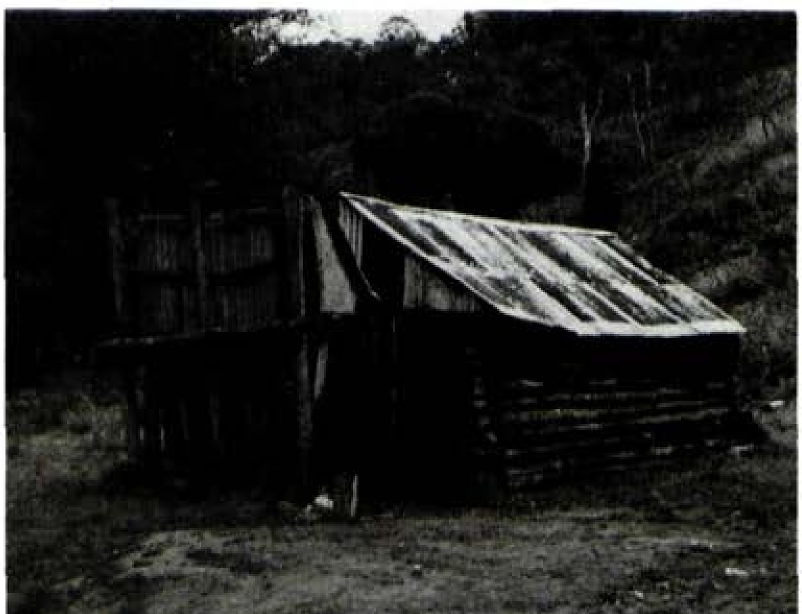
The Channels - a feature on the Avon River

spots along this road, the most notable are at the Quarries reserve, which has rough camping as well as picnicking facilities, and the Blue Pool, which features a deep pool in the creek suitable for swimming and scuba diving. Other picnic areas are located on the Valencia and George Creeks.

One of the most popular walking tracks in the study area is that which leads to Lake Tarli Karng, starting from Golden Point. This relatively undisturbed area has considerable value for wilderness recreation.

Panoramic views can be obtained from lookouts at Pearson Point, Mount Hedrick, Ben Cruachan, and Mount Moornapa.

Public land east of Briagolong is used for the small but growing sport of orienteering.



Golden Point hut, located on private land in the north of the block, is often visited by bushwalkers, trail-bike riders, and four-wheel-drive enthusiasts

Organised horse safaris, which operate out of Valencia Creek and Briagolong, ride through public land.

Some of the more rugged parts of the block are popular with four-wheel-drive and trail-bike enthusiasts as well as with deer-shooters.

3. Wood production

Much of this block is covered in dry foothill forests that have a low capability for hardwood production.

Small areas of mountain forest occur in the headwaters of the McColl Creek and north of Mount Blomford. These stands, the principal timber species of which is messmate, have a high potential productivity. The moist foothill forests, on the more-protected aspects, have a moderate capability for sawlogs and pulpwood.

Pulpwood is supplied to the A.P.M. mill at Maryvale, and the quantities taken will increase in the future due to the planned expansion of this mill.

Areas of foothill forests on the sandy hills between Stockdale and Briagolong, although they contain similar tree species to the steep country further north, are more important for hardwood production because of their accessibility. White stringybark, which predominates in these forests, is cut extensively for fence posts.

Although, with the exception of small trial plots, no pine plantations occupy public land, the sandy foothill areas referred to above have been identified by the Forests Commission as meeting the site requirements for the establishment of such plantations. A.P.M. has plantations of *Pinus radiata* on adjacent private land.

4. Agriculture

Almost all the privately owned farmland is used for grazing, with beef cattle production being the major enterprise. The plains country east of Briagolong also supports flocks of sheep grown primarily for wool. Small areas of vegetables are grown near Briagolong.

Cattle graze over significant areas of public land, both west of the Avon River and east of Valencia Creek. The seven annual licences covering this land are held by eight graziers. The cattle use the area mainly between November and May, grazing only on the river and creek flats and the more accessible slopes. A number of smaller blocks of public land are also grazed under licence.

Most of the public land has a low capability for forest grazing.

Public land on the low, sandy Stockdale hills has moderate agricultural potential. The small intermontane basin on New Place Creek, west of Mount Blomford, would also have some potential, but it is very isolated and completely surrounded by steep, forested country. In contrast, the block of forest red gum at Briagolong is surrounded by flat agricultural land and could itself be highly productive. No other significant areas of public land are suitable for agricultural development.

5. Water production

This block forms part of the catchment to the Avon River and includes its main tributaries - the Freestone, Valencia, and Ben Cruachan Creeks. The Avon River rises on the slopes of Mount Wellington, approximately 20 km north of the study area boundary.

While the mean annual discharge of the Avon River at the Valencia Creek bridge is 143,000 ML, flows can vary considerably from year to year. The Avon and its tributaries virtually dried up during the severe drought of 1967/68.

The 91 licences and permits issued for the diversion of water from the Avon and its tributaries represent an annual volume of just under 6,700 ML. Most of this is used for irrigation, with smaller quantities used for domestic and stock and industrial purposes. Such diversion by direct pumping from streams has reached a point where all streams are committed to the extent of available summer flows, other than for domestic and stock purposes. Further diversions would only be available if an off-stream storage is provided to store excess winter stream flows.

Groundwater is used in insignificant quantities.

There are no immediate plans for the construction of storages or for significant increases in water use. However, the planned industrial expansion in the Latrobe Valley will need more water than can be provided from the Latrobe River system, and one of the options being canvassed to make up this shortfall is diversion of water from the Avon River.

6. Mining and quarrying

Of two goldfields on Freestone Creek, one is centred on Culloden and the other upstream of the junction with Sportsman Creek. A mineral search licence is current over portion of the latter area.

Forest tracks are surfaced from a small gravel pit south of Cobbannah.

7. Utilities

A fire lookout operated by the Forests Commission is located on Mount Moornapa. The Briagolong cemetery is situated on a small block of public land east of the township.

D. Hazards and Conflicts

The nature of the forests and the terrain combine to make fire the most serious hazard. The dry, predominantly stringybark forests with shrubby understoreys, in which readily flammable fuel builds up rapidly, are very fire-prone. The steeply dissected topography facilitates the spread of fire and makes efforts at its suppression more difficult. Wildfires are not only a threat to life, property, and valuable timber resources, they can also have a devastating effect on wildlife, catchment values, and floral values (especially) understorey composition).

Blackberries are a problem in some of the more inaccessible gullies where they cannot be reached by sprays. Other noxious weeds and vermin, while present, are manageable.

Soil erosion is not a serious problem on public land.

Both of the main conflicts involve the increased use of public land for intensive forms of wood production.

The first results from the increased requirements for pulpwood. Concern has been expressed that short-rotation, clear-felling harvesting techniques, if used to produce this product, will lead to an alteration in the forest' floral composition with fast growing, fecund species like silvertop dominating, loss of wildlife and the destruction of their habitat, increase in soil erosion and a consequent decrease in water quality, and a decrease in honey flows.

The second involves the possibility of the conversion of native hardwood forest to softwood plantations. This would result in the loss of native flora and fauna, reduction in some recreational opportunities, decrease in the area available to apiarists, and the loss of hardwood timber values.

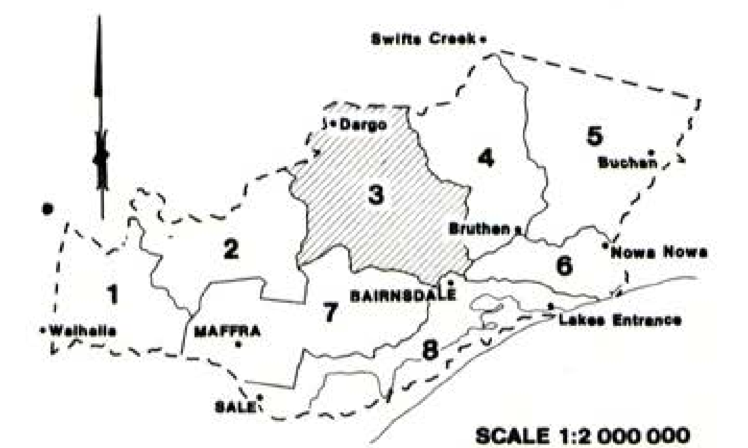
3. MITCHELL

A. General

1. Land tenure and location

Of almost 150,000 ha in Mitchell block, public land occupies approximately 105,000 ha - more than 90,000 ha of it being unreserved Crown land.

Most of the 10,000 ha of reserved forest is located in the low hills south of Bullumwaal.



3. MITCHELL

In the Tabberabbera area, the State Rivers and Water Supply Commission owns more than 1,000 ha, purchased in connection with the Mitchell River dam project.

Other, smaller areas of public land include the 143-ha Glenaladale national park, the only such park in the study area, and a number of Crown land reserves used for a variety of public purposes.

B. Nature of the Land

1. Climate

All the hilly to mountainous sections of the study area have very few permanent stations collecting climatic data. This is the case for the Mitchell block, which contains only two weather stations - in the Dargo area. Thus, the climate of an area is often inferred from an examination of topography and vegetation patterns.

Rainfall within the block varies considerably - firstly as a result of changes in elevation (with more rain at the higher altitudes), and secondly due to the rain-shadow effect in the deep river valleys. This effect is particularly pronounced in the Mitchell River valley, where, for instance, Tabberabbera receives a mean annual rainfall of 659 mm compared with 1,080 mm for Bullumwaal on the bordering high country. Likewise, the Dargo High Plains, just to the north of this block, receives rainfall of between 1,200 and 1,600 mm annually; by comparison, the adjacent rain-shadow region of the Wonnangatta River valley receives less than 700 mm.

In general, temperatures increase from north to south, as elevations decrease. Bairnsdale (immediately south of the Mitchell block) has relatively mild temperatures throughout the year, with a mean annual maximum temperature of 19.9°C and a mean annual minimum of 8.7°C. While the corresponding figures for Dargo are not available, these would undoubtedly be considerably lower.

2. Geology and geomorphology

The major structural feature within the block is the Mitchell syncline that formed a broad shallow depositional basin in which a series of Carboniferous sediments were laid down. A thick sequence of Ordovician sandstones, siltstones, and shales surrounds the basin.

Two granitic intrusions occur in the area, one at Dargo and the other at Castleburn. Porphyritic rocks are exposed in the vicinity of Mount Taylor. To the south, deposts of Tertiary and Quaternary age form a thin veneer covering the southern margin of the highlands. The Mitchell River flood plain forms a broad alluvial valley situated between Iguana Creek and Bairnsdale.

3. Soils

Medium-textured loams dominate the Ordovician sediments in the highlands, although skeletal soils are common on the steeper slopes. A range of sandy loams and duplex soils (including podzols) have developed on the granitic parent materials at Dargo and Castleburn, while podzolic soils occur extensively on the Carboniferous bedrock.

The lowland areas of the block carry a wide range of soil types. Podzolized soils are common except in flood-plain areas, where coarse sands, loams, and clays predominate.

4. Vegetation

The most common open forest IV is the messmate--mountain grey gum unit, examples of which occur primarily west of the Baldhead Road and north of Morris Peak. Other more isolated examples occur north of Bullumwaal, east of Dargo, at Peel Gap, and at Mount Steve, where the only stand of mountain ash also grows. Understoreys in these tall open forests can vary - from one typical of wet sclerophyll forests, with an intermediate stratum of wattles and a dense stratum of shrubs, to one dominated by bracken.

Open forest III is scattered throughout; the most common units are the mountain grey gum--messmate--white stringybark forests, which occupy the drainage lines and protected aspects, and the white stringybark forests, which are widely distributed on the low hills and to a lesser extent in the high country. Also, isolated examples of the silvertop unit grow on some of the exposed ridges and slopes, with an understorey of sparse shrubs and herbs.

Red stringybark--red box open forest II is widespread, but especially prevalent in the dry hills that form the head-waters to the Wentworth River. Open forest I of similar composition is also found in this area. These units grow on steep, exposed slopes, where the soils are shallow and stoney and have low fertility and moisture-retention properties. The harsh growing conditions are reflected in the understoreys, which are generally sparse and dominated by low shrubs and herbs.

Associated with these dry forests are areas of closed wattle scrub, in most cases the result of repeated fires. For instance, wattle scrub in the Glenaladale National Park has resulted from a serious wildfire in 1965.

Along the Mitchell River and in Musk Gully near Melwood are found examples of warm-temperate rainforest. These closed forests, with their distinctive understoreys, are found only in the most protected and sheltered sites below 600 m elevation.

5. Fauna

The forest environment represented on public land include patches of closed forest, limited areas of tall open forest and riverine forest, and much more extensive areas of open forest and foothill woodland. Examples of the farmland environment occur on cleared public land at Tabberabbera and along the Mitchell River west of Bairnsdale.

The fauna can be generally predicted from the nature of these environments, and for details the reader should refer to Chapter 10 and Appendices 2-6.

The Mitchell River upstream of Glenaladale and its tributaries - the Dargo, Wentworth, and Wonnangatta Rivers - have a gravel or rubble bed, with extensive areas of ripples and rapids, and carry cold, fast-flowing water. Native fish species are widespread and abundant in these upland fresh-water rivers.

Between Glenaladale and Bairnsdale, the Mitchell River flows slowly, contains turbid water, and has extensive pool areas. This habitat type favours many introduced fish species over the smaller native fish. However, it does have particular value as it supports a small number of Australian bass, a species considered uncommon in Victoria.

Not surprisingly, some birds that are associated with warm-temperate rainforest - for example, the black-faced monarch and the brown gerygone - are at or near the westernmost limit of their distribution. Peregrine falcons breed on cliffs in the Mitchell River gorge.

C. Present Use and Capabilities

1. Nature conservation

While all the forested public land has at the least a moderate capability for nature conservation, some areas are more important than others. For instance, the Mitchell River gorge is renowned for its special floral and geological features. The sheltered sandstone gorge supports the study area's greatest concentration of the rare warm-temperate rainforest. These stands have a high biogeographic significance, being close to the most westerly occurrence of such rainforest. The gorge also represents the most westerly extension of the rare ericoid shrub *Bertya cunninghamii* and the fern *Polystichum formosum*.

Important geological features of the Mitchell River gorge are the spectacular sandstone cliffs, excellent exposures of the upper units of the Avon River Group, and several fossil sites. The tributary Woolshed Creek gorge contains the well-known Den of Nargun, a small

Mitchell River gorge at Billy Goat bend cavern that has formed at the base of a waterfall in the creek. This is the largest known example of this cavern formation and is of particular significance for its decoration with large stalactites. It is protected by the Glenaladale National Park.

Apart from the rare plants in the Mitchell River gorge, 29 other significant species have been recorded in this block, including the rare prostrate herb *Desmodium brachypodum* and *Cyperus sphaeroidens*, a newly described sedge known at only two Victorian localities.

A good example of warm-temperate rainforest also occurs in Musk Gully near Melwood. An area along the Cobbannah Creek contains the study area's best example of the distinctive brittle gum forests.

A number of sites along the Mitchell River, where it flows through the agricultural flats, feature interesting geological exposures.

2. Recreation

Rivers and streams constitute the major focus for recreation on public land.

The study area's most popular bushwalking track follows the Mitchell River from Angusvale to downstream of the Glenaladale National Park. There are a number of camp sites and picnic areas along the length of this track.

This section of the Mitchell River provides some of the best white-water canoeing to be had anywhere in Victoria. The 'Slalom Rapid' on the river below Angusvale has been the venue for championship competition at both State and National levels. The Wonnangatta River is a less-demanding, but equally popular, stream for canoeing.

Glenaladale National Park, while only small, has proved to be very popular, attracting approximately 16,000 visitors each year.

The remains of the ill-fated bluestone dam on the Mitchell River downstream of the park add historical interest to the area. This dam, which was intended to supply water to Bairnsdale, was completed in 1893, but never operated due to repeated flood damage.

Old mining sites of interest to fossickers are situated on the Dargo River north of Dargo and on the Wentworth near Tabberabbera. Other such sites are found at Bullumwaal and near Mount Hoad.

Opportunities for pleasure driving exist on the road from Glenaladale through to Dargo and beyond. This includes particularly pleasing stretches coming out of the mountains into the rolling pastoral country at Dargo. Another very scenic drive can be taken along the Old Dargo Road, which follows the Dargo River to its confluence with the Wonnangatta River.

Deadcock den on Woolshed Creek in the Glenaladale National Park

Horse-riding tours operate on public land from a base at Mount Taylor.

3. Wood production

Small areas of tall open forest are located in the northern part of the block west of the Mount Baldhead road and south of Mount Steve. With the exception of the mountain ash stand below Mount Steve, these comprise primarily messmate and have a high capability for hardwood production, especially sawlogs.

The bulk of the block is covered by foothill forests, which range from moist forests on the protected sites, with a moderate capability, to dry, slow-growing forests with a low capability. The forests of the block provide hardwood sawlogs to sawmills located at Stratford, Mount Taylor, and Bairnsdale.

Currently only small quantities of pulpwood are taken; however, the eastern section of the block forms part of a larger area of east Gippsland, which may become a major supplier of pulpwood.

The government is currently considering a statement of the environment effects of extracting 800,000 cu.m of pulpwood per annum from the forests in the eastern portion of the study area and east Gippsland.

A small school softwood plantation occupies public land at Mount Taylor. In addition, the Forests Commission has identified land north of Stockdale and south of Bullumwaal that meets the site requirements for the establishment of such plantations. The A.P.M. Calajero plantations are located on adjacent private land.

4. Agriculture

Beef cattle production is the most common agricultural enterprise on privately owned land. The pastoral land in the Dargo--Tabberabbera--Castleburn area is almost exclusively cattle country, whereas further south, roughly between Glenaladale and Clifton Creek, sheep are also raised, for both wool and meat.

The Mitchell River flats constitute one of Victoria's most productive vegetable-growing areas. Indeed, more beans are grown for processing here than in any other part of the State. The flats also grow lucerne and maize crops as well as irrigated pasture, which supports dairy and beef cattle.

Other areas for vegetable production are at Mount Taylor and Dargo, the latter area also having a number of walnut orchards. There are apple orchards just north of Bairnsdale.

More than half the public land is subject to cattle-grazing by 15 different graziers, who between them hold a total of 22 grazing licences. This includes mostly-cleared farmland at Tabberabbera, which was purchased by the State Rivers and Water Supply Commission in association with the Mitchell River dam project. A number of small blocks of public land are also held under grazing licences. Most of the public land is not suitable for forest grazing. Even within the licensed areas, only the creek and river flats and the more accessible slopes are actually grazed.

Walnut plantation south of Waterford

Only small areas on the southern margins of the public land would have any better than low agricultural capability. The bulk of public land is not suitable for agricultural development.

5. Water production

This block contains most of the Mitchell River and sections of its major tributaries, the Wonnangatta, Dargo, and Wentworth Rivers. Less than one-quarter of the Mitchell's catchment is within the study area, the bulk being in the high country to the north. Most of the Mitchell River's flow is generated in this alpine segment of the catchment.

Mean annual discharge for the Mitchell River at Glenaladale is 936,000 ML, making it the largest stream in the study area. The corresponding figure for the river at Bairnsdale is 847,000 ML.

One of the reasons for this reduction in stream flow is the diversion for irrigation on the river flats between the gauging stations: 149 licences are issued annually to irrigators diverting water from this stretch of the Mitchell River. In addition, water is taken for domestic and stock and industrial purposes. The Mitchell and its tributaries are now committed to the extent of . available summer flows, other than for domestic and stock purposes. As such, further diversions would only be available *on condition that on- or off-stream* storage is provided to store excess winter stream flows.

Bairnsdale Waterworks Trust currently takes water from the Mitchell River just above Bairnsdale. However, the Trust intends to replace its existing pumping plant with a pipeline offtaking from a low diversion weir to be sited approximately 2 km upstream from the Glenaladale bridge. The catchment down to this point has been proclaimed according to the provisions of the *Land Conservation Act* 1970 and the *Soil Conservation and Land Utilization Act* 1958.

Other water supply authorities that use water from the Mitchell River are the Lindenow and Paynesville Waterworks Trusts. The former supplies water to Lindenow, Lindenow South, and Walpa, and the latter buys a bulk supply from the Bairnsdale Waterworks Trust for distribution to Paynesville, Eagle Point, and Raymond Island.

Considerable use is made of the shallow aquifers under the river flats for irrigation. In fact, about one-third of the area under irrigation is watered by groundwater. Any significant increase in the use of groundwater from this area would need to involve a programme of aquifer recharge during periods of high river flows. It has been claimed that such a programme would achieve the same results as the impoundment of surface water on the Mitchell River. These claims are currently being investigated.

Government has approved the construction of a dam on the Mitchell River just below its junction with the Wentworth. The water to be impounded in this planned storage is to be used primarily to safeguard existing irrigation development on the Mitchell River flats. It will also provide a regional storage for future urban and industrial development. Although no other storages are currently planned, one of the options being canvassed for the provision of additional water to faciliate industrial expansion in the Latrobe Valley is allocation from the Mitchell. This proposal involves diversion via the Perry River to Lake Wellington, and would probably require some form of storage to be constructed on the Mitchell.

6. Mining and Quarrying

There are small gold-fields both north and south of Dargo and a larger one lies north of Bullumwaal. A gold-mining lease is current over portion of the field north of Dargo.

A number of small gravel pits, scattered throughout the forested public land, are used almost exclusively for the maintenance of forest tracks. The Shire of Bairnsdale and the Country Roads Board extract rhyolite, which is then crushed and used in road construction, from a quarry on public land at Yellowman Knob. The Mitchell River Improvement Trust extracts sandstone for use in streambank stabilization work from a quarry on public land at Flaggy Creek.

Minor deposits of arsenic, bismuth, cobalt, mercury, and nickel are found near Bullumwaal. Three separate mineral search licences are current for this area.

There is also a possibility of a copper sulfide ore body being present in the Tabberabbera area.

7. Utilities

A fire lookout operated by the Forests Commission is situated on Mount Taylor, at the foot of which is the Mount Taylor forestry station. The State Electricity Commission and Telecom also have facilities on Mount Taylor.

D. Hazards and Conflicts

As in so much of the study area, the major potential hazard in this block is that posed by the spread of wildfires. The predominantly dry forest types, coupled with the rugged and in many places isolated terrain, facilitate the spread of wildfires while at the same time operating against their suppression. The area has suffered numerous fires over the years, including one in 1965 that burnt stands of rainforest in the Glenaladale National Park.

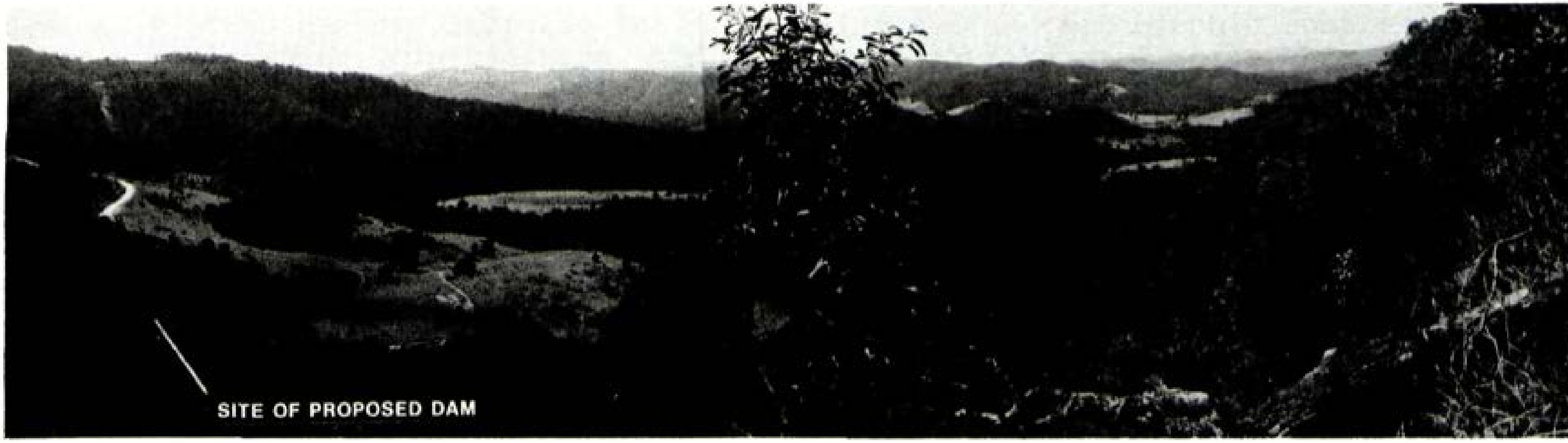
Noxious weeds are a problem, particularly in isolated, inaccessible areas where spraying cannot be carried out. The Wentworth River in particular has bad infestations of blackberry.

Wild dogs can cause stock losses from time to time, especially in the mountainous country where farmland adjoins forested public land. Rabbits are an ever-present - but perhaps in this area, manageable - hazard.

The cinnamon fungus (*Phytophthora cinnamomi*), which causes dieback in eucalypt forests, is widely scattered east of Mount Taylor. It has also been found in the lower foothill forests west of the Mitchell River.

While some erosion has affected forest tracks, soil erosion is not currently a serious hazard on public land. However, the potential is present for serious erosion, both on- and off-site, if forest management is not maintained at a conservative level.

Conflicts exist over the use of Mitchell River water. Many people are concerned that the planned Mitchell River dam at



Mitchell River valley, looking upstream from the proposed dam site

Tabberabbera, as well as inundating valuable farming land, important geological exposures, and Aboriginal relics, will affect the character of one of the State's few remaining large unregulated rivers. Furthermore, any diversion of flows to the Latrobe Valley would probably require a larger storage, and hence exacerbate the conflict. Without an additional storage, such diversions could only take place at the expense of downstream irrigators.

Concern has also been expressed regarding the implications of a statement, now being considered by the government, of the environmental effect of greatly increasing the level of pulpwood harvesting east of the Mitchell River.

Pulpwood is currently being harvested as sawlog residue from such areas. If the intensity of these operations were to be increased beyond current levels, there could be an adverse effect on flora and fauna values, an increase in soil erosion, and a decrease in water values.

Any conversion of the native hardwood forests to softwood plantations would reduce the environmental, recreational, and hardwood timber values, as well as conflicting with the interests of beekeepers.

4. NICHOLSON

A. General

1. Land tenure and location

Nicholson block covers almost 105,000 ha. Public land occupies approximately 88,000 ha, more than half of which is unreserved Crown land.

Reserved forest covers about 39,000 ha, including the 48-ha Fairy Dell scenic reserve west of Bruthen, which is reserved under section 50 of the *Forests Act*.

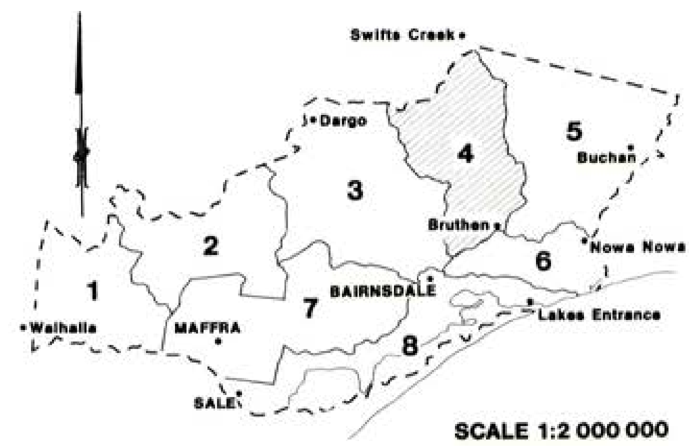
Also, the agricultural land near Bruthen, Sarsfield, and Ensay contains a few small Crown land reserves.

B. Nature of the Land

1. Climate

Rainfall in this block, as for the rest of the central and eastern parts of the study area, most often results from a low pressure system centred over the eastern coast of Australia or near Gabo Island. This contrasts with the bulk of southern Victoria, where rain results from the passage of depressions across the State from the west.

The Marthavale--Mount Hoad area receives the highest rainfall - around 1,000 mm annually. Rainfall decreases with elevation. Sarsfield, on the low hills above the Gippsland plain, receives just over 700 mm. Areas along the Tambo River valley are effected by a rain shadow, with the result that places such as Ensay and Swifts Creek (just north of the study area), despite their relatively high elevation, receive only 715 mm and 612 mm respectively.



4. NICHOLSON

Generally, temperatures increase the lower the elevation. In addition, the elevated valleys almost certainly have a longer frost season and higher frost incidence than corresponding areas at lower altitudes. These factors would serve to reduce the growing season on the agricultural land in the Ensay district.

Especially during winter, snow commonly falls on areas above 600 m, although it rarely lies on the ground for any length of time. North- and east-facing slopes will be denuded of snow cover earlier than south- and west-facing slopes.

2. Geology and geomorphology

Ordovician sandstones, siltstones, and shales are the most common rock types represented in the block, although considerable areas of granitic and associated metamorphic rocks occur at Marthavale, Ensay, and Tambo Crossing. Extensive intermontane basins are centred on these igneous and metamorphic complexes, the largest one being in the Ensay district. Elevated plateaux at Mount Dow and Mount Elizabeth probably represent the remains of a prior landscape surface that has been destroyed elsewhere by weathering and erosion.

3. Soils

The Ordovician sediments carry a range of uniform soils, grading from skeletal stony loams to sandy loams. Sandy loams and podzolic soils have developed on the igneous and metamorphic complexes, although skeletal soils are a common occurrence. Podzolic soils of various types have developed on the Tertiary sediments.

4. Vegetation

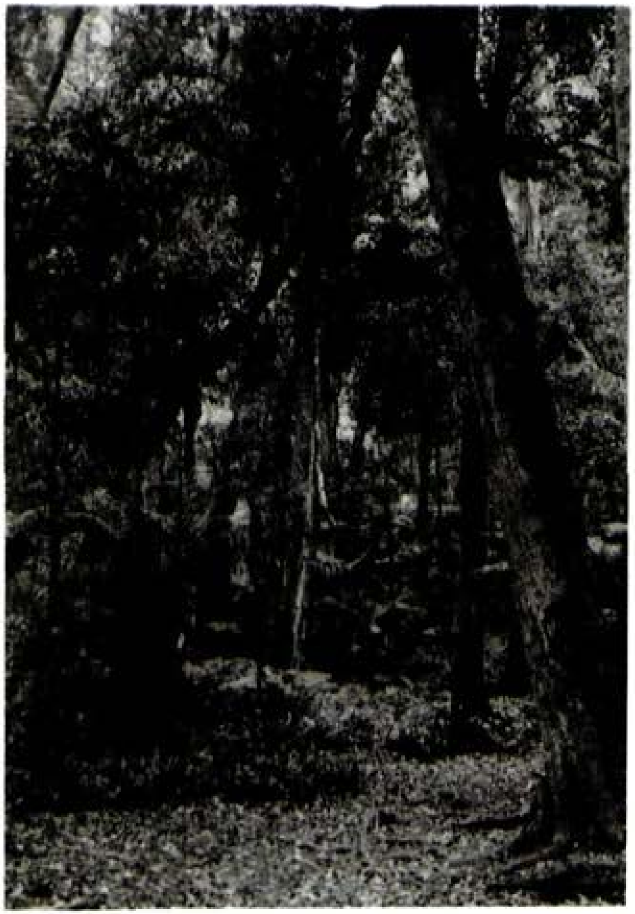
The majority of tall open forest types in the study area occur in this block. They are located at relatively high altitudes in the headwaters of the Nicholson River and the Haunted Stream.

Mountain ash forests generally occur at the highest elevations, usually between 800 and 900 m, while messmate-- mountain grey gum forests grow in association with the ash stands. They cover a more extensive area, ranging down to relatively low elevations in the Ash Range. Understoreys in these moist forests are generally typical of wet sclerophyll forests, with an intermediate stratum of wattles associated with a dense stratum of shrubs. At lower elevations the messmate unit may have less complex understoreys; in some places bracken may dominate.

Silvertop open forest III occupies some of the drier ridge tops in the same general area as the above open forest IV units. It has a much less-dense understorey than the adjoining wetter forest types.

Other open forest III units represented include the white stringybark and yellow stringybark units that occupy drier sites north and south respectively of the Ash Range. The area north and west of Bruthen contains the best and most extensive stands of yellow stringybark to be found anywhere in the study area.

The mountain grey gum--stringybark unit is the most widespread of all the open



Warm-temperate rainforest, Fairy Dell

forest III types, ranging from the highest altitudes in the north of the block right through to elevations of only approximately 100 m in the south. It commonly occupies the drainage lines and sheltered slopes. At the higher altitudes, messmate is the dominate stringybark, gradually being replaced by white stringybark as elevations decrease. Below the Ash Range yellow stringybark dominates. Because of the unit's relatively wide environmental tolerances its understorey can vary considerably - from a bracken-dominated to a wet-gully type.

Red stringybark--red box open forest II occupies the most exposed and driest sites. The understoreys in these low open forests are generally sparse, with low shrubs and grasses dominating.

Quite large areas on the Angora Range and adjacent to Haunted Stream are covered by wattle scrub. It occupies mainly steep north- and west-facing slopes and probably results from repeated fires (which have favoured the replacement of eucalypt forest by acacia scrub).

On Deep Creek, west of Bruthen, is the study area's largest example of warm-temperate rainforest. It is the major feature of, and the reason for, the Fairy Dell scenic reserve.

5. Fauna

The forested environments represented on public land include a patch of closed forest, significant areas of tall open forest, open forest, and foothill woodland, and narrow stretches of riverine forest.

The fauna can be generally predicted from the nature of these environments, and for details the reader should refer to Chapter 10 and Appendices 2-6.

The riverine environment along the Nicholson River exhibits the typical focusing effect of a vegetation strip that is well suited to wildlife passing through a drier environment of less-favoured plant species.

Several gold-mine shafts and drives in the Deptford area are used by the eastern horseshoe bat and common bent-wing bat.

C. Present Use and Capabilities

1. Nature conservation

While all the forested public land has at least a moderate capability for nature conservation, some areas are more important than others. For instance, the Fairy Dell scenic reserve contains the study area's largest single stand of warm-temperate rainforest, a rare forest type near the western limit of its distribution in this area.

Nine significant plant species have been recorded in this block, including the rare alpine orchid *Chiloglottis pescottiana* and a rare liane *Marsdenia flavescens*.

The dusky antechinus is a widespread ground-dwelling mammal

2. Recreation

Pleasant scenic driving can be enjoyed on forest tracks west of Bruthen. This drive affords panoramic views of the Gippsland Lakes and plains from the Devil's Elbow and passes the Fairy Dell scenic reserve, which has picnicking facilities.

Other lookouts are located at Mount Little Dick and Mount Sugarloaf.

The old gold-mining settlements of Deptford and Stirling are popular destinations for fossickers and picnickers. Haunted Stream and, to a lesser extent, the Nicholson River provide good freshwater angling, primarily for trout. Deer-hunting, rally driving, and bush camping are other recreational uses of public land.

3. Wood production

The headwaters of the Nicholson River and Haunted Stream contain the study area's largest area of highly productive forests. The stands of mountain ash and messmate have a high capability for hardwood production, especially sawlogs. Ash timber is also highly prized as a raw material for paper-making, and quantities are taken for pulpwood.

Foothill forests west of Bruthen and south of the Ash Range are also very valuable for timber production - firstly because of their accessibility, and secondly because of the occurrence of yellow stringybark. This species is very highly regarded for sawn timber and is sought-after for house framing and general construction. Fence posts and sleepers are also cut from the foothill forests. Sawlogs from the block provide raw material to sawmills at Swifts Creek, Mount Taylor, Bairnsdale, and Bruthen.

Forests over the remainder of the block range in productivity from low to moderate, and are not generally considered to be of great commercial value.

While currently only small quantities of pulpwood are taken, this block forms part of a larger area of East Gippsland, which may become a major supplier of pulpwood. The government is currently considering a statement of the environmental effects of extracting 800,000 cu. m of pulpwood per annum from the forest in the eastern portion of the study area and East Gippsland.

A small school softwood plantation occupies public land at Granite Creek. In addition, on the basis of preliminary reconnaissance, the Forests Commission has identified land between Sarsfield and Waterholes that meets the site requirements for such plantations.

4. Agriculture

Approximately equal areas of the private land at Ensay and Tambo Crossing are used for beef cattle production and raising sheep for wool and meat. A greater proportion of the freehold land in the south is used for beef cattle. No public land is held under grazing licence. Indeed, the great bulk of public land has a low capability for forest grazing.

Public land on the low sandy hills between Bruthen and Sarsfield has moderate agricultural potential. The small, isolated intermontane basin at Marthavale also has some potential. However, most of the public land is not suitable for agricultural development.

5. Water production

The great bulk of the Nicholson River catchment is contained within this block. This river, although the largest

Construction gang on the Omeo Highway in the early 1900s stream in the block, is small by comparison with others in the study area. It has a mean annual discharge at Deptford of 44,000 ML.

Lakes Entrance Waterworks Trust draws water from the Nicholson River north of Sarsfield. The river's catchment to this point has been proclaimed according to the provisions of the *Land Conservation Act* 1970 and the *Soil Conservation and Land Utilization Act* 1958. Water from this source supplies Lakes Entrance, Kalimna, and Metung.

Tambo River runs through the north-eastern corner of this block but will be discussed in the Tambo block description.

There are no authorised extractions from groundwater anywhere in the block.

Neither construction of storages nor significant increases in water use are currently planned.

6. Mining and quarrying

Two parallel gold-fields are located entirely on public land, one along the Nicholson River between Marthavale and Deptford and the other to the east centred on the old gold-mining settlement of Stirling.

The only current mining tenement is a lease covering a gold-mine on the Yahoo Creek, operated as a tourist attraction.

A number of small gravel pits, scattered throughout the forested public land, are used almost exclusively for the maintenance of forest tracks.

7. Utilities

Fire lookouts operated by the Forests Commission are situated on Mount Sugarloaf and Mount Little Dick.

The Clifton Creek Primary School is also located on a small block of public land.

Bruthen rubbish tip is situated on public land north of the township.

D. Hazards and Conflicts

Because this block contains a relatively high proportion of wet mountain forests, wildfires do not pose the same threat as in other sections of the study area. This is not to say they don't occur, in fact the fire hazard is quite high in the drier foothill forests to the south. It is also in these southern forests that the root-rot fungus, *Phytophthora cinnamomi*, is scattered.

Many of the inaccessible streams in the mountain country, especially those disturbed by mining (for example, Nicholson River and Haunted Stream), are badly choked by blackberries.

Soil erosion is not generally a sérious hazard in the forested public land; however, there is some track erosion.

Proposals to greatly increase the volume of pulpwood to be extracted from this and other parts of east Gippsland have caused many people concern. Their main concerns are the conflicts with non-wood forest values they consider would result if greater intensity and frequency of harvesting resulted from the extraction of wood for pulp.

Another potential conflict is the possible conversion of hardwood forests to softwood plantations. If such conversion were to occur it would result in the loss of native flora and fauna, a reduction in recreational opportunities, a decrease in the area available to bee-keepers, and the loss of valuable hardwood timber resources.

5. TAMBO

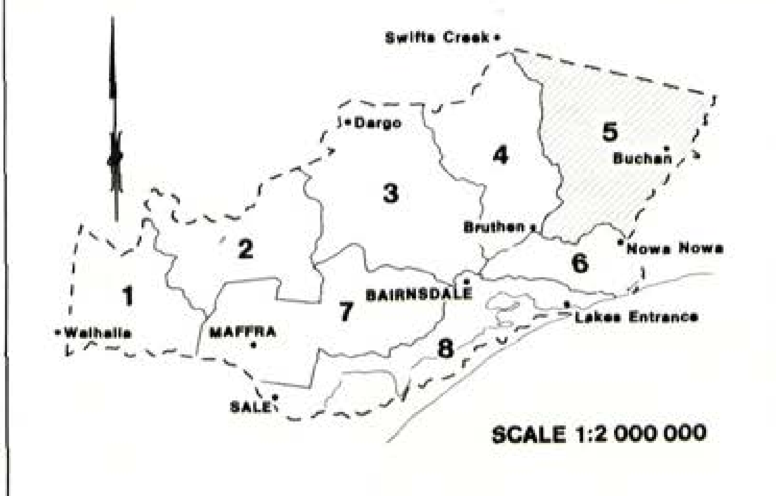
A. General

1. Land tenure and location

Public land occupies approximately 105,000 ha - some 70% - of the 150,000-ha Tambo Block. Most of this (about 87,000 ha) carries reserved forest.

Crown land reserves are mostly located in the Buchan area and many protect the area's outstanding limestone caves. The largest of these, the 285-ha Buchan Caves reserve, is controlled by the Department of Crown Lands and Survey. In addition relatively large Crown land reserves south of Buchan South include public-purposes reserves of about 160 ha and an 80-ha racecourse reserve, which contains the Kanni racecourse and the Buchan golf course.

The balance of public land is almost entirely made up of unreserved Crown land.



5. TAMBO

B. Nature of the Land

1. Climate

In common with other parts of the study area, this block varies climatically - largely in response to changes in elevation. Generally, the transition from the warmer and drier lowlands to the cooler and wetter highlands is gradual, although local orographic variations can give rise to sharp gradations in climate.

Annual rainfall varies from a maximum of around 1,000 mm near Murrindal to less than 700 mm in the Tambo River valley north-west of Ensay. Despite the latter area's relatively high elevation, it has only low rainfall due to the valley's rain-shadow effect.

Temperatures are lower, frost incidence is higher, and snowfalls are more common in the northern section of this block than in the south. This is particularly significant for the agricultural areas around Ensay and Buchan, inasmuch as the cooler conditions tend to limit their growing season.

2. Geology and geomorphology

The western portion of the block consists of Ordovician sedimentary rocks that have been intruded in several places by granitic rocks. The large igneous and metamorphic complex occurring in the Ensay district extends into the north-western corner of this block, while in the east volcanic rocks of Devonian age outcrop over a wide area. An isolated occurrence of these volcanic rocks is located at Mount Elizabeth.

A fault-controlled basin aligned along a north--south axis in the Buchan district contains a series of Devonian limestones. A large intermontane basin occurs in association with these limestones and an interesting karst landscape has developed at several places.

The Buchan Valley golf club is located on public land between Buchan and Nowa Nowa

To the south the highlands are flanked by alluvial fans composed of Tertiary sands and gravels. The isolated outcrops of Tertiary rocks in the vicinity of the Timbarra River and its tributaries could have been deposited along former stream courses that have since been diverted by river capture. Residuals of Tertiary basalt flows occur between Buchan South and Dinner Hill Gap.

3. Soils

Uniform medium-textured soils predominate on the Ordovician bedrock throughout the block, although some podzolization has occurred on this parent material. Podzolized soils and loams have developed on the igneous and metamorphic complex in the north. Loams and skeletal soils are common on the Devonian volcanics in the east, and well-structured, friable gradational soils have been derived from the limestones in the Buchan district. The Tertiary sediments in the south support a range of duplex soils, paricularly podzols.

4. Vegetation

The plateau remnant that forms Mount Elizabeth supports the only substantial stands of tall open forest. Mountain ash open forest IV grows at the higher elevations (around 900 m), while the messmate--mountain grey gum forests are located just below these stands.

Both units have understoreys that in the main are typical of wet sclerophyll forests; an intermediate stratum of wattles is associated with a dense stratum of shrubs and tree ferns.

The mountain grey gum and stringybark unit is the most widespread of all the open forest III units, ranging from the highest altitudes in the north, where it may occupy extensive areas, through to the lowest elevations in the south, where it is generally confined to drainage lines and protected aspects. At the higher elevations messmate is the dominant stringybark, gradually being replaced by white stringybark as elevations decrease. Because of the unit's relatively wide environmental tolerances, its understorey can vary greatly.

At higher elevations, white stringybark open forest III grows in association with the above unit, occupying the drier sites. It becomes the dominant forest type in the southern portion of the block.

The driest, steepest, and rockiest sites carry red stringybark--red box open forest II. The harsh conditions under which this widespread unit grows are reflected by the sparse understorey dominated by low shrubs and grasses. On a number of these dry slopes, areas of wattle scrub have replaced eucalypt forests as a result of repeated fires.

Isolated patches of silver-leaf stringybark low woodland occur on both sides of the Bruthen--Buchan road, below Buchan South. This unit occupies poorly drained sites, usually with a shallow sandy topsoil underlain by a heavy clay or hard pan layer. Understoreys reflect the soil's poor drainage characteristics, with sedges, rushes, and bottlebrush being common.

5. Fauna

The forest environments represented on public land include isolated patches of closed forest, larger but still relatively insignificant areas of tall open forest, narrow stretches of riverine forest, and large areas of both open forest and foothill woodland. An example of the farmland environment occurs on cleared public land at the Buchan

Caves reserve. Here 'tame' kangaroos feed from the tourists.

The fauna can be generally predicted from the nature of these environments, and for details the reader should refer to Chapter 10 and Appendices 2-6.

Many of the caves in the Buchan--Murrindal area are utilized by bats - as staging areas, as occasional roosting sites, or for overwintering. Some, such as those on the Snowy River at New Guinea Point, which house two breeding colonies of bent-wing bat, are used as maternity caves. Clogg Cave, near Buchan, is reported also to have a small breeding colony of large-footed myotis.

The rare brush-tailed rock wallaby has been recorded in the Snowy River gorge to the north of the study area. It is possible that this species may also be found on cliffs along the river in this block.

The koala is re-establishing itself in open forest areas, particularly in this block. The species is now widespread, but still uncommon, between Buchan and Nowa Nowa.

Introduced mammals include feral goats, which have been recorded in the Tambo River valley and along the Snowy River gorge. Small numbers of red deer have also been reported in the Snowy River area, and fallow deer have been shot near Buchan.

C. Present Use and Capabilities

1. Nature conservation

The most significant natural attributes in this block are the important geological features associated with the Buchan--Murrindal limestone basin. This area contains the best examples of surface karst and cave development in Victoria, and indeed has few equals anywhere in Australia.

One of the more important features here, the Anticline cave at Murrindal, is rated as of international significance. This consists of a single chamber about 90 m long, with a spectacular anticlinal ceiling. It contains some fine cave decoration and is used as a maternity cave by the eastern horseshoe bat.

Other features of national significance occur south of Murrindal and include Scrubby Creek cave (which is drained by a permanent stream, resulting in the formation of a series of tufa terraces at its entrance), the Potholes area (which provides the best examples of karst topography and associated cave formations in south-eastern Australia), and, at the Pyramids, Victoria's best example of an underground stream drainage and associated active and well-decorated cave system where the Murrindal River flows underground.

The Buchan area has great significance for its cave development, with 75 known

Tufa terraces at the entrance to Scrubby Creek cave

caves. It includes the most extensive cave system in the State with 4--5 km of stream passage, cut at several levels. Some of the best cave decoration known in Victoria is found in this system.

The area of limestone geology contains a number of significant plant species, including the calcicolous (limestone-restricted) ferns *Pteris vittata* and *Christella dentata*. The maidenhairs *Adiantum hispidulum*, *Athyrium japonicum*, and *Polystichum formosum* are ferns that although not calcicolous, are rare outside this area. Other significant species include the velvety shrub *Rulingia pannosa*, which is found on cliffs of the Murrindal River, and the native sorghum *Sorghum leiocladum*. Both species are known only from a few other Victorian records. *Centaurea australis* has only been collected in Victoria at the Murrindal River and Lake Omeo.

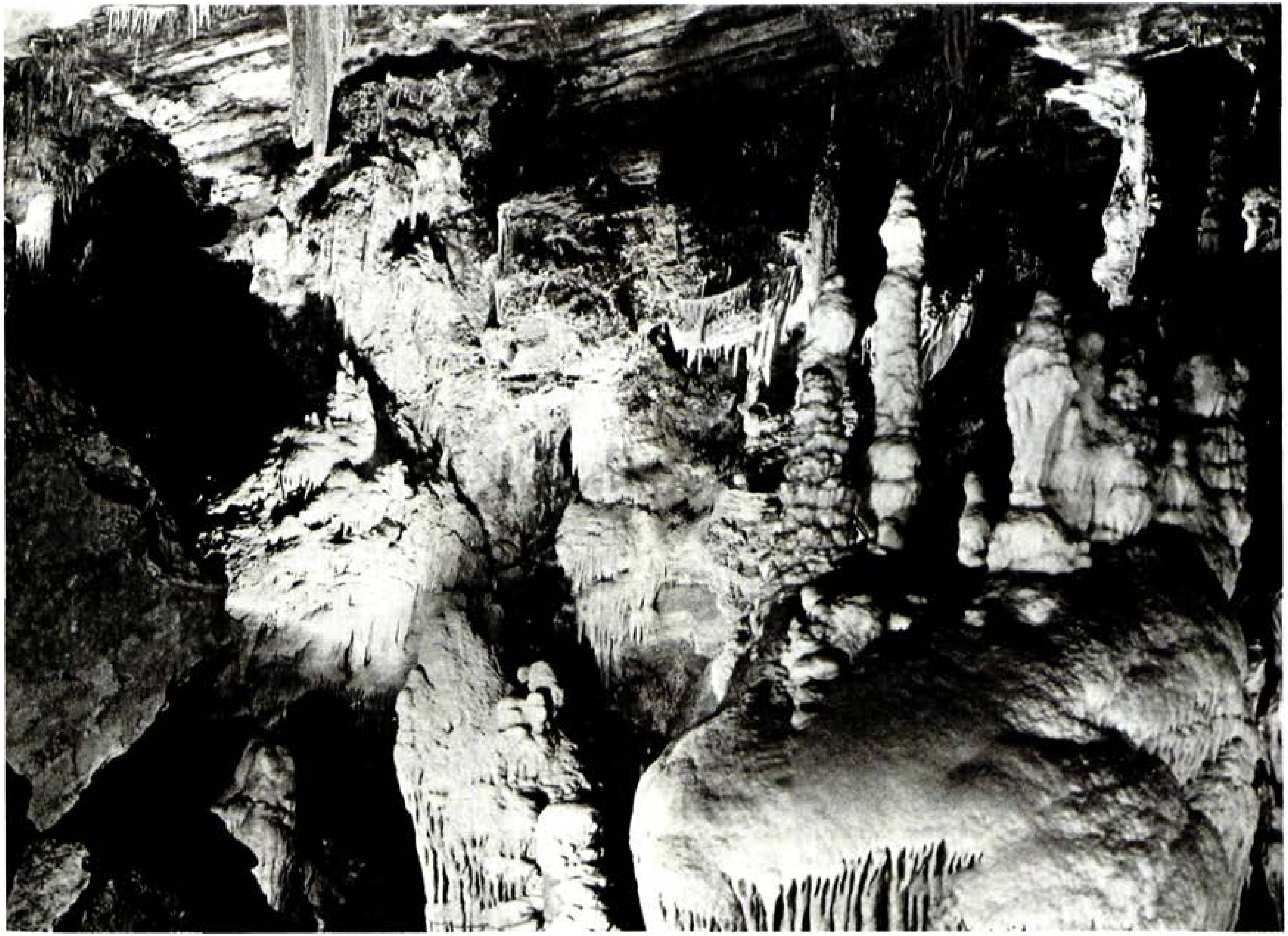
In addition to fine stands of mountain ash regrowth, the plateau remnant comprising Mount Elizabeth supports three rare species. The shrub *Hibbertia hermanniifolia*, which has been collected from the summit, has been recorded at only one other locality in the State. *Phebalium squameum* subsp. *coriaceum* is a Victorian endemic otherwise known only from the headwaters of the Macalister River. The third rare species is the showy *Boronia ledifolia*.

Many of the caves in the Buchan--Murrindal area are used by cave bats.

The most important of these are the breeding or maternity caves, which constitute the centre of a population. As already mentioned, the eastern horseshoe bat uses Anticline cave for such purposes. The rarest of the three species of cave bat found in Victoria, large-footed myotis, has a maternity colony in Clogg cave near Buchan - the only such colony in the State.

2. Recreation

Approximately 80,000 people annually visit the Buchan Caves reserve, making it one of the most popular recreation resources in the study area. Guided tours are conducted through some of the more decorative of the limestone caves,



Limestone decoration in one of the Buchan Caves and camping and swimming facilities are also available in the reserve.

Many caves in the Buchan--Murrindal area provide the most important venue in Victoria for the sport of caving, and are among the best in Australia.

The Snowy River is one of the finest canoeing streams in the State. Other rivers used by canoeists are the Buchan and Tambo. These three, plus the Timbarra River, are all popular fishing streams.

Major scenic drives follow the Omeo Highway, along the Tambo River between Bruthen and Swifts Creek, and the Buchan--Murrindal road, with its spectacular views of the surrounding rolling countryside.

Three waterfalls are found in this block on the Timbarra River and the Basin and Running Creeks.

Picnic areas are located at a number of sites along the Tambo River at Mount Elizabeth and the Buchan Caves reserve, and where the Buchan River enters the Snowy River.

A number of organized sports are catered for on public land. These include a rifle range south of Buchan South and a golf course and racecourse that share an area further south again. Orienteers use public land between the Tambo River and Bruthen.

3. Wood production

With the exception of isolated areas of tall open forest in the north, the forests that cover this block are of limited commercial value.

The largest (but still small) areas of mountain forests are the mountain ash and messmate stands at Mount Elizabeth. These have high capability for hardwood production. Capability of the foothill forests, which grow over the greater part of the block, ranges from moderate for the moist forests, in the protected sites, to low for the drier, slower-growing forests. The sawlogs that are produced are converted to sawn timber at Ensay, Buchan, Buchan South, and Nowa Nowa.

While currently only small quantities of pulpwood are taken, this block forms part of a larger area of east Gippsland, which may become a major supplier of pulpwood. The government is currently considering a statement of the environmental effects of extracting 800,000 cu. m of pulpwood per annum from the forests in the eastern portion of the study area and east Gippsland.

With the exception of small trial plots, no softwood plantations occupy public land. However, on the basis of preliminary reconnaissance, the Forests Commission has identified land east of Bruthen that meets the site requirements for such plantations.

4. Agriculture

Beef cattle production is the most common agricultural enterprise on privately owned land. On isolated blocks west of Buchan South and on the Timbarra River and Fryingpan Creek, only cattle are raised. Approximately three-quarters of the pastoral land in the Buchan region is grazed by beef cattle, with the balance supporting sheep grown both for wool and meat. At Ensay and Tambo Crossing, beef cattle and sheep occupy about half the freehold land each.

Cattle are grazed on public land north of Buchan by eight different graziers, each with one licensed area. In addition, a number of much smaller blocks of public land are held under licence. The great bulk of public land has a low capability for forest grazing.

Substantial areas of public land on the low hills south of Buchan South have moderate agricultural potential. The remaining steep and dry public land to the north is generally not suitable for agricultural development.

5. Water production

The major streams are the Tambo River and its main tributary, the Timbarra River, and the Snowy River (which forms the study area's north-eastern boundary) and its tributary, the Buchan River. As do other major rivers in the study area, the Tambo and Snowy Rivers both have

Beef cattle are raised on this alluvial flat south of Timbarra

catchments that extend far into the alpine areas, and these northern sections are far more productive than those parts within the study area.

Records from gauging stations within the block indicate that mean annual discharge for the Tambo River at Bruthen is 216,000 ML and the corresponding figure for the Buchan River at Buchan is 189,000 ML.

The Bruthen Waterworks Trust supplies water to the townships of Wiseleigh, Mossiface, and Bruthen from an offtake on the Tambo River just below the latter township. Likewise, the Buchan Waterworks Trust supplies water from the Buchan River to the township of Buchan.

Around 50 licences and permits are issued annually for the diversion of water from streams within the block. Almost all of these authorizations are for irrigation or domestic and stock purposes.

There are no current proposals for increased regulation or use of stream flows.

The largest user of groundwater is an irrigator near Buchan, who has an authorized annual extraction of 241 ML.

6. Mining and quarrying

The small gold-field east of Buchan South is not presently being mined.

Silver and lead occur at a number of sites both north and south of Buchan. While there are no known large concentrations of the minerals, active exploration is continuing. Earlier mining in this area met with little success.

A number of bodies of iron ore and manganese ore have been found in the Buchan--Nowa Nowa area. The largest deposit, north of Nowa Nowa, contains six million tonnes of high-grade ore, but it lies beneath a thick overburden of hard rhyodacite. Over a period of 20 years up to 1980, a total of 23,500 tonnes of iron ore has been extracted from this ore body on public land. The area is currently held under a mining lease.

Small amounts of molybdenum and tungsten were mined near the Tambo River early this century. Minor deposits of platinum and antimony are found around Buchan.

A 26-km linear outcrop of Devonian limestones extends from Buchan South to north of Murrindal, mostly on private land. Marble has been quarried from this outcrop for many years and used for building purposes. Agricultural lime from crushed limestone has been supplied from sites south and east of Buchan. Recent exploration has established the subsurface occurrence of copper and molybdenum south of Mount Johnston.

A quarry north of Nowa Nowa produces crushed or broken hard rock for roadworks, for railway ballast, and for use by the Ports and Harbors Division in stabilization and construction work. A number of small gravel pits, scattered throughout the forested public land, are used almost exclusively for the maintenance of forest tracks.

7. Utilities

Fire lookouts operated by the Forests Commission are located on Mount Johnston, Mount McLeod, and Mount Nowa Nowa. The latter peak also carries a number of communication facilities, including a Telecom radio-telephone station and a television translator station.

The Buchan tip is located on public land south of the township.

D. Hazards and Conflicts

The nature of the forests and the terrain combine to make fire the most serious hazard. The dry, predominantly stringybark forests with shrubby understoreys, in which readily flammable fuel builds up rapidly, are very fire-prone. The steeply dissected topography facilitates the spread of fire and makes efforts to suppress it more difficult. Wildfires are not only a threat to life, property, and valuable timber resources, they can also have a devastating effect on wildlife, catchment values, and floral values (especially understorey composition).

Blackberries are a problem in some of the more inaccessible gullies where they cannot be reached by sprays. Other noxious weeds and vermin, while present, are manageable.

Soil erosion is not a serious problem on public land, with the erosion of forest tracks being the most widespread form.

Both of the main conflicts involve the increased use of public land for intensive forms of wood production.

The first results from the increased requirements for pulpwood. Concern has been expressed that short-rotation, clear-felling harvesting techniques, if used to produce this product, will lead to an alteration in the forests' floral composition with fast-growing, fecund species like silvertop dominating. Loss of wildlife and the destruction of their habitat, increase in soil erosion and a consequent decrease in water quality, and a decrease in honey flows are also feared.

The second involves the possibility of the conversion of native hardwood forest to softwood plantations. This would result in some loss of native flora and fauna, reduction in some recreational opportunities, decrease in the area available to apiarists, and the loss of hardwood timber values.

Conflict also arises between the recreational use of the area's limestone caves and the conservation of their special natural features. Many of the caves have been damaged by vandals, and disturbance by people constitutes the major threat to the important colonies of cave bats. It has been suggested that Moon Cave, one of the Buchan group, has been polluted by effluent from the Buchan Caves reserve toilet block.

6. COLQUHOUN

A. General

1. Land tenure and location

About half of the roughly 50,000 ha Colquhoun block comprises public land. Of this 25,000 ha, about 22,000 ha is reserved forest, which includes 3,720 ha of the Lake Tyers forest park, reserved under section 50 of the *Forests Act*. The other portion of this park, which surrounds Lake Tyers and in all covers 5,315 ha, is in the East Gippsland study area.

A number of small Crown Land reserves are mostly located in and around Nowa Nowa and along the Princes Highway. The largest of these is a 240-ha public-purposes reserve south of Nowa Nowa.

The balance of public land is almost entirely made up of unreserved Crown Land.

B. Nature of the Land

1. Climate

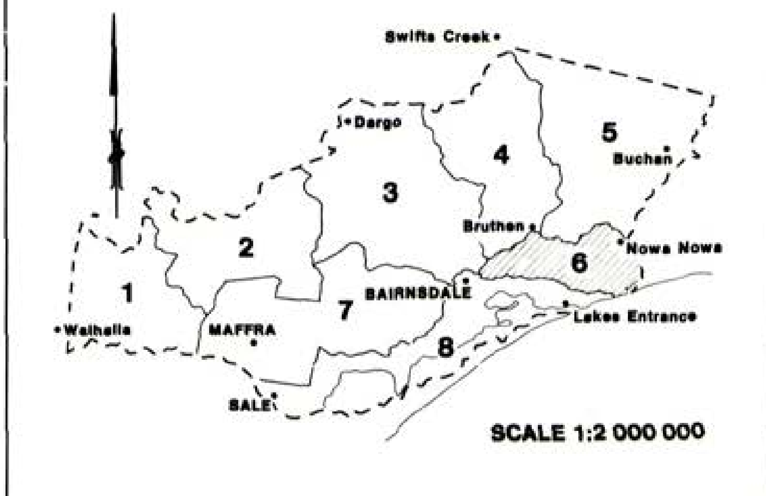
As a result of this block's relatively small size, and consistent and subdued topography, it has a reasonably uniform climate.

Rainfall varies from around 700 mm in the south to 850 mm in the north.

Temperatures are generally mild, with frosts uncommon and snowfalls a very rare occurrence.

2. Geology and geomorphology

The eastern section of the block is covered by Tertiary deposits consisting mainly of sands, clays, and gravels of alluvial origin. Localized occurrences



6. COLQUHOUN

of Tertiary marine deposits (including limestones and sandstones) outcrop in the cliffs around Lake Tyers and in the Tambo and Nicholson River valleys south of the Bairnsdale--Bruthen road.

Two small outliers of granitic rock occur between Bruthen and Nowa Nowa, but as the cover of Tertiary rocks thins towards the north of the block, larger areas of granite and other Palaeozoic bedrock are exposed. A small outcrop of Ordovician sandstones is exposed along the Tambo River valley east of Bruthen.

Between Bairnsdale and the Tambo River, several high-level terraces of Quaternary age occur. These have developed in response to a fluctuating sea level throughout the Quaternary period.

3. Soils

Podzolic soils dominate in areas of Tertiary outcrop, while a range of loams and yellow mottled duplex soils (including podzols) has developed on the Quaternary deposits. In some situations it is difficult to distinguish whether the parent material is of Tertiary or Quaternary age.

4. Vegetation

The low sandy hills of this block mainly carry medium open forests dominated by white stringybark and silvertop. The latter species may grow in pure stands on broad flat ridge-tops with deep soils. Understorey species reflect the area's relatively well-drained soils and its history of frequent fires. Common species include saw banksia, sunshine wattle, and shining cassinia, with a ground layer dominated by bracken.

Many of the drainage lines and protected aspects support mountain grey gum--messmate forests. While most of these stands are less than 40 m high, the most favourable, wettest sites carry tall open forest IV. All of these forests have understoreys of the wet-gully type.

The study area's best remaining representatives of the distinctive Gippsland grey box open forests occur on small areas fringing Lake Tyers. This unit occupies well-drained sites and has a typically grassy understorey.

5. Fauna

Open forest is the major forest environment represented on public land. Others include very small areas of closed forest and tall open forest, and narrow stretches of riverine forest. The estuarine Lake Tyers provides an inland wetlands environment.

The fauna can be generally predicted from the nature of these environments, and for details the reader should refer to Chapter 10 and Appendices 2-6.

Within the study area, populations of the red-necked wallaby are restricted to

Section of the maternity colony of bent-wing bat in Nargun cave

this block and an area north of Buchan. Nargun cave, south-west of Nowa Nowa, contains the largest breeding colonies of bent-wing bat and eastern horseshoe bat in Victoria.

The flowering red ironbark, which is part of the open forest environment here, is favoured by nectar-feeding birds and attracts forest honeyeaters, musk lorikeets, and king parrots. This block contains the only regular occurrences of swift parrot in Gippsland.

The lowland fresh-water tract of the Tambo River supports fish communities characterized by a predominance of introduced species such as common carp, redfin, pigmy perch, and goldfish. However, it also supports a small number of Australian bass, a species considered uncommon in Victoria. Lake Tyers contains estuarine fish such as bream, flathead, flounder, and garfish, as well as prawns.

Lake Tyers supports a nesting colony of little tern, a resident population of waterfowl, and a seasonal population of migratory waders. Waders use the shallow margins of the lake and the ephemeral islands near the sand bar barrier.

C. Present Use and Capabilities

1. Nature Conservation

The Lake Tyers forest park contains excellent examples of many of the foothill and coastal vegetation communities, including stands of warm-temperate rainforest and the distinctive and now-restricted Gippsland grey box. Seventeen eucalypt species have been recorded in the park, and understoreys vary from bracken to Banksia to wet-gully types. The area's conservation significance is further enhanced by the relatively low intensity of logging operations in the recent past.

Seven significant plant species recorded in this block include the rare fern *Cystopteris filix-fragilis*, which is usually restricted to rocky alpine sites, and the coastal daisy bush *Olearia viscosa*, which is known only from the Gippsland Lakes area and Tasmania.

The block contains a number of limestone caves, the most notable of which is Nargun cave on Casey Creek. As well as being of geological interest this cave contains the largest Victorian maternity colonies of common bent-wing bat and eastern horseshoe bat. About 60,000 females of the former species roost and breed in the Nargun cave during summer. They leave the colony when the young are independent, usually in March, and disperse to caves and mine shafts both locally and interstate. The eastern horseshoe bat has a similar breeing pattern, producing about 10,000 young each year in Nargun cave, which is the southern-most maternity colony of this bat in the world.

Lake Tyers is one of a string of estuaries and marshes along the coast of Gippsland that are important for waterbirds. Significant species include three waders - grey plover, lesser golden plover, and ruddy turnstone - all of which are transequatorial migrants, a nesting colony of little tern, and the blue-billed duck, which is an occasional visitor to the Toorloo Arm.

2. Recreation

Lake Tyers and the adjacent forest park are the most important recreational areas in this block. The lake is suitable for most forms of water sports, but is perhaps most popular for the excellent estuarine fishing it provides. Its sheltered waters contrast with the larger lakes and favour some activities such as flatwater canoeing.

It is estimated that the Lake Tyers forest park attracts between 20,000 and 25,000 visitors per year. It contains a number of picnic sites, both beside the lake and adjacent to the Princes Highway. A network of forest tracks provides pleasant bush driving conditions and a number of short walking tracks have also been developed.

Forested public land outside the forest park is also used quite extensively for passive recreation. Many picnic sites are scattered throughout the Colquhoun forest, where the Forests Commission organizes guided self-drive 'Forestours' during school holidays. As many as 1,200 people each year take part in the escorted tours and around 3,000 take the self-guided tours. Features of interest in this area include old sawmill sites, disused tramways, and the wooden trestle bridge on the Orbost railway line.

Those portions of the Nicholson and Tambo Rivers in this block are among the most heavily fished stretches of water in the study area.

3. Wood production

While the coastal forests of this block do not have high potential productivity, they are important producers of various timber products. Silvertop, mountain grey gum, messmate (small quantities), and white stringybark all produce sawlogs; fence posts are cut from white stringybark, red ironbark, and Gippsland grey box; the last two species also produce sleepers and piles while red box is cut for firewood. These readily accessible forests have had a long history of use for timber production including heavy past production of sawlogs from Dead Horse Creek and Colquhoun forests.

Currently only small quantities of pulpwood are taken; however, this block forms part of a larger area of East Gippsland, which may become a major supplier of pulpwood. The government is currently considering a statement of the environmental effects of extracting 800,000 cu.m, of pulpwood per annum from the forests in the eastern portion of the study area and East Gippsland.

No softwood plantations are grown on public land.

4. Agriculture

Both beef cattle and sheep (for wool and meat) are raised on pastoral land in the west of this block. The Nowa Nowa--Lake Tyers area carries beef cattle only.

Irrigated land on the Tambo River flats south of Bruthen produces vegetables, lucerne, and maize crops. The irrigated pastures support both dairy and beef cattle.

Apple orchards are located just northwest of Bairnsdale, while apples, pears, passionfruit, and Chinese gooseberries are grown north of Lakes Entrance.

Angora goats are raised on a property north of Lake Bunga.

No public land is held under grazing licence. The low, sandy Nowa Nowa hills, which have moderate agricultural capability, take in almost all the public land.

5. Water Production

This block has a low capability for water production. The only streams of any consequence with public land as part of their catchment are Mississippi and Stony Creek. The lower reaches of the Tambo and Nicholson Rivers pass through the block, and there is some minor diversion from them for irrigation and domestic and stock purposes.

Small amounts of groundwater are used for irrigation.

6. Mining and quarrying

All bar the north of this block has the potential for discovery of oil and gas.

The Stony Creek railway bridge west of Nowa Nowa

The entrance to Nargun cave

In the past, granite has been extracted from quarries on the Mississippi Creek. The material was used for breakwater and groyne construction at Lakes Entrance. A number of small gravel pits are scattered throughout the forested public land. These are used almost exclusively for the maintenace of forest tracks.

Limestone for agricultural purposes has been extracted at Toorloo Arm.

7. Utilities

The Bairnsdale to Orbost railway line passes through the public land in this block from east of Mossiface to Nowa Nowa.

D. Hazards and Conflicts

Wildfires are the major hazard. The coastal forests have a high fire risk because of the characteristic fibrous bark of the stringybark eucalypts (which provides a link between ground and crown fuel and will act as firebrands to accelerate the spread of fire) and the shrubby understoreys.

The rate of fuel build-up is high, and strong winds in spring and summer desiccate dead and living vegetation alike to create extended periods of high fire danger. The last serious fire occurred in November 1980, when a large one burnt through the northern section of the Colquhoun forest, at one stage threatening the township of Nowa Nowa.

Cinnamon fungus (*Phytophthora cinnamomi*), which causes dieback in eucalypt forests, is scattered throughout the lowland forests.

Soil erosion is not currently a serious hazard on public land. Both vermin and noxious weeds occur on public land; however, neither is considered to be a major hazard.

Conflict could arise out of proposals now being considered by government to greatly increase the level of pulpwood-harvesting east of the Mitchell River.

If short-rotation clear-felling harvesting techniques are used for intensive pulpwood production, flora and fauna values and water quality would be adversely affected, soil erosion would increase, and honey flora would be reduced.

Inadvertent disturbance of the bat colonies by over-zealous fossil collectors, together with deliberate vandalism including shooting of bats, is a problem at Nargun cave.

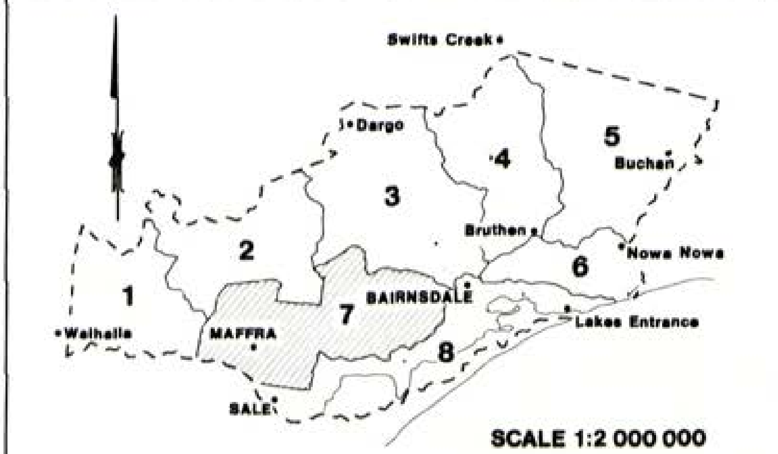
7. GIPPSLAND PLAINS

A. General

1. Land tenure and location

Although in total area this is one of the larger blocks, covering more than 135,000 ha, it contains only approximately 5,000 ha of public land.

Reserved forest occupies around 2,000 ha (including the Moormurng forest park south-west of Bairnsdale, which is reserved under section 50 of the *Forests Act*).



7. GIPPSLAND PLAINS

A large number of relatively small Crown land reserves scattered throughout the block are used for a variety of public purposes. They include the Knob recreation reserve at Stratford, the Newry recreation reserve (containing a golf course and football and cricket ground), and a public-purposes reserve west of Boisdale, which contains the Maffra and District car club hill-climb circuit. The largest of these reserves is a 154-ha railway-purposes reserve west of Fernbank, adjacent to and north of the Melbourne--Bairnsdale railway line.

The largest single block of public land is the unreserved Crown land that straddles the Princes Highway near the Perry River.

B. Nature of the Land

1. Climate

Climatic conditions throughout the block do not vary greatly, due to the fact that the Gippsland plains themselves are topographically quite uniform.

Annual rainfall increases gradually from south to north, being generally in the range between 600 mm and 700 mm. The driest area, around Maffra, is in a rain shadow created by the mountains to the west, and receives mean annual rainfall of only 572 mm.

The Maffra district is not only one of the driest parts of the study area, it is also one of the hottest. While this district is mainly below 30 m in elevation, summer day temperatures are not significantly tempered by sea breezes as they are further to the east. Mild winter weather over the plains and coastal areas is a feature of Gippsland's climate. Northerly winds in the east of the State, particularly those bringing rain to the north-eastern highlands, become quite warm when descending from the mountains. This is known as the Föhn effect and under its influence it is not uncommon for the area to record the highest temperatures in the State for that period.

2. Geology and geomorphology

The block is dominated by a series of coastal terraces of Quaternary age. They consist of sands, clays, and gravels and have developed as the result of a fluctuating sea level during this period. The terraces actually mark the positions of former shorelines.

In addition, numerous south-west--north-east trending dune ridges and sand sheets are widely distributed across the Gippsland Plains; they overlie the coastal terraces and are also of Quaternary age, but their mode of formation is uncertain.

The Quaternary sediments overlie Tertiary deposits that are exposed around Stockdale and in several creek valleys, including the lower reaches of Tom Creek south of Fernbank. The western section of the block contains the Thomson--Macalister and Avon River flood plains, which are separated by several coastal terraces extending from Boisdale to the western shore of Lake Wellington near Sale.

3. Soils

Extensive development of duplex (mainly podzolic) soils has occurred on the coastal terraces, while on the dunefields the soils consist mainly of undifferentiated siliceous sands, which have been podzolized in some areas. The podzolization process is also widespread on the Tertiary deposits as well as a mottled duplex soil.

The flood-plain areas carry fine-textured uniform soils, the most common being a dark-coloured clay, but coarse alluvial gravels and sands are also present. Sandy loams are a frequent component of the younger terraces bordering the major streams in the area.

This shining peppermint woodland with a heathy understorey is typical of the vegetation on the broad sandy ridges of the Providence Ponds area

4. Vegetation

The low sandy hills between Stockdale and Glenaladale support white stringybark open forest III. White stringybark is also the dominating tree species for much of the public land adjacent to the Perry River near Fernbank. However, in the latter locality, the structural form varies between open forest and woodland due to the poorer site quality. In both localities understoreys reflect the sites' relatively well-drained soils and their history of frequent fires. Bracken is the dominant component of the ground layer.

Low woodlands of shining peppermint, rough-barked manna gum, yertchuk, and white stringybark have developed on the east--west trending dunes that cover significant areas of the plains, but remain in public ownership only in the Moormurng forest park and beside the Perry River. Understoreys on these deep sands are typically heathy, with saw banksia and bracken being common species. Fresh-water swamps occur in the inter-dune depressions and carry closed sedgeland.

The largest remaining stand of the once-widespread forest red gum is located in the Moormurng forest park. Other smaller representations are at Stratford and east of the Perry River. Forest red gum occurs on flat land with heavy soils that are often seasonally waterlogged. Main ground cover species are grasses and sedges.

5. Fauna

The only environments significantly represented on the small amount of public land in this block are open forest and foothill woodland.

The fauna can be generally predicted from the nature of these environments, and for details the reader should refer to Chapter 10 and Appendices 2-6.

The heathy understorey of the Providence Ponds forests supports East Gippsland's only recorded inland population of the rare New Holland mouse. This same dense understorey provides cover for large numbers of black wallaby.

Sandy soils and the open nature of the forest at Providence Ponds are ideal conditions for the lace monitor, which is common here. It can also be found in the Moormurng forest park, where more than 90 native bird species have been recorded. Among these are two birds of prey - the wedge-tailed eagle and swamp harrier - which breed in the park.

C. Present Use and Capabilities

1. Nature Conservation

Moormurng forest park and the public land at Providence Ponds are the only substantial areas of forest on the whole of the Gippsland Plains, most of which is now cleared for agriculture. As such they constitute very valuable remnants, containing examples of land types, vegetation, and faunal communities. (albeit altered since settlement) typical of the plains.

The study area's largest remaining stand of forest red gum is located in the Moormurng forest park. Two smaller stands of this once-widespread forest type can be found at the Knob recreation reserve and on public land adjacent to the highway east of Stratford.

The Providence Ponds forest contains a number of significant plant species, including the only Victorian record of the grass *Eragrostis trachycarpa*, the rare trailing shrub *Isopogon anemonifolius*, and the uncommon water lily *Philydrum lanuginosum*. It is also renowned for its colourful wildflower displays.

These remnant forests are important refuge areas for native fauna. Significant species include the rare New Holland mouse, which has been recorded at Providence Ponds. Expanses of permanent water that occur on small blocks of public land south and north-east of Fernbank are important for a variety of water birds.

2. Recreation

Public land in this block is not used extensively for recreational activities.

Naturalists often visit the Moormurng forest park and the Providence Ponds area. The forest park is also used for orienteering.

A number of recreation reserves cater for organized sports such as football, cricket, tennis, golf, car-racing, and equestrian events. The Knob recreation reserve is also a popular area for picnicking and contains a lookout that provides fine views across the Avon River and its adjacent flats.

Public land on the Princes Highway east of Stratford has recently been developed as a highway park.

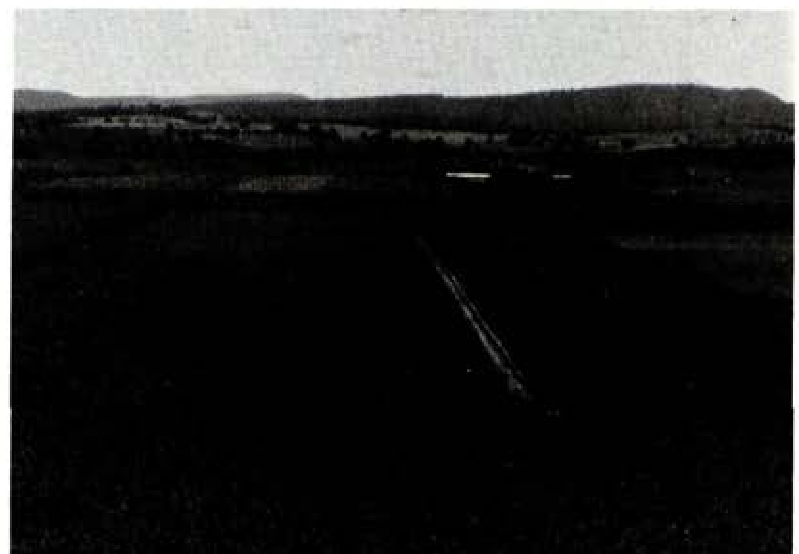
3. Wood production

The small areas of public land remaining in this block have a generally low capability for hardwood production. The major timber species are white stringybark and forest red gum, both of which are cut primarily for fencing materials.

Currently the only pine plantation on public land is a small trial plot on the Princes Highway east of the Perry River However, most of the public land, including that near Stockdale and adjacent to the Perry River, has been identified by the Forests Commission as meeting the site requirements for the establishment of softwood plantations. A.P.M. has, and is continuing to establish, plantations of *P. radiata* on adjacent private land.

4. Agriculture

Wool production from Merino sheep is the major agricultural industry on private land between Stratford and Bairnsdale. Beef cattle are also raised. The Macal-



Vegetable crops on the Mitchell River flats ister Irrigation District between Heyfield and Stratford supports primarily dairy cattle, with some beef cattle and vegetable crops.

Grazed public land includes the railway-purposes reserve west of Fernbank and many small blocks scattered throughout the plains. Up to 110 cattle are run on agistment in the Moormurng forest park for periods ranging from one to four weeks. Such grazing is valuable as a fire-protection technique in the forest red gum areas.

The undulating, sandy country that constitutes the bulk of the public land has only a moderate agricultural capability. In contrast, the flat land supporting forest red gum would make highly productive agricultural land.

5. Water production

While major rivers such as the Avon, Thomson, and Macalister pass through the block, there is little contribution to stream flows as a result of this passage.

Many authorised diversions from these major streams supply irrigation, domestic and stock, and industrial purposes. Such diversion by direct pumping from streams has reached a point where all streams are committed to the extent of available summer flows, other than for domestic and stock purposes. Further diversions would only be available on condition that on- or off-stream storage was provided to store excess winter stream flows.

Perry River and Tom Creek are the only streams of any consequence that have the bulk of their catchment within the block. Neither has a year-round flow of water.

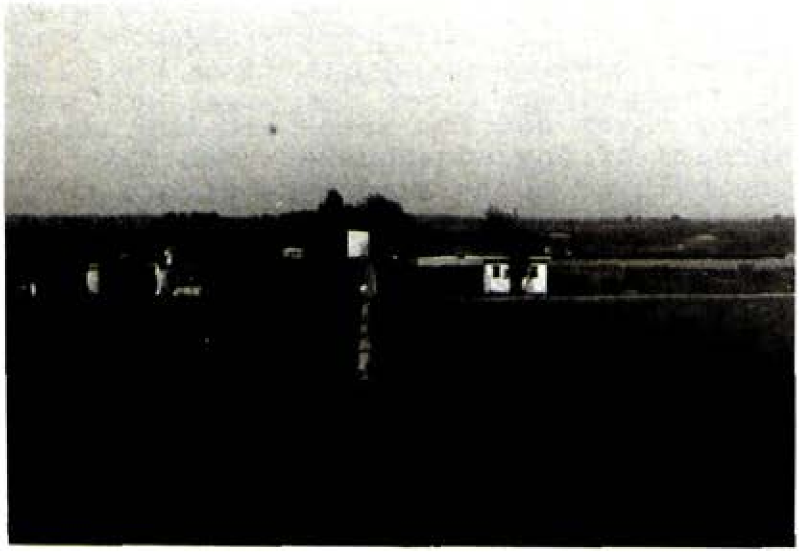
Maffra Waterworks Trust supplies almost 5,000 people with water drawn from the Macalister River near Maffra. Stratford Waterworks Trust also receives water from the Macalister River ex State Rivers and Water Supply Commission channel.

Briagolong and Boisdale both use groundwater drawn from bores sunk by the Briagolong Waterworks Trust. There is also considerable use of groundwater for irrigation on the plain between Sale and Bairnsdale.

6. Mining and quarrying

This block lies within the Gippsland sedimentary basin, which is rich in hydrocarbons. There is therefore a possibility of the accumulation of oil and gas deposits. In addition, brown coal resources of the coastal hinterland are currently being assessed by exploration companies.

Gravel, which is used for roading and general-purpose aggregate, is extracted from the bed of the Avon River at times of low stream flow. Gravel is also extracted from small blocks of public land



Maffra sewage treatment works

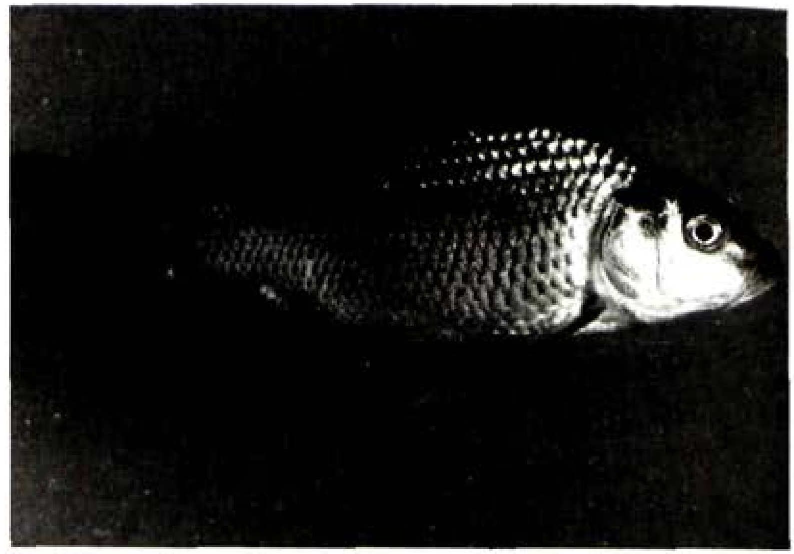
near Boisdale and Fernbank. Private contractors extract sand from a quarry on public land at Tom Creek.

7. Utilities

Cemeteries are located on public land at Lindenow South and south of Stratford.

A railway siding is situated on public land at Hillside, while the Melbourne to Bairnsdale railway line traverses the northern section of the Providence Ponds public land.

A 220-kV power line swung on steel towers is proposed for a route between Montgomery and Bairnsdale. A number of alternative routes are being considered,



European carp, a pest species

one of which will pass through the public land at Providence Ponds and Moormurng.

The Boisdale rubbish tip is situated on public land west of the township.

D. Hazards and Conflicts

Danger of wildfires is lower in this block than in the foothill and coastal forests. While the forest types are fire-prone, the relatively flat terrain, good access, and proximity to populated areas make easier the detection and suppression of any fires that do start.

Vermin and noxious weeds can be a problem, especially on the perimeter of public land where it abuts farmland.

The lower reaches of the streams flowing into the Gippsland Lakes contain European carp, a pest species whose feeding habits increases water turbidity, which in turn affects native fish and wildlife habitats.

On farms and along road reserves, the remaining forest red gums have suffered severe dieback. The primary cause is probably extensive and periodic defoliation by leaf-eating insects, including Christmas beetle, leaf beetle, lerps, gum-leaf skeletonizer moth, and mottled cup moth.

The only significant form of soil erosion is stream-bank erosion. This is particularly serious along the Avon River.

A major potential conflict would arise from any decision to convert native hardwood forests to softwood plantations. Such conversion would result in some loss of native flora and fauna, reduction in some recreational opportunities, decrease in the area available to beekeepers, and loss of hardwood timber values. The important nature conservation values that have been recognized for the land at Providence Ponds heighten the conflict in this area.

All of the major rivers are subject to flooding. Flooding of a magnitute that causes some inconvenience to the landholders immediately adjacent to streams occurs quite frequently. More-serious flooding, resulting in considerable property damage and community disruption, is a less frequent but not uncommon hazard.

8. GIPPSLAND LAKES

A. General

1. Land tenure and location

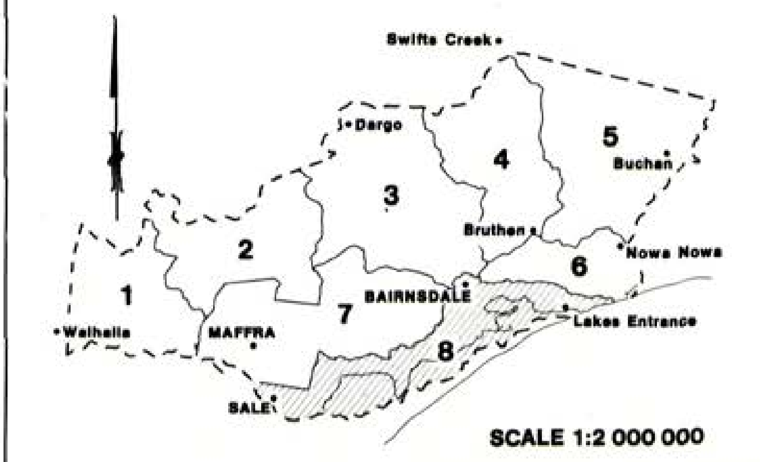
Public land occupies about 45,000 ha, or almost 40% of the block's total area of approximately 115,000 ha.

Almost all of it is under or beside the lakes. A permanent reserve of about 34,000 ha covers the beds of the lakes themselves. The public-purposes reserve surrounding them, although broader in places, is mostly only about 30 m wide.

The Fisheries and Wildlife Division has six areas of public land, totalling 2,690 ha, under its control. They consist of five State game reserves - Clydebank Morass (640 ha), north of Lake Wellington and adjacent to the Avon River, Macleod Morass (520 ha), south of Bairnsdale, Blond Bay (812 ha), north of Lake Victoria, Jones Bay (110 ha), north of Lake King, and Heart Morass (300 ha), north of the Latrobe River and adjacent to Lake Wellington - and the Sale Common State game refuge (308 ha) within the City of Sale. A substantial proportion of what now constitutes these reserves was once privately owned land. Over the years the Division has purchased this land and in fact continues to negotiate sales in order to expand the area of wildlife reserves around the lakes.

Of the four major islands in the lakes, only Raymond and Rigby Islands contain significant areas of public land. Almost 90% of the latter's 125 ha is public-purposes reserve, while Raymond Island contains approximately 160 ha.

Other areas of public land adjoining the lakes include a 400-ha property owned by



8. GIPPSLAND LAKES

the Gas and Fuel Corporation, on the shores of Lake Victoria, and the 178-ha Nyerimilang Estate overlooking Reeve channel. The latter property was purchased by the government in 1976 and came under National Parks Service management in 1980.

The balance of public land is made up almost entirely of small Crown land reserves used for a variety of public purposes and unreserved Crown land.

B. Nature of the Land

1. Climate

Annual rainfall in this block varies from a high of 856 mm at Lake Tyers to as inferred low of around 500 mm at Hollands Landing.

The study area's warmest district is around Sale and Maffra, with 45.6°C (at Sale) being the highest temperature ever recorded in the area. In contrast, sea breezes significantly temper summer day temperatures at sites further to the east. Conversely, minimum temperatures along the seaboard are higher than those at inland stations because of the blanketing effect that moist air has on outgoing radiation. Thus Lakes Entrance consistently experiences lower maximum and higher minimum temperatures than either Maffra or East Sale.

As is the case for the plains, coastal areas experience mild winter weather as a result of the warm northerly winds that descend from the mountains. Under this influence it is not uncommon during winter for stations along the coast to record the highest temperatures in the State. Frosts can be expected primarily in the period May to September. The higher minimum temperatures close to the sea reduce the incidence of frosts in comparison with stations inland. Lakes Entrance, for instance, experiences an average of only 9 frosts per year, while East Sale has 34.

2. Geology and geomorphology

The eastern section of the block consists of Tertiary rocks, which are exposed in the cliffs between Tambo Bluff and Red Bluff at Lake Tyers. These cliffs mark the coastline prior to the development of the sandy barriers that now enclose the Gippsland Lakes system. Residuals of earlier barrier systems occur on the Banksia Peninsular and Raymond Island.

Quaternary coastal terraces are the dominant features along the northern shores of the lakes between Sale and Bairnsdale. These terraces are dissected by numerous streams, including the Latrobe, Avon, Perry, and Mitchell Rivers.

Extensive swamps have developed in the deltaic sections of most streams entering the lakes, and considerable areas of lakeshore are reed-fringed and backed by fresh-water swamps. Sand and gravel beaches and spits are common, however, along the northern shores of Lake Victoria and Lake King, where re-working of older Tertiary and Quaternary deposits is occurring. A large sandy spit at the eastern end of Lake Wellington has restricted its connection with Lake Victoria to a narrow channel known as McLennan Strait.

Extensive deltas have developed at the mouths of all major streams entering the lakes. The relatively sheltered, low-energy environment created within the lakes has been an important factor in the development of these deltas, the largest of which is at the mouth of the Mitchell River.

3. Soils

Podzolic soils and other duplex types characterize both the Tertiary and Quaternary terrace deposits, while undifferentiated sands, pozolized in part, are a feature of the Quaternary dune-fields. Deltaic areas and swamps consist of a variety of alluvial sediments, ranging from gravels to organic clays and peats.

4. Vegetation

Vegetation in this block is primarily associated with low-lying swampy areas surrounding the lakes or sandy coastal areas.

Swamp paperbark closed scrub is widespread around the lake shores - its best development adjoins Lake Wellington. It occurs on the landward side of either *Phragmites* grassland or saltmarsh.

Phragmites grassland grows best in waterlogged soils on the margins of swamps, streams, and the Gippsland Lakes where salinity is not excessive. The more saline areas that are subject to inundation carry saltmarsh dominated by *Salicornia* spp. This herb-field unit is best represented at Point Fullarton, Slaughterhouse Creek, and Rigby Island.

Tussock sedgeland or rushland occupies sites with soil salinity intermediate between the *Phragmites* grassland and *Salicornia* herb-field units. Examples of this unit occur on Roseneath peninsular, around Lake Kakydra, adjacent to Jones and Blond Bays, at Maringa Creek, and on the mud islands in Lake Tyers.

Tussock rushland dominated by giant rush is found only in Macleod Morass and is restricted to an area that contains shallow standing water in all seasons.

Low open forests and woodlands of rough-barked manna gum are found on sandy plains and ridges north of Lake Victoria. They generally have a heathy understorey although the manna gum stands on Raymond Island have a bracken-dominated understorey.

Saw banksia woodlands are found north and west of Lake Victoria, occurring on deep sand sheets between the lake shores

Parts of the Mitchell River silt jetties are submerged when Lake King water levels are high

and the plateau hinterland. Small areas of coast banksia woodlands, which have developed on deep, unstructured sand in the lee of the barrier dune, are located at Lakes Entrance and Rigby Island.

The primary dune vegetation between Lakes Entrance and Lake Tyers is typical of that elsewhere along the Ninety Mile Beach. It ranges from low hairy spinifex and marram grass closest to the sea, through to a closed scrub of coast tea-tree on the leeward side of the dune.

Significant areas of public land have little or no tree cover and the vegetation could best be described as grassland. Most of this land had been privately owned farmland until purchased by the government or public authorities. Examples include the Nyerimilang Estate, the Mitchell River silt jetties, the Gas and Fuel Corporation property north of Lake Victoria, and portions of a number of State game reserves.

5. Fauna

The Gippsland Lakes and their associated swamps comprise an important inland wetland environment that forms part of the entire coastal wetland system, which extends south, east, and west of the study area. Public land adjacent to these wetlands and to the coast form faunal environments of coastal woodland and scrub, and farmland.

The fauna can be generally predicted from the nature of these environments, and for details the reader should refer to Chapter 10 and Appendices 2-6.

Almost one-third of the 298 species of bird found in the study area are partially or totally dependent on wetlands. Almost all of these occur on or around the lakes, and can often be seen in very large numbers. Dabbling and wading species such as most ducks, herons, and

Gippsland's only breeding colony of pied cormorants is located in Tucker Swamp

black swans prefer the shallow water of lake margins and swamps. However, the species that feed on fish (such as cormorants and pelicans) will be found in the open deeper waters of the lakes.

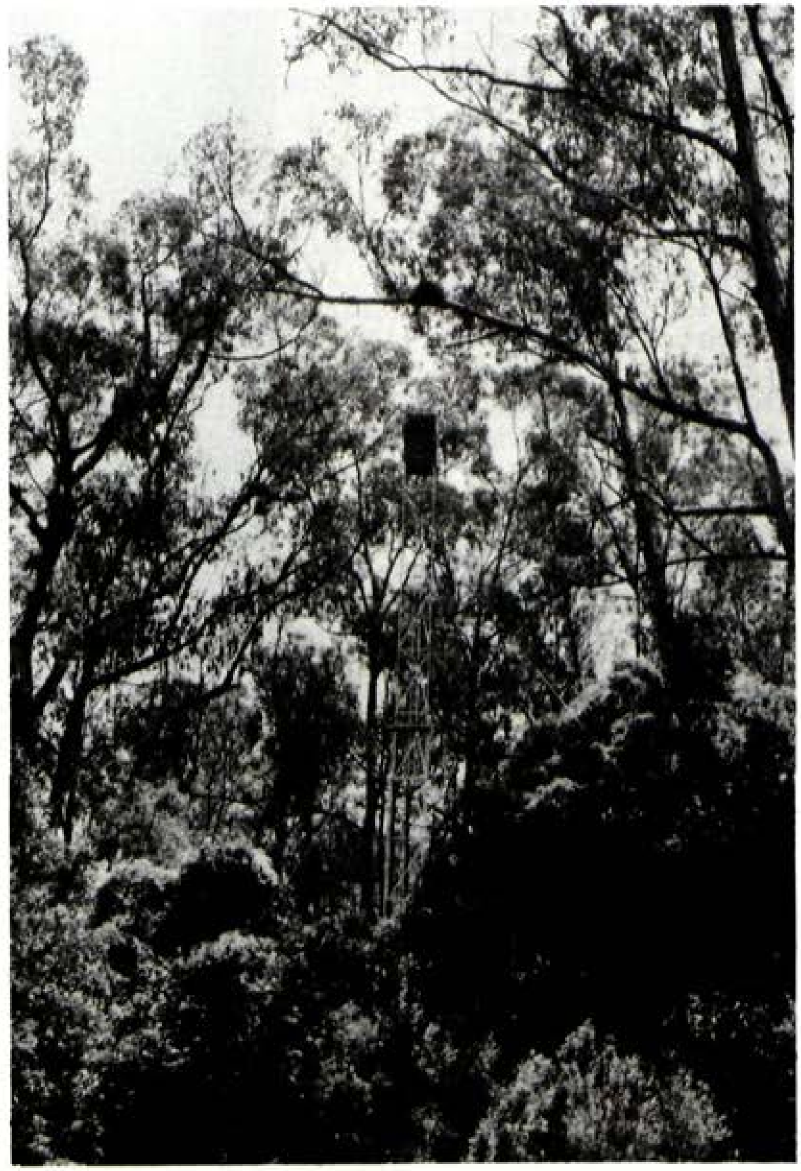
Many of the species are regular migrants (both intercontinental and interstate), appearing in the wetland area in non-breeding seasons and leaving to breed elsewhere. A number, however, are permanent residents and the fresh-water marshes are very important as breeding grounds. For instance, the sacred ibis and straw-necked ibis have large breeding colonies in Macleod Morass, and Tucker Swamp contains the only breeding colony of pied cormorants in Gippsland.

Significant dryland species that have been recorded in this block include the white goshawk, which nests in gully vegetation on the Nyerimilang Estate, and the rare regent honeyeater, which has been observed in Bairnsdale. The black-faced flycatcher and Lewin honey-eater are close to the south-eastern limit of their range in the cliff-face vegetation between Kalimna and Nungurner. The potoroo - a common inhabitant of the heathy understorey in the coastal woodland environment - is often seen foraging in the gardens of houses at Lake Tyers.

C. Present Use and Capabilities

1. Nature conservation

The Gippsland lakes and surrounding low-lying public land constitute one of Victoria's most important wetland areas. The large expanses and wide variety of wetlands - ranging from deep fresh-water marshes to salt flats - are of particular significance as water-bird habitat. Although total numbers vary according to seasonal conditions, many water-birds - including regular migrants, nomads, and local breeding species - depend on these wetlands. Indeed they constitute Aust-



An elevated hide on the Nyerimilang Estate, put in place to observe and photograph a nesting white gashawk ralia's most important drought refuge for water-birds. Most wetland types are used for a variety of functions, such as nesting, feeding, resting, and refuge from hunting.

The significane of the Gippsland lakes wetlands for wildlife conservation has been recognized by the Fisheries and Wildlife Division, which has developed almost 2,700 ha as wildlife reserves.

The few small stands of dryland forests or woodlands that remain in public ownership take on an added conservation significance because of their remnant status. Such stands include the lakeside cliff vegetation between Metung and Lakes Entrance, the open forest of southern mahogany on Raymond Island, and the isolated examples of Gippsland grey box forests between Eagle Point and Lakes Entrance.

Around the lakes are a number of sites of geological or geomorphological significance. They are either exposures of geological formations or examples of geomorphological processes. The most important of them, the Mitchell River 'silt jetties', form a classic example of a digitate delta. This site ranks as one of the finest examples of this type of land form in the world.

2. Recreation

Attracting about 400,000 visitors annually the lakes can be regarded as one of the State's most important recreational resources. The broad expanses of relatively shallow water are ideal for many water sports, including boating, yachting, fishing, water-skiing, and swimming. The lakes and surrounding wetlands also provide opportunities for duck-shooting and bird-watching.

The coastline between Lakes Entrance and Lake Tyers contains a number of popular swimming beaches and is used along its entire length by surf fishermen.

The Nyerimilang Estate, with its old homestead, farm buildings, and gardens situated on the cliff-top overlooking Reeve Channel, provides a pleasant venue for passive recreation. The estate also features a nature trail, as does the Lake Bunga area.

3. Wood production

Virtually no public land has the capability to produce commercial quantities of either hardwood or softwood timber.

4. Agriculture

The major agricultural enterprise on private land between Sale and Bairnsdale is wool production from Merino sheep. Between Bairnsdale and Lake Tyers, both sheep and beef cattle are raised in approximately equal proportions.

A number of areas of public land are held under grazing licence. These in-

The homestead on the Nyerimilang Estate

clude low-lying areas adjacent and close to Lake Wellington and McLennans Strait, the Gas and Fuel Corporation property near Wattle Point, land on and behind Point Fullarton, and the Nyerimilang Estate east of Nungurner. In order to reduce fire hazard, the Fisheries and Wildlife Division may also allow seasonal grazing of certain areas under its control.

Much of the public land is swampy and so has low agricultural capability. However some public land that is not subject to inundation could be successfully farmed. Indeed, certain areas are being used primarily as grazing properties.

5. Water production

This block plays virtually no part at all in the generation of surface stream flows, even though most of the major rivers pass through it prior to entering the lakes system.

Here the more important source of supply is groundwater. The study area's largest centre of population, Sale, receives its domestic water supply from a series of bores within the city boundary. Irrigators have also tapped the shallow coastal aquifers.

Although no storages are planned for the major rivers, an embankment on McLennans Strait to produce a controlled storage with a greater capacity than the present Lake Wellington is a possibility. This is one of the options being canvassed for the provision of additional water to facilitate industrial expansion in the Latrobe Valley.

6. Mining and quarrying

This block lies within the Gippsland sedimentary basin, which is rich in hydrocarbons. A small onshore reservoir of oil was tapped near Lakes Entrance, and between 1925 and 1950 it produced around 8,000 barrels of heavy crude. Subsequent onshore exploration has been unsuccessful, although it is highly probable that other accumulations of oil and gas do occur. There has also been recent interest in the exploration of this area for brown coal.

7. Utilities

The Ports and Harbors Division of the Public Works Department operates the public harbor facilities on and around the Gippsland Lakes. These facilities include 46 public jetties and wharves, together with boat harbors and slipways, at Lakes Entrance and Paynesville, and a system of navigation lights - most of which are located on water, with some based at strategic locations on public land.

A 220-kV power line swung on steel towers is proposed for a route between Montgomery and Bainsdale. A number of alternative routes are being considered,

Land slips are a problem on the steep cliffs fringing the Reeve Channel between Kalimna and Nungurner one of which will pass through Macleod Morass.

Cemeteries are situated on public land south of Bairnsdale and north of Lakes Entrance.

The Metung Primary School occupies public land north of the township.

A rubbish tip is located on public land on Raymond Island.

D. Hazards and Conflicts

Following the die-back of the fringing reed-swamp, wave erosion has become an increasing problem around the shores of the Gippsland Lakes. This has been particularly evident on the internationally renowned Mitchell River silt jetties around Sperm Whale Head, and on parts of the Lake Wellington shoreline.

Land slips on the steep cliff face between Kalimna and Nungurner are also a problem.

Water quality in the lakes, especially Lake Wellington, is adversely affected by the industrial, residential, and agricultural land uses in the catchments to the Latrobe and Macalister Rivers. These water-quality problems could only be expected to worsen, given the planned industrial expansion in the Latrobe Valley and the consequent necessary diversion of fresh water from the lakes' catchment streams.

European carp are a problem in the lakes and lower reaches of the input streams. Their feeding technique, which involves stirring up the bottom sediments, leads to increased water turbidity, which in turn causes the loss of aquatic vegetation. In this way carp adversely affect the habitat of native fish and waterbirds.

In an area such as this, where recreation use is high, inevitably conflict with other uses will arise. Thus, some recreational activities may be inappropriate in prime water-bird habitats, drainage of swamplands for recreation developments may conflict with nature conservation interests, and the heavy use of ocean beaches may result in damage to fragile dune systems.

A perceived, but unproved, conflict is that between commercial fishing and recreational angling in the Gippsland Lakes. It is often claimed that commercial fishing depletes fish numbers to the detriment of the amateur angler. However, the Fisheries and Wildlife Division considers that the small number of professional fishermen currently working in the lakes, coupled with restrictions as to where and when they may operate, ensures that an adequate share of the fish stock is available to the recreational angler.

Flooding of the major streams is a frequent hazard, which may sometimes become very serious.

Major floods, such as those experienced in January 1971 and June 1978 when vast areas were inundated, result in substantial damage to property and cause considerable disruption and inconvenience to the community. High stream flows, combined with a tide-like phenomenon in the lakes - generated by wind - can cause local flooding of land around the lakes.

APPENDICES

Appendix 1

SIGNIFICANT PLANT SPECIES

Scientific name	Common name	Typical occurrence(general area only)	Comment
Acacia howittii	Sticky wattle	Mount Steve	A large shrub, known only at South Gippsland Ranges and upper Macalister River watershed.
Acronychia oblongifolia	Yellow-wood	Mount Little Dick; Swan Reach; Waterholes; Davey Knob	Small tree of warm-temperate rainforest extending west to Mitchell River Gorge.
Agropyron pectinatum	Comb wheat-grass	Scorpion Creek; Murrindal; Mount Nowa Nowa	A grass restricted in Victoria to escarpments of East Gippsland.
Agrostis rudis	Bent	Nowa Nowa	A grass rare in Victoria, recently collected from East Gippsland.
Amphipogon strictus	Grey-beard grass	Sale	A grass generally confined to sandy plains in western Victoria but rare in East Gippsland.
Asplenium trichomanes	Common spleenwort	Murrindal; Toorloo Arm	A widely distributed but uncommon fern of rock crevices and ledges.
Athyrium japonicum	Japanese lady-fern	Murrindal	A rare ground fern known only in East Gippsland in Victoria.
Bertya cunninghamii	Sticky bertya	Davey Knob	Rare shrub of rocky areas.
Beyeria lasiocarpa	Wallaby-bush	Stirling; Ensay South; Holstons; Mount Tara; Pheasant Hill; Waterholes	A shrub with discolouring leaves, sometimes found in dense thickets on dry slopes.
Boronia ledifolia	Showy boronia	Mount Elizabeth No. 2	A showy, tall shrub of dry foothills; the only Victorian occurrences are in the Snowy River catchment.
Brachycome petrophilia	Rock daisy	Murrindal	A herb of rocky montane sites - more widespread than previously considered and probably endemic to East Gippsland.
Caladenia tessellata	Thick-lip spider orchid	Sale; Lake Wellington; Perry Bridge	A spider orchid, rare and restricted to coastal heathlands in East Gippsland, but widespread elsewhere in Victorian lowlands.
Calystegia sepium	Large bindweed	Swan Reach	Widespread creeper of lowland stream margins.
Carex gunniana	Sedge	Mount Thomson	Small sedge, scattered through southern Victoria, but rare in East Gippsland.
Casuarina pusilla	Dwarf she-oak	Paynesville	Small shrub of sandy soils, common in Western Victoria.
Centaurea australis	Austral cornflower	Murrindal	Very rare shrub known by only two records for Victoria; possibly extinct in State.
Chenopodium trigonon	Lax goosefoot	Mount Welcome; Upper Merrijig Creek; Castleburn; Swamp Creek	Occasional hastate-leafed herb, restricted in Victoria to East Gippsland

Appendix 1 (continued)

Scientific name	Common name	Typical occurrence(general area only)	Comment
Chiloglottis pescottiana	Bronzy bird-orchid	Doctors Flat	A rare alpine orchid of forested slopes in East Gippsland and Tasmania.
Sphaeropteris australis		Waterholes	Treefern localized in Victoria to a few eastern 'jungle' pockets, but quite frequent in these places.
Christella dentata		Scorpion Creek	Small fern known in Victoria only in limestone in the Buchan district.
Cymbonotus lawsonianus	Austral bear's-ear	Murrindal	Herb of very localized and disjunct occurrence in Victoria; known only in north-west Mallee and Eastern Highlands.
Cyperus polystachyos	Bunchy flat-sedge	Providence Ponds	Known in Victoria only at Providence Ponds.
Cyperus sphaeroideus		Mount Taylor; Morris Peak	A newly described sedge, known in Victoria in only two eastern localities.
Cystopteris filix-fragilis	Brittle bladder-fern	Toorloo Arm /Lake Tyers	Rare fern usually restricted to rocky alpine situations.
Desmodium brachypodum	Large tick-trefoil	Upper reaches Purchen Creek; Mount Taylor	A rare prostrate herb of sandy ground, known in Victoria only in East Gippsland.
Deyeuxia contracta	Bent-grass	Mount Taylor	A grass scattered throughout montane forests east of Melbourne.
Echinopogan caespitosus		Lake Glenmaggie	A grass recently discovered in Victoria.
Eragrostis trachycarpa	Rough-grain love-grass	Providence Ponds	Grass known at only Providence Ponds in Victoria, but not collected since 1955.
Eriostemom verrucosus	Fairy wax-flower	Mount Dow; Mount Steve	Generally western shrub, with occasional records in East Gippsland.
Eucalyptus maculata	Spotted gum	Mount Tara	A mottled typically northern tree with a disjunct occurrence in the Mount Tara area.
Gahnia microstachya	Slender saw-sedge	North and east of Ben Cruachan; west of Castleburn	A small saw-sedge of rocky areas; recent collections suggest this species more common than previously thought.
Goodenia grandiflora	Pinnate goodenia	West of Ben Cruachan	Semi-shrub; rare and localized in dry, rocky habitats of Macalister and Upper Snowy watersheds.
Goodenia heterophylla		West of Ben Cruachan	Recently recorded procumbent herb of dry stony ground, but restricted in Victoria to Gippsland, where rare.
Helichrysum elatum	Everlasting	North of Mount Nowa Nowa	Uncommon semi-shrub, restricted in Victoria to lowland sites in far East Gippsland.

Appendix 1 (continued)

Scientific name	Common name	Typical occurrence(general area only)	Comment
Hibbertia hermannii-folia	Guinea-flower	Reedy Flats	Very localized occurrence of shrub otherwise known only from early New South Wales record.
Hibbertia procumbens	Guinea-flower	North-east of Walhalla	Prostrate shrub, occasional through much of Victoria, also known in Tasmania.
Isopogon anemoni-folius	Drumstick cone-bush	Near Fernbank	A trailing shrub with sporadic southernmost occurrences in East Gippsland.
Laxmannia gracilis	Slender wire-lily	South-west of Buchan South; Sale; Mount Taylor; Mount Elizabeth 2	Dwarf lily, localized in East Gippsland to dry open sites.
Lepidosperma semi-teres	Wire rapier-sedge	Ben Cruachan	Sedge, not uncommon on lowlands west of Port Phillip Bay, but only one occurrence in East Gippsland.
Lepidosperma tort-uosum	Tortuous rapier-sedge	Upper Merrijig Creek	Twisted sedge of scattered distribution in eastern Victoria.
Lepidosperma visci-dum	Sticky sword-sedge	Ben Cruachan	A sedge of Western Victoria, but with dis-junct occurrence in Gippsland.
Libertia paniculata	Branching grass-flag	Mount Welcome	Native iris of shaded sites in near-coastal forests of East Gippsland, and an isolated sub-alpine record for Victoria.
Lycopodium scariosum	Spreading club-moss	Providence Ponds	A low scrambling club moss, rare and, with the exception of this recording, localized in Victoria to a few alpine soaks of the Central and Eastern Highlands.
Marsdenia flavescens	Yellow milk-vine	Swan Reach; Mount Taylor; Nowa Nowa; Mount Little Dick	A rare, robust liane of a few lowland rain-forests of eastern Victoria.
Marsilea hirsuta	Short-fruit nardoo	Mount Taylor	Clover-like fern of swampy ground, typically of western Victoria.
Muehlenbeckia rhyti-carya	Wrinkle-nut lignum	Tambo Crossing	An ovate-leafed climber with its southernmost occurrence in East Gippsland.
Nymphoides sp.		'Hoyldene'; East of Munro; Providence Ponds; Lindenow South	An undescribed water lily, apparently endemic and localized to lagoons of East Gippsland.
Olearia adenophora	Scented daisy-bush	West of Ben Cruachan	A localized shrub, restricted in Victoria to dry montane habitats in East Gippsland.
Olearia viscosa	Daisy-bush	Swan Reach	Coastal daisy-bush, known only in Gippsland Lakes area and Tasmania.
Olearia sp. (aff. *glutinosa)*		Davey Knob; South of Tabberabbera	Undescribed daisy-bush, only collected from the Mitchell River Gorge.
Olearia sp.(Billy Goat Bend)		Billy Goat Bend	Undescribed daisy-bush, only collected from the cliffs above the Mitchell River Gorge.

Appendix 1 (continued)

Scientific name	Common name	Typical occurrence(general area only)	Comment
Phebalium squameum ssp. *cori*	Satinwood	Mount Elizabeth; Wulgulmerang	A shrub endemic to East Gippsland.
Philydrum lanuginosum	Woolly water lily	Providence Ponds	Linear-leafed water lily, uncommon in eastern Victoria.
Pittosporum revolutum	Rough fruit pittosporum	North of Nowa Nowa; north-west of Mount Nowa Nowa	A large-leafed shrub; the southernmost limit of its distribution is far East Gippsland.
Platysace ericoides	Heath platysace	Ben Cruachan; north of Ben Cruachan; west of Ben Cruachan; west of Seaton; Lake Glenmaggie	Small shrub restricted in Victoria to the eastern foothills, where it is localized and rare.
Polystichum formosum	Broad shield-fern	Davey Knob; Murrindal	Fern scattered within shaded sites near waterways east of the Mitchell River.
Pratia purpurascens	Purplish pratia	Melwood	Occasional matted herb, known in Victoria in coastal East Gippsland.
Prostanthera saxicola	Slender mint-bush	Ben Cruachan	A rare mint-bush known in Central Victoria and East Gippsland.
Prostanthera walteri	Monkey mint-bush	Reedy Flats	Mint-bush restricted in Victoria to a few granite sites.
Pseudoraphis paradoxa	Slender mud grass	Point Bolodun; Swan Reach Bay; (Lake King)	Grass known only in swamp margins of East Gippsland in Victoria; prior to survey, not collected since early 1900's.
Pterostylis baptistii	King greenhood	Lake Glenmaggie	Large-flowered greenhood orchid, restricted in Victoria to damp flats of East Gippsland.
Pterostylis grandiflora	Cobra greenhood	Davey Knob; Ward Crossing	Large-flowered greenhood orchid of moist sandy ground in eastern Victoria.
Pteris vittata	Chinese brake	Murrindal; Buchan	Fern, rare and localized in Victoria to limestone features within the Buchan and Murrindal districts.
Pultenaea foliolosa	Bush-pea	South of Mount Blomford	A sprawling shrub rare in East Gippsland.
Pultenaea largiflorens	Bush-pea	Waterholes; Ward Crossing; Lake Glenmaggie; east of Mount Hedrick	A bush-pea typical of western gold fields, with a few disjunct occurrences in East Gippsland.
Pultenaea viscosa	Bush-pea	Upper Merrijig Creek; south of Mount Blomford; upper Purchen Creek; east of Mount Tabberabbera	
Salvia plebeia	Austral sage	Murrindal	Rare riparian herb, restricted in Victoria to river valleys of East Gippsland.
Sambucus australasica	Yellow elderberry	South of Buchan South	Very rare shrub of lowland rainforests, and in Victoria confined to a few localities in East Gippsland.

Appendix 1 (continued)

Scientific name	Common name	Typical occurrence(general area only)	Comment
Selaginella gracillima	Tiny selaginella	Providence Ponds; east of Munro	An uncommon small club moss of coastal area.
Sicyos angulata	Star cucumber	Scorpion Creek	A rare weak climber of lowlands in East Gippsland.
Solanum gracilius		Mount Taylor; Point Bolodun	Bushy, short-lived perennial; a typically northern species with an isolated occurrence in the Mitchell.
Sorghum leiocladum	Wild sorghum	Murrindal	Grass restricted in Victoria to dry, hilly regions of East Gippsland.
Sparganium erectum		Mount Taylor	Riparian reed collected from south-west and eastern Victoria.
Styphelia adscendens	Golden heath	Mount Moornapa	Two isolated Gippsland localities exist for the low-growing predominantly western heath.
Thesium australe	Austral toad-flax	Point Bolodun	Parasitic perennial herb of extremely limited occurrence in south-eastern Australia.
Thryptomene micrantha	Ribbed thryptomene	Paynesville; Lake Wellington; Plover Point; Blond Bay(Lake Victoria); Steel Bay(Lake Victoria)	Shrub known in the Gippsland Lakes area only in Victoria.
Zieria smithii	Sandfly zieria	North of Mount Difficulty	A shrub known in Victoria only in East Gippsland, with an interesting small-leafed form occurring at Genoa Peak.

The information contained in this appendix has been compiled from a document prepared by the National Herbarium, Victoria, for the Ministry for Conservation, on sites of botanical significance in the East Gippsland area.

Appendix 2

MAMMALS

These lists apply only to the study area. Neighbouring areas are not considered. The following abbreviations are used. An asterisk (*) indicates an introduced species; an X indicates a recent record of the species in that habitat; a question mark (?) indicates the species was formerly or is possibly present in that habitat.

Habitat		Status	
1.	Closed forest	M	Migratory
2.	Tall open forest	C	Common
3.	Open forest	U	Uncommon
4.	Riverine forest	R	Rare
5.	Foothill woodland	V	Vagrant
6.	Coastal woodland	E	Extinct
7.	Farmland		
8.	Towns		
9.	Ocean		
10.	Inland wetlands		

Common names and their sequence have been taken from *Bulletin of the Australian Mammal Society* 6(2) 1980.

Common name	Scientific name	Habitat 1	2	3	4	5	6	7	8	9	10	Status
Short-beaked echidna	*Tachyglossus aculeatus*	X	X	X	X	X	X					C
Platypus	*Ornithorhynchus anatinus*										X	U
Brown antechinus	*Antechinus stuartii*	X	X	X	X	X						C
Dusky antechinus	*Antechinus swainsonii*	X	X	X			X					U
Tiger quoll	*Dasyurus maculatus*	X	X	X			X					R
Eastern quoll	*Dasyurus viverrinus*					?		?				E
Brush-tailed phascogale	*Phascogale tapoatafa*					?		?				R
White-footed dunnart	*Sminthopsis leucopus*			X			X					U
Southern brown bandicoot	*Isoodon obesulus*			X			X					U
Long-nosed bandicoot	*Perameles nasuta*	X	X	X			X					U
Mountain brushtail possum	*Trichosurus caninus*	X	X	X	X							C
Common brushtail possum	*Trichosurus vulpecula*			X		X	X	X	X			C
Feathertail glider	*Acrobates pygmaeus*	X	X	X	X	X	X					C
Yellow-bellied glider	*Petaurus australis*		X	X	X							U
Sugar glider	*Petaurus breviceps*	X	X	X	X	X	X					C
Common ringtail possum	*Pseudocheirus peregrinus*	X	X	X	X		X		X			C
Greater glider	*Schoinobates volans*		X	X	X							C
Eastern pigmy-possum	*Cercartetus nanus*	X	X	X	X	X	X					C
Eastern grey kangaroo	*Macropus giganteus*			X		X	X	X				C
Red-necked wallaby	*Macropus rufogriseus*			X		X		X				R
Brush-tailed rock-wallaby	*Petrogale penicillata*			?								R
Long-nosed potoroo	*Potorous tridactylus*						X					U
Long-footed potoroo	*Potorous longipes*			?								E
Red-bellied pademelon	*Thylogale billardieri*						?					E
Swamp wallaby	*Wallabia bicolor*			X	X	X	X	X				C
Koala	*Phascolarctos cinereus*			X	X		X					U
Common wombat	*Vombatus ursinus*	X	X	X	X	X	X	X				C
Grey-headed flying-fox	*Pteropus poliocephalus*	?						?	?			Rm
Little red flying fox	*Pteropus scapulatus*							?	?			Vm
Eastern horseshoe-Bat	*Rhinolophus megaphyllus*			X		X		X				
White-striped mastiff-bat	*Tadarida australis*	?	X	X	X	X	X	X	X			U
Gould's wattled-bat	*Chalinolobus gouldii*	?	X	X	X	X	X	X	X			C
Chocolate wattled-bat	*Chalinolobus morio*	?	X	X	X	X	X	X	X			U
Little forest bat	*Eptesicus vulturnus*	X	X	X	X	X	X	X	X			
Common bent-wing bat	*Miniopteris schreibersii*			X		X		X				
Large-footed myotis	*Myotis adversus*			X		X		X				R
Lesser long-eared bat	*Nyctophilus geoffroyi*			X	X	X	X	X	·X			C
Greater long-eared bat	*Nyctophilus timoriensis*			X								U
Great pipistrelle	*Pipistrellus tasmaniensis*		X	X	X							U
*Brown hare	*Lepus capensis*							X				U
*European rabbit	*Oryctolagus cuniculus*				X	X	X	X				C
Rabbit-eared tree rat	*Conilurus albipes*			?		?	?					E
Water-rat	*Hydromys chrysogaster*										X	C
*House mouse	*Mus musculus*					X	X	X	X		X	C
New Holland mouse	*Pseudomys novaehollandiae*			X			X					R
Bush rat	*Rattus fuscipes*	X	X	X	X		X					C
Swamp rat	*Rattus lutreolus*						X	?			X	U
*Brown rat	*Rattus norvegicus*								?			
*Black rat	*Rattus rattus*						X	X	X		X	C
Dingo wild dog	*Canis familiaris*		X	X	X	X						U
*Fox	*Vulpes vulpes*		X	X	X	X	X	X	X			C
*Cat	*Felis catus*		X	X	X	X	X	X	X			C
*Ferret	*Mustela putorius*							?				

Common name	Scientific name	Habitat										Status
		1	2	3	4	5	6	7	8	9	10	
*Horse	*Equus caballus*			?		?						
*Goat	*Capra hircus*	X		X	X	X						U
*Hog deer	*Axis porcinus*						X					C
*Red deer	*Cervus elaphus*			X		X		?				
*Sambar (deer)	*Cervus unicolor*		X	X	X	X						U
*Fallow deer	*Dama dama*			X		X						R
*Pig	*Sus scrofa*						?					
New Zealand fur-seal	*Arctocephalus forsteri*									X		R
Australian fur-seal	*Arctocephalus pusillus*									X		U
Leopard seal	*Hydrurga leptonyx*									X		R
Elephant seal	*Mirounga leonina*									X		R
Minke whale	*Balaenoptera acutorostrata*									X		R
Sperm whale	*Physeter catadon*									X		R
Common dolphin	*Delphinus delphis*									X	?	U
Pilot whale	*Globicephala melaena*									X		R
Bottle-nosed dolphin	*Tursiops truncatus*									X	?	C

Appendix 3

BIRDS

These lists apply only to the study area. Neighbouring regions are not considered. The following abbreviations are used. An asterisk (*) indicates an introduced species; an X indicates a recent record of the species in that habitat; a question mark (?) indicates the species was formerly or is possibly present in that habitat.

Habitat

1.	Closed forest
2.	Tall open forest
3.	Open forest
4.	Riverine forest
5.	Foothill woodland
6.	Coastal woodland and scrub
7.	Farmland
8.	Towns
9.	Ocean
10a.	Flooded river flats
10b.	Freshwater meadows
10c.	Shallow freshwater marshes
10d.	Deep permanent marshes
10e.	Permanent open water
10f.	Temporary saline wetlands
10g.	Permanent saline wetlands

Status

M	Trans-equatorial migrant
m	Migrant to other areas of Australasia or further south
C	Common
U	Uncommon
R	Rare
V	Vagrant
E	Extinct
B	Breeding

Common names and their sequence have been taken from the publication:

The Emu - Journal of the Royal Australasian Ornithologists Union. Volume 77 Supplement, May 1978.

Common name	Scientific name	Habitat 1	2	3	4	5	6	7	8	9	10a	10b	10c	10d	10e	10f	10g	Status	Nest location
Emu	*Dromaius novaehollandiae*			X	X	X	X	X										C B	Ground
Great crested grebe	*Podiceps cristatus*													X	X	X	X	U B	Floats on water
Hoary-headed grebe	*Poliocephalus poliocephalus*												X	X	X	X	X	C B	"
Australasian grebe	*Tachybaptus novaehollandiae*												X	X				C B	"
King penguin	*Aptenodytes patagonicus*									X								V	
Little penguin	*Eudyptula minor*									X								U	Cavities or burrows
Wandering albatross	*Diomedea exulans*									X								U	Ground
Black-browed albatross	*Diomedea melanophrys*									X								U	"
Yellow-nosed albatross	*Diomedea chlororhynchos*									X								R	"
Shy albatross	*Diomedea cauta*									X								U	"
Southern giant-petrel	*Macronectes giganteus*									X								R	"
Northern giant-petrel	*Macronectes halli*									X								R	"
Cape petrel	*Daption capense*									X								R	"
White-headed petrel	*Pterodroma lessonii*									X								R	"
Mottled petrel	*Pterodroma inexpectata*									X								R	"
Broad-billed prion	*Pachyptila vittata*									X								R	Burrow
Lesser broad-billed prion	*Pachyptila salvini*									X								R	"
Antarctic prion	*Pachyptila desolata*									X								R	"
Slender-billed prion	*Pachyptila belcheri*									X								R	"
Fairy prion	*Pachyptila turtur*									X								U	Cavities or beneath dense low plants
Sooty shearwater	*Puffinus griseus*									X								R M	Burrow
Short-tailed shearwater	*Puffinus tenuirostris*									X								C M	"
Fluttering shearwater	*Puffinus gavia*									X								U	"
Wilson's storm-petrel	*Oceanites oceanicus*									X								R m	"
White-faced storm-petrel	*Pelagodroma marina*									X								R m	"
Common diving-petrel	*Pelecanoides urinatrix*									X								U	"
Australian pelican	*Pelecanus conspicillatus*									X				X	X	X	X	C	Ground
Australasian gannet	*Morus serrator*									X								C	"
Darter	*Anhinga melanogaster*													X	X			R	Low tree over water
Black-faced shag	*Leucocarbo fuscescens*									X							X	R	Rock ledge
Great cormorant	*Phalacrocorax carbo*									X				X	X	X	X	C B	Rock ledge, tree branch, low bush
Pied cormorant	*Phalacrocorax varius*													X	X		X	U B	Tree branch, low bush, ground
Little black cormorant	*Phalacrocorax sulcirostris*												X	X	X	X	X	C	Tree branch
Little pied cormorant	*Phalacrocorax melanoleucos*												X	X	X		X	C	" "
White-tailed tropicbird	*Phaethon lepturus*									X								V	Rocky cliff
Pacific heron	*Ardea pacifica*										X	X	X	X				U	Tree branch over or near water
White-faced heron	*Ardea novaehollandiae*							X			X	X	X	X		X	X	C B	Tree branch
Cattle egret	*Ardeola ibis*										X			X				C	Tree in a swamp
Great egret	*Egretta alba*										X	X	X	X		X		C	Tree branch over or near water
Little egret	*Egretta garzetta*													X		X	X	R	"
Intermediate egret	*Egretta intermedia*												X					R	"
Eastern reef egret	*Egretta sacra* (One record only)									?							?		Rock, low tree branch

									Habitat										
Common name	Scientific name	1	2	3	4	5	6	7	8	9	10a	10b	10c	10d	10e	10f	10g	Status	Nest location
Rufous night heron	*Nycticorax caledonicus*												X	X				U	Tree branch
Little bittern	*Ixobrychus minutus*													X				R	Emergent aquatic vegetation
Australasian bittern	*Botaurus poiciloptilus*													X				U	"
Glossy ibis	*Plegadis falcinellus*										X		X	X				R	Tree branch over water
Sacred ibis	*Threskiornis aethiopica*							X			X	X	X	X		X	X	C B	"
Straw-necked ibis	*Threskiornis spinicollis*							X			X	X	X	X				C B	Emergent aquatic vegetation
Royal spoonbill	*Platalea regia*												X	X		X	X	U	Tree branch over water
Yellow-billed spoonbill	*Platalea flavipes*												X	X		X		U B	"
Magpie goose	*Anseranas semipalmata* (Reintroduced)																		Emergent aquatic vegetation
Plumed whistling-duck	*Dendrocygna eytoni*										X			X				R	Ground
Black swan	*Cygnus atratus*										X		X	X	X	X	X	C B	"
Freckled duck	*Stictonetta naevosa*													X		X		R	Emergent aquatic vegetation
Cape Barren goose	*Cereopsis novaehollandiae* (Released into area)							X											Ground
Australian shelduck	*Tadorna tadornoides*										X	X	X	X	X	X	X	C B	Tree hollow
Pacific black duck	*Anas superciliosa*										X	X	X	X	X	X	X	C B	Tree hollow, ground
•Mallard	*Anas platyrhynchos*													X			X	R	"
Grey teal	*Anas gibberifrons*											X	X	X	X	X	X	C B	"
Chestnut teal	*Anas castanea*												X	X	X	X	X	C B	"
Australasian shoveller	*Anas rhynchotis*												X	X	X	X	X	U B	Ground
Pink-eared duck	*Malacorhynchus membranaceus*												X	X				R	Tree hollow, ground
Hardhead	*Aythya australis*												X	X	X			U	"
Great skua	*Stercorarius skua*									X								R m	Ground
Arctic jaegar	*Stercorarius parasiticus*									X								U m	"
Silver gull	*Larus novaehollandiae*									X	X		X	X	X	X	X	C	"
Pacific gull	*Larus pacificus*														X		X	C	"
Kelp gull	*Larus dominicanus*									?					?		?	R	"
Whiskered tern	*Chlidonias hybrida*												X	X	X		X	U B	Floats on water
White-winged tern	*Chlidonias leucoptera*													X	X			R M	"
Gull-billed tern	*Gelochelidon nilotica*													X	X		X	R m	"
Caspian tern	*Hydroprogne caspia*														X	X	X	U	Ground
Common tern	*Sterna hirundo*														X		X	U M	"
White-fronted tern	*Sterna striata*																X	R m	"
Little tern	*Sterna albifrons*														X	X	X	U B	"
Fairy tern	*Sterna nereis*																X	R B	"
Crested tern	*Sterna bergii*														X		X	C	"
•Feral pigeon	*Columba livia*							X	X									U	Tree
•Spotted turtle-dove	*Streptopelia chinensis*						X	X	X									C	"
Peaceful dove	*Geopelia placida*			X		X	X											R	"
Common bronzewing	*Phaps chalcoptera*		X	X	X	X	X											C B	Shrub, tree
Brush bronzewing	*Phaps elegans*		?		X		X											U	Dense bush, small tree
Wonga Pigeon	*Leucosarcia melanoleuca*	X	X	X	X													C	Tree

Common name	Scientific name	Habitat																Status	Nest location
		1	2	3	4	5	6	7	8	9	10a	10b	10c	10d	10e	10f	10g		
Glossy black-cockatoo	*Calyptorhynchus lathami*						X											R	Tree hollow
Yellow-tailed black-cockatoo	*Calyptorhynchus funereus*		X	X	X	X	X											C B	" "
Gang-gang cockatoo	*Callocephalon fimbriatum*		X	X	X	X	X	X										C B	" "
Galah	*Cacatua roseicapilla*							X										U	" "
Sulphur-crested cockatoo	*Cacatua galerita*					X		X										C B	" "
Rainbow lorikeet	*Trichoglossus haematodus*						X		X									U B	" "
Musk lorikeet	*Glossopsitta concinna*			X	X		X		X									U	" "
Purple-crowned lorikeet	*Glossopsitta porphyrocephala*			X			X											R	" "
Little lorikeet	*Glossopsitta pusilla*			X	X													R	" "
Australian king-parrot	*Alisterus scapularis*	X	X	X	X			X										U B	" "
Ground parrot	*Pezoporous wallicus*						X											R	" "
Swift parrot	*Lathamus discolor*		?	?	?		?											R	" "
Crimson rosella	*Platycercus elegans*		X	X	X	X	X	X	X									C B	" "
Eastern rosella	*Platycercus eximius*					?	X	X	X									C B	" "
Red-rumped parrot	*Psephotus haematonotus*							X										R	" "
Blue-winged parrot	*Neophema chrysostoma*		?		?		X	X										U m	" "
Orange-bellied parrot	*Neophema chrysogaster*						?											R m	" "
Pallid cuckoo	*Cuculus pallidus*					X	X	X	X									U B m	Parasitic
Brush cuckoo	*Cuculus variolosus*	X	X	X	X													U m	"
Fan-tailed cuckoo	*Cuculus pyrrhophanus*			X	X	X	X	X	X									C B m	"
Horsfield's bronze-cuckoo	*Chrysococcyx basalis*					X	X	X	X									U m	"
Shining bronze-cuckoo	*Chrysococcyx lucidus*	X	X	X	X	X	X	?	?									C B m	"
Powerful owl	*Ninox strenua*		X	X	X													R B	Tree hollow
Southern boobook	*Ninox novaehollandiae*	?	X	X	X	X	X	X										C	" "
Barn owl	*Tyto alba*					X	X	X	X									U	" "
Masked owl	*Tyto novaehollandiae*	X					X	X										R	" "
Sooty owl	*Tyto tenebricosa*	?	?															R	" "
Tawny frogmouth	*Podargus strigoides*		X	X	X	X	X	X	X									C B	Tree branch
Australian owlet-nightjar	*Aegotheles cristatus*		X	X	X	X	X											U B	Tree hollow
White-throated nightjar	*Caprimulgus mystacalis*			X	X	X	X											U B	Ground
White-throated needle tail	*Hirundapus caudacutus*	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	C M	Tree
Fork-tailed swift	*Apus pacificus*	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	R M	Rocks, gullies or buildings
Azure kingfisher	*Ceyx azureus*	X			X													U B m	Tunnel in bank
Laughing kookaburra	*Dacelo novaeguineae*	X	X	X	X	X	X	X	X									C B	Tree hollow
Red-backed kingfisher	*Halcyon pyrrhopygia*				?													V	Creek bank
Sacred kingfisher	*Halcyon sancta*			X	X	X	X	X										C B m	Hole in tree or bank
Rainbow bee-eater	*Merops ornatus*					?		X										U B m	Tunnel in sand
Dollarbird	*Eurystomus orientalis*				X			X										U m	Tree

Common name	Scientific name	Habitat 1	2	3	4	5	6	7	8	9	10a	10b	10c	10d	10e	10f	10g	Status	Nest location
Superb lyrebird	*Menura novaehollandiae*	X	X	X	X													C B	Ground, rock ledge, tree stump
Singing bushlark	*Mirafra javanica*							?										R	Ground
*Skylark	*Alauda arvensis*							X										C	"
Welcome swallow	*Hirundo neoxena*				X		X	X	X		X	X	X	X	X	X		C B m	Under bridges, caves, culverts
Tree martin	*Cecropis nigricans*			X	X	X	X	X			X	X	X	X	X	X		U B m	Tree hollow, cliff
Fairy martin	*Cecropis ariel*							X	X		X	X						U B m	Eaves, ledges, caves.
Richard's pipit	*Anthus novaeseelandiae*						X	X	X									C B	Ground
Black-faced cuckoo-shrike	*Coracina novaehollandiae*				X	X	X	X	X	X								C B m	Tree branch
White-bellied cuckoo-shrike	*Coracina papuensis*				?		?	?										R m	" "
Cicadabird	*Coracina tenuirostris*			X	X													R m	" "
White-winged triller	*Lalage sueurii*				X		X		X									U B m	Tree fork
White's thrush	*Zoothera dauma*		X	X	X	X												C B	"
*Blackbird	*Turdus merula*					X			X	X								C B	Shrub, thicket
*Song thrush	*Turdus philomelos*									?								R	Dense, low vegetation
Rose robin	*Petroica rosea*		X	X	X	X												U B	Tree fork
Pink robin	*Petroica rodinogaster*		X	X		X												R	Small tree, bush
Flame robin	*Petroica phoenicea*				X	X	X	X	X	X								C B	Tree fork, hollow log, rocky, crevice
Scarlet robin	*Petroica multicolor*				X		X	X	X									C B	Tree fork, stump
Red-capped robin	*Petroica goodenovii*				X		?		?									R B	Tree fork
Hooded robin	*Melanodryas cucullata*				X		X	X	?									R B	"
Eastern yellow robin	*Eopsaltria australis*		X	X	X	X		X	X	X								C B	"
Jacky winter	*Microeca leucophaea*				X		X		X	X								C B	"
Crested shrike-tit	*Falcunculus frontatus*				X	X	X											U B	Tree branch
Olive whistler	*Pachycephala olivacea*		X	X		X		X										U	Dense, low vegetation
Golden whistler	*Pachycephala pectoralis*		X	X	X	X	X	X		X								C B	Tree fork
Rufous whistler	*Pachycephala rufiventris*		X	X	X	X	X	X										C B m	Tree
Grey shrike-thrush	*Colluricincla harmonica*		X	X	X	X	X	X	X	X								C B	Shrub, tree, ground
Black-faced monarch	*Monarcha melanopsis*		X	X		X												R B m	Tree fork
Leaden flycatcher	*Myiagra rubecula*				X		X	X										U B m	Tree branch
Satin flycatcher	*Myiagra cyanoleuca*			X	X	X	X	X										U B m	"
Restless flycatcher	*Myiagra inquieta*						X	X	X									U B	Tree fork
Rufous fantail	*Rhipidura rufifrons*		X	X		X		?										C B m	Tree branch
Grey fantail	*Rhipidura fuliginosa*		X	X	X	X	X	X		X								C B	"
Willie wagtail	*Rhipidura leucophrys*						?		X	X								C B	"
Eastern whipbird	*Psophodes olivaceus*		X	X		X		X										C B	Shrub, thicket
Spotted quail-thrush	*Cinclosoma punctatum*				X		X											C B	Ground
Clamorous reed-warbler	*Acrocephalus stentoreus*													X	X			C B m	Emergent aquatic vegetation
Little grassbird	*Megalurus gramineus*													X			X	U	Grass tussocks, reeds
Golden-headed cisticola	*Cisticola exilis*								X					X			X	U B	Thick, low vegetation
Rufous songlark	*Cinclorhamphus mathewsi*						?	?	X								?	U B	Ground
Brown songlark	*Cinclorhamphus cruralis*								X									R B	"

Common name	Scientific name	1	2	3	4	5	6	7	8	9	10a	10b	10c	10d	10e	10f	10g	Status	Nest location
									Habitat										
Superb fairy-wren	*Malurus cyaneus*			X	X		X	X	X									C B	Shrub, grass
Southern emu-wren	*Stipiturus malachurus*						X						?					U B	Shrub, grass
Pilotbird	*Pycnoptilus floccosus*	X	X		X													U	"
Long-billed scrub-wren	*Sericornis magnirostris*	X	X															R	Tree fork
White-browed scrub-wren	*Sericornis frontalis*	X	X	X	X		X											C B	Shrub, grass
Chestnut-rumped hylacola	*Sericornis pyrrhopygius*			X		X	X											R	"
Calamanthus	*Sericornis fuliginosus*						X											U B	"
Speckled warbler	*Sericornis sagittatus*			?		X		?										R	"
Weebill	*Smicrornis brevirostris*					X												U	"
Brown gerygone	*Gerygone mouki*	X																R B	Tree
White-throated gerygone	*Gerygone olivacea*			?		?		X	X									R	"
Brown thornbill	*Acanthiza pusilla*	X	X	X	X	X	X		X									C B	Low shrub
Buff-rumped thornbill	*Acanthiza reguloides*			X		X	X	X										U B	Tree hollow, shrub, ground
Yellow-rumped thornbill	*Acanthiza chrysorrhoa*					X		X										C B	Tree branch
Yellow thornbill	*Acanthiza nana*					X	X		X									U B	" "
Striated thornbill	*Acanthiza linearta*	X	X	X	X	X	X											C B	" "
Varied sittella	*Daphoenositta chrysoptera*			X	X	X	X											U B	Tree fork, branch
White-throated treecreeper	*Climacteris leucophaea*		X	X	X	X	X											C B	Tree hollow
Red-browed treecreeper	*Climacteris erythrops*		X	X	X													U	" "
Brown treecreeper	*Climacteris picumnus*					X		X										U	" "
Red wattlebird	*Anthochaera carunculata*		X	X	X	X	X		X									C B	Tree branch
Little wattlebird	*Anthochaera chysoptera*			X			X											C B	Tree fork
Spiny-cheeked honeyeater	*Acanthagenys rufogularis*						X											R	" "
Noisy friarbird	*Philemon corniculatus*			X		X												U B	Tree branch
Little friarbird	*Philemon citreogularis*						X											R	Tree foliage
Regent honeyeater	*Xanthomyza phrygia*			?					X									R	Tree fork
Bell miner	*Manorina melanophrys*				X													C B	Tree fork
Noisy miner	*Manorina melanocephala*					X	X	X	X									C B	Tree branch
Lewin's honeyeater	*Meliphaga lewinii*	X	X															U	" "
Yellow-faced honeyeater	*Lichenostomus chrysops*	X	X	X	X	X	X		X									C B	Shrub, tree
Singing honeyeater	*Lichenostomus virescens*						?		?									R	Bush, low tree
White-eared honeyeater	*Lichenostomus leucotis*			X	X	X	X		X									C B	Low shrub
Yellow-tufted honeyeater	*Lichenostomus melanops*				X													C B	" "
Fuscous honeyeater	*Lichenostomus fuscus*			X			?											R	Tree branch
White-plumed honeyeater	*Lichenostomus penicillatus*				X			X	X									U	Tree foliage
Brown-headed honeyeater	*Melithreptus brevirostris*		X	X	X	X	X		X									C B	Tree branch
White-naped honeyeater	*Melithreptus lunatus*	X	X	X	X	X	X		X									C B	" "
Painted honeyeater	*Grantiella picta*						?											R	" "
Crescent honeyeater	*Phylidonyris pyrrhoptera*	X	X	X	X		?											C B	Low shrub
New Holland honeyeater	*Phylidonyris novaehollandiae*			?	X		X		X									C B	" "
Tawny-crowned honeyeater	*Phylidonyris melanops*						X											U	" "
Eastern spinebill	*Acanthorhynchus tenuirostris*		X	X	X	X	X		X									C B	Tree branch
Scarlet honeyeater	*Myzomela sanguinolenta*						X											R	" "
White-fronted chat	*Ephthianura albifrons*						X	?								X		C B	Low shrub, tall grass
Mistletoebird	*Dicaeum hirundinaceum*			X		X	X											U	Low tree
Spotted pardalote	*Pardalotus punctatus*	X	X	X	X	X	X		X									C B	Tunnel in bank, tree hollow
Striated pardalote	*Pardalotus striatus*	X	X	X	X	X	X		X									C B	" " "

Common name	Scientific name	Habitat 1	2	3	4	5	6	7	8	9	10a	10b	10c	10d	10e	10f	10g	Status	Nest location
Silvereye	*Zosterops lateralis*	X	X	X	X	X	X	X	X									C B	Shrub, tree
*European goldfinch	*Carduelis carduelis*						X	X	X									C B	" "
*European greenfinch	*Carduelis chloris*						?	?	?									R	" "
*House sparrow	*Passer domesticus*							X	X									C B	Trees, shrub, building crevices
*Tree sparrow	*Passer montanus*							X										U	" "
Red-browed firetail	*Emblema temporalis*		X		X		X	X										C B	Small tree, shrub
Beautiful firetail	*Emblema bella*				?		X											R	Low scrub
Diamond firetail	*Emblema guttata*			X		X		X										U B	Dense shrub or tree
*Common starling	*Sturnus vulgaris*						X	X	X									C B	Tree hollow, crevice
*Common mynah	*Acridotheres tristis*							X	X									C	" " "
Olive-backed oriole	*Oriolus sagittatus*			X	X	X												U B	Tree branch
Spangled drongo	*Dicrurus hottentottus*						?	X										R	" "
Satin bowerbird	*Ptilonorhynchus violaceus*	X		X	X			X	X									C B	Tree fork, mistletoe
White-winged chough	*Corcorax melanorhamphos*			X		X		X										U B	Tree branch
Australian magpie-lark	*Grallina cyanoleuca*						X	X	X		X	X						C B	" "
Masked woodswallow	*Artamus personatus*							?										R	Bushes, fence post
White-browed woodswallow	*Artamus superciliosus*					X		X										U B	Shrub, tree
Dusky woodswallow	*Artamus cyanopterus*			X		X	X	X										C B	Tree branch
Grey butcherbird	*Cracticus torquatus*			X	X	X	X	X	X									U B	" "
Australian magpie	*Gymnorhina tibicen*					X	X	X	X									C B	" "
Pied currawong	*Strepera graculina*	X	X	X	X			X	X									C B	Tree fork
Grey currawong	*Strepera versicolor*		X	X	X	X	X											C B	" "
Australian raven	*Corvus coronoides*		X	X	X	X	X	X										C B	" "
Little raven	*Corvus mellori*					X		X	X									C B	" "

Appendix 4

REPTILES

These lists apply only to the study area. Neighbouring areas are not considered. The following abbreviations are used. An X indicates a recent record of the species in that habitat; a question mark (?) indicates the species was formerly or is possibly present in that habitat.

Habitat

1. Closed forest
2. Tall open forest
3. Open forest
4. Riverine forest
5. Foothill woodlands
6. Coastal woodland
7. Farmland
8. Towns
9. Ocean
10. Inland wetlands

Status

- C Common
- U Uncommon
- R Rare
- V Vagrant

Common name	Scientific name	Habitat 1	2	3	4	5	6	7	8	9	10	Status
Long-necked tortoise	*Chelodina longicollis*										X	C
Mountain dragon	*Amphibolurus diemensis*			X								U
Jacky lizard	*Amphibolurus municatus*			X		X	X					U
Eastern water dragon	*Physignathus lesueuri*	X			X							C
Lace monitor	*Varanus varius*			X		X		?				C
Coppertailed skink	*Ctenotus taeniolatus*					X		X				U
Mourning skink	*Egernia coventryi*						?				?	
Cunningham's skink	*Egernia cunninghami*					X		X				U
Black rock skink	*Egernia saxatilis*	X		X		X	X					C
White's skink	*Egernia whitei*			?			X					U
Three-toed skink	*Hemiergis decresiensis*					X						U
McCoy's skink	*Hemiergis maccoyi*	X	X	X	X							C
Delicate skink	*Lampropholis delicata*				X		X	X	X			C
Garden skink	*Lampropholis guichenoti*			X	X	X	X	X	X			C
Weasel skink	*Lampropholis mustelina*				X		X	X	X			U
Coventry's skink	*Leiolopisma coventryi*		X	X	X							U
Grass skink	*Leiolopisma entrecasteauxii*			X	X							U
Red-throated skink	*Leiolopisma platynota*			X		X		X				U
Spencer's skink	*Leiolopisma spenceri*		X	X	X							U
Three-lined skink	*Leiolopisma trilineata*			X		X	X	X				C
Bougainville's skink	*Lerista bougainvillii*						X					R
Water skink (C.T.)	*Sphenomorphus tympanum*		X	X	X			X				C
Water skink (W.T.)	*Sphenomorphus tympanum*	X		X	X			X				C
Southern blue-tongue	*Tiliqua nigrolutea*			X	X	X	X	X	X			C
Common blue-tongue	*Tiliqua scincoides*					X	X	X	X			C
Copperhead (Lowlands)	*Austrelaps superbus*						X	X				C
Copperhead (Highlands)	*Austrelaps superbus*			X	X			X				C
Small-eyed snake	*Cryptophis nigrescens*			X	X	X						U
White-lipped snake	*Drysdalia coronaides*						X	X				C
Tiger snake	*Notechis scutatus*	X	X		X		X	X				C
Red-bellied black snake	*Pseudechis porphyriacus*				X		X	X				C
Brown snake	*Pseudonaja textilis*					?	X	X				U
Yellow-bellied sea-snake	*Pelamis platunus*										X	V

Appendix 5

AMPHIBIANS

These lists apply only to the study area. Neighbouring areas are not considered. The following abbreviations are used. An X indicates a recent record of the species in that habitat; a question mark (?) indicates the species was formerly or is possibly present in that habitat.

Habitat

1. Open forest
2. Tall open forest
3. Open forest
4. Riverine forest
5. Foothill woodland
6. Coastal woodland
7. Farmland
8. Towns
9. Ocean
10. Inland wetlands

Status

C Common
U Uncommon
R Rare

Common name	Scientific name	Habitat 1	2	3	4	5	6	7	8	9	10	Status
	Geocrinia victoriana		X		X						X	C
Giant burrowing frog	*Heleioporous australiacus*				X						X	R
Eastern banjo frog	*Limnodynastes dumerili*		X		X		X	X	X		X	C
Brown-striped frog	*Limnodynastes peronii*				X		X	X			X	C
Spotted grass frog	*Limnodynastes tasmaniensis*						X	X	X		X	C
Haswell's frog	*Paracrinia haswelli*						X	X			X	C
	Pseudophryne dendyi			X	X						X	U
Southern toadlet	*Pseudophryne semimarmorata*						X	X			X	C
Common eastern froglet	*Ranidella signifera*	X	X	X	X		X	X	X		X	C
Yellow-spotted toadlet	*Uperoleia marmorata*					?	X	X			X	U
Green and golden bell frog	*Litoria aurea*				X		X	X	?		X	C
Blue Mountains tree frog	*Litoria citropa*				X	?					X	R
Brown tree frog	*Litoria ewingii*	X	X		X		X	X	X		X	C
Jervis Bay tree frog	*Litoria jervisiensis*		X								X	U
Rocky River tree frog	*Litoria lesueurii*	X		X	X						X	C
Peron's tree frog	*Litoria peronii*				X			X			X	U
Leaf-green tree frog	*Litoria phyllochroa*	X			X						X	C
	Litoria raniformis				X		X	X	X		X	C
Verreaux's tree frog	*Litoria verreauxii*						X	X	X		X	C

Appendix 6

FISH

The following abbreviations are used. An X indicates a recent record of the species in that habitat.

Habitat		Comments	
1.	Upland freshwater river	A	Amateur or commercial value
2.	Lowland freshwater river	F	Freshwater spawning
3.	Freshwater lake	I	Introduced
4.	Estuarine river	U	Uncommon
5.	Estuarine lake		

Common name	Scientific name	Habitat 1	2	3	4	5	Comments
Southern anchovy	*Engraulis australis*				X	X	A
Bass	*Macquaria novemaculeata*		X		X		A U
Blackfish	*Gadopsis marmoratus*	X	X	X			A F
Black bream	*Acanthopagrus butcheri*				X	X	A
Cobbler	*Gymnapistes marmoratus*				X	X	
Long-finned eel	*Leptocephalus wilsoni*				X	X	A
Short-finned eel	*Anguila australis*	X	X	X	X	X	A
Serpent eel	*Ophisurus serpens*				X	X	
Short-headed worm eel	*Muraenichthys breviceps*					X	
Estuary perch	*Macquaria colonorum*		X		X	X	A
Dusty flathead	*Neoplatycephalus fuscus*				X	X	A
Greenback flounder	*Rhombosolea tapirina*				X	X	A
Long-snouted flounder	*Ammotretis rostratus*				X	X	A
Garfish	*Hemiramphus melanochir*				X	X	A
Bridled goby	*Arenigobuis bifrenatus*				X	X	
Big-headed gudgeon	*Philypnodon grandiceps*		X		X	X	F
Globe fish	*Atopomycterus nichtemerus*					X	
Grayling	*Prototroctes maraena*	X	X				F
Small-mouthed hardy head	*Atherinasoma microstoma*				X	X	
Silver hardy head	*Atherinasoma presberytoides*				X	X	
Six-spined leatherjacket	*Meuschenia multiradiatus*				X	X	A
Ling	*Genyptems blacodes*				X	X	A U
Luderick	*Girella tricuspidata*				X	X	A
Flat-tail mullet	*Liza argentea*				X	X	U
Sand mullet	*Myxus elongatus*				X	X	U
Sea mullet	*Mugil cephalus*				X	X	A
Yellow-eye mullet	*Aldrichetta forsteri*		X		X	X	A
Oldwife	*Enoplosus armatus*					X	
Pipefish	*Several species*					X	
Redfin	*Pera fluviatilis*	X	X	X			AFI
Snapper	*Chrysophris unicolor*					X	A
Blue sprat	*Spratelloides robustus*					X	
Sprat	*Clupea bassensis*					X	
Snook	*Australuzza novaehollandiae*					X	A U
Sole	Species unknown				X	X	U
Native trout	*Galaxius maculatus*	X	X	X	X	X	
Brown trout	*Salmo trutta*	X	X	X	X		AFI
Rainbow trout	*Salmo gairdneri*	X		X			AFI U
Smooth toadfish	*Torquigener glaber*				X	X	
Prickly toadfish	*Contusus richei*				X	X	
Australian smelt	*Retropinna semoni*	X	X	X	X	X	F
Tommy rough	*Arripis georgiana*				X	X	A
Tupong	*Pseudaphritis urvilli*				X	X	
Tailor	*Pomatus saltator*				X	X	A
Trevally	*Vsacaranx georgianus*				X	X	A
Yellowtail scad	*Trachurus mccullochi*				X	X	
King George whiting	*Sillaginodes punctatus*				X	X	A

Appendix 7

NOXIOUS WEEDS OF THE GIPPSLAND LAKES HINTERLAND AREA

Common name	Botanical name
Hedge wattle	*Acacia armata*
Amsinckia	*Amsinckia* sp.
Angled onion	*Allium triquetrum*
Apple of Sodom	*Solanum sodomeum*
Bathurst burr	*Xanthium spinosum*
Bindweed	*Convolvulus arvensis*
Blackberry bramble	*Rubus* sp.
Boneseed	*Chrysanthemoides monilifera*
Boxthorn	*Lycium ferocissimum*
Californian thistle	*Cirsium arvense*
Cape broom	*Genista monspessulana*
Cape tulip, one-leaf	*Homeria breria breyniana*
Cape tulip, two-leaf	*Homeria miniata*
Chilean cestrum	*Cestrum parqui*
English broom	*Cytisus scoparious*
Erect prickly pear	*Opuntia stricta*
Fennel	*Foeniculum vulgare*
Five-spined saltbush	*Bassia quinquecuspis*
Flax-leaved broom	*Genista linifolia*
Furze	*Ulex europaeus*
Great mullein	*Verbascum thapsus*
Hawthorn	*Crataegus monogyna*
Hemlock	*Conium maculatum*
Hoary cress	*Cardaria draba*
Horehound	*Marrubium vulgare*
Nodding thistle	*Carduus nutans*
Nut grass	*Cyperus rotundus*
Ox-eye daisy	*Chrysanthemem leucanthemum*
Paterson's curse	*Echium plantagineum*
Ragwort	*Senecio jacobaea*
Saffron thistle	*Carthamus lanatus*
St Johns wort	*Hypericum perforatum*
Sand mustard or sand rocket	*Diplotaxis tenuifolia*

Scotch thistle or heraldic thistle	*Onopordum acanthium*
Serrated tussock	*Nassella trichotoma*
Skeleton weed	*Chondrilla juncea*
Slender thistle or shore thistle	*Carduus tenuiflorus*
Soursob	*Oxalis pes-caprae*
Spear thistle	*Cirsium vulgare*
Spiny emex or three-cornered Jack	*Emex australis*
Stinkwort	*Inula graveolens*
Sweet briar	*Rosa rubiginosa*
Thorn apple	*Datura ferox*
Tree of heaven	*Ailanthus altissima*
Tufted honeyflower	*Melianthus comosus*
Variegated thistle	*Silybum marianum*
Viper's bugloss	*Echium vulgare*
Wheel cactus	*Opuntia robusta*
Wild mignonette	*Reseda luteola*
Wild teasel	*Dipsacus fullonum*
Wild watsonia	*Watsonia bulbillifera*

Appendix 8

AUTHORIZED DIVERSIONS FROM SURFACE WATER RESOURCES

Major Stream System	Stream or tributary	State of regulation regulated R; unregulated U.R.	Licenses and permits issued: Irrigation	Licenses and permits issued: Domestic and stock	Licenses and permits issued: Industrial	Irrigated area (ha): Total	Irrigated area (ha): Pasture	Irrigated area (ha): Lucerne	Irrigated area (ha): Other	Annual Volume (ML)
Avon	Avon R.	U.R.	46	14	2	676.5	616.5	14.1	46.0	4,308.8
	Freestone Ck.	"	12	2	-	104.4	96.4	4.0	30.0	857.7
	Nuntin Ck.	"	2	-	-	107.9	107.9	-	-	647.0
	Valencia Ck.	"	12	1	-	143.5	143.5	-	-	862.2
	Total		72	17	2	1,068.3	964.3	18.0	76.0	6,675.7
Macalister	Macalister R.	U.R.	10	6	-	80.0	76.0	4.0	-	499.8
	Macalister R.	R.	42	5	2	516.5	516.5	-	-	8,168.5
	Glenmaggie Ck.	U.R.	6	5	-	48.3	40.3	8.0	-	303.2
	Newry Ck.	"	35	1	-	238.8	238.8	-	-	1,436.1
	L. Glenmaggie	"	4	53	1	24.0	24.0	-	-	317.4
	Total		97	70	3	907.6	895.6	12.0	-	10,725.0
Thomson	Thomson R.(1)	U.R.	20	4	-	459.8	427.8	2.0	30.0	2,790.0
	Thomson R.(2)	"	22	10	-	388.0	388.0	-	-	2,379.2
	Thomson R.(3)	"	10	2	-	160.9	160.9	-	-	970.6
	Back Ck.	"	1	-	-	6.2	6.2	-	-	37.0
	Boggy Ck.	"	13	1	-	136.0	136.0	-	-	818.5
	Lavers Ck.	"	7	-	-	27.4	27.4	-	-	164.4
	Stoney Ck.	"	-	1	-	-	-	-	-	2.2
	Wickhams Ck.	"	4	-	-	23.7	23.7	-	-	142.8
	Sale Canal	"	2	1	-	15.0	15.0	-	-	92.2
	Flooding Ck.	"	3	1	-	53.6	53.6	-	-	324.2
	Total		82	20	-	1,270.6	1,238.6	2.0	30.0	7,721.1
Mitchell	Mitchell R.(4)	U.R.	149	57	1	1,979.6	1,319.2	-	660.4	12,157.9
	Mitchell R.(5)	"	16	2	-	129.3	44.1	21.2	64.0	785.8
	Boggy Ck.	"	2	3	1	14.5	14.5	-	-	87.0
	Clifton Ck.	"	9	-	-	69.8	69.8	-	-	420.0
	Dargo R.	"	5	2	-	39.3	33.3	6.0	-	247.4
	Iguana Ck.	"	-	1	-	-	-	-	-	6.6
	Pound Swamp	"	1	-	-	6.2	6.2	-	-	37.0
	Forge Ck.	"	1	-	-	5.8	5.8	-	-	35.0
	Total		183	65	2	2,244.5	1,492.9	27.2	724.4	13,776.7

Major stream system	Stream or tributary	State of regulation regulated R; unregulated U.R.	Licenses and permits issued			Irrigated area(ha)				
			Irri-gation	Domestic and stock	Industrial	Total	Pasture	Lucerne	Other	Annual Volume (ML)
Tambo	Tambo R.(6)	U.R.	5	17	-	30.9	27.9	3.0	-	219.2
	Connors Ck.(7)	"	1	-	-	1.2	1.2	-	-	7.4
	Deep Ck.	"	-	1	-	-	-	-	-	2.2
	Little R.	"	2	11	1	13.5	13.5	-	-	136.5
	Total		8	29	1	45.6	42.6	3.0	-	365.3
Buchan	Buchan R.	U.R.	7	2	-	113.8	81.0	22.8	-	696.8
	Back Ck.	"	1	-	-	5.0	5.0	-	-	30.0
	Murrindal R.	"	1	-	-	10.3	10.3	-	-	62.0
	Total		9	2	-	129.1	96.3	22.8	-	788.8
Perry	Perry R.	U.R.	3	6	1	13.7	10.7	-	3.0	95.6
Nicholson	Nicholson R.	U.R.	2	3	-	8.0	8.0	-	-	54.6
Bunga Ck.	Bunga Ck.	U.R.	1	-	-	4.2	4.2	-	-	25.0
Latrobe	Latrobe R.	U.R.	2	3	-	33.0	30.0	-	3.0	204.6
Snowy	Boggy Ck.	U.R.	1	6	1	6.2	6.2	-	-	65.8

(1) above Macalister--Thomson junction
(2) old course of Thomson R.
(3) below Macalister--Thomson junction
(4) above barrage at Bairnsdale
(5) below barrage at Bairnsdale
(6) below Timbarra R. junction (lower Tambo)
(7) above Timbarra R. junction (upper Tambo)

Appendix 9

AUTHORIZED ANNUAL EXTRACTIONS FROM GROUNDWATER RESOURCES

Parish	No. of licences	Irrigated areas (ha)	Authorized extraction (ML)
Bairnsdale	6	95.1	559.0
Bengworden	1	60.7	371.0
Bengw. South	4	397.0	2,407.0
Briagolong	21	159.8	925.0
Bumberrah	7	70.1	459.0
Bundalaguah	17	98.3	676.2
Buchan	1	43.0	241.0
Coongulmerang	64	955.6	5,524.0
Colquhoun	8	48.0	330.0
Glenaladale	3	-	16.0
Glenmaggie	2	-	11.0
Goon Nure	2	40.0	250.0
Maffra	27	76.0	583.2
Meerlieu	10	631.2	3,830.2
Moormurng	21	384.0	2,242.0
Nindoo	2	26.3	165.0
Nuntin	54	557.2	3,578.0
Stratford	14	115.3	708.0
Tambo	4	22.0	143.3
Tinamba	83	113.8	1,082.0

Parish	No. of licences	Irrigated areas (ha)	Authorized extraction (ML)
Tongo Munjie East	2	-	523.0
Wa-De-Lock	12	99.2	677.5
Wuk Wuk	18	311.1	1,721.0
Wy Yung	10	237.7	1,370.0
Yeerung	4	140.5	964.0
Sale	30	59.8	479.0

Notes: Domestic and stock use is registered, but no volumetric entitlement is granted.

Average use may be of the order of 2.5 ML per bore.

F D Atkinson Government Printer Melbourne