May 1976

Land Conservation Council Victoria

Corangamite Study Area

$4.00
Price [redacted]

REPORT

on the

CORANGAMITE STUDY AREA

Land Conservation Council, Victoria
Melbourne: May 1976

384/76—PL

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FOREWORD

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

This report sets out to describe and assess the natural resources of the public land in the Corangamite 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 will itself study, and so make informed and constructive suggestions to the Council for its consideration.

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

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

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

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 14 of the *Land Act* 1958 and State forest;

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

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

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

"Reserved forest" and "State forest" have the same meanings as in section 3 of the *Forest 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 Utilisation Act* 1958; and

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

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

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

(a) publish a report of the investigation;

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

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

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

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

Section 10.

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

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

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

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

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

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

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

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

Section 11

A copy of every recommendation of the Council made under sub-section (1) of section 5 and of the proposals of the Council submitted to the Minister pursuant to section 7 shall be laid before both Houses of Parliament within fourteen days of the making thereof 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.

ACKNOWLEDGMENTS

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 Mines; the Fisheries and Wildlife Division of the Ministry for Conservation; the Forests Commission; the National Parks Service; the Soil Conservation Authority; and the State Rivers and Water Supply Commission.

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

Messrs. J. Raven, T. Pescott, E. Joyce and the government bodies listed above provided photographs for use in this report.

PART I INTRODUCTION

AIMS AND METHODS

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

It describes the physical nature of the land and its environment, examines the 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 mammals and plants.

Although public land has been emphasized, the report considers all land in the study district to place public land in perspective.

The text is divided into four main sections. Part I, an introductory section, outlines the conservation and ecological principles that are followed and gives a brief description and history of the area.

Part II describes the main features of the environment for the whole study district. Maps included show physiography, geology, and topography and rainfall. Another map in a pocket at the back of this report delineates plant communities. Mammal, bird, and reptile habitats are described in terms of these communities.

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

Part IV provides more detailed information and, for convenience, the study district has been divided into 11 blocks. The information is set out in a consistent format of headings so that the reader can readily find specific information for any block and compare it with others.

A number of appendices give details of fauna, flora, and climatic data for the study district and information on water-quality standards.

CONSERVATION

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 is aware of long-term needs, and recognizes that a community requires land for recreational, 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. The expansion of Victoria's economy last century 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 or pasture may increase or decrease over time. Animal and plant communities and landscape fall within this class. 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 the development of sound management techniques based on those principles. An ecosystem typically contains many components that are interrelated. 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 technology 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 technique and only emerge in the long term - the use of insecticides can increase the production of food or fibre dramatically, but may also reduce the populations of predatory birds and insects and so encourage the build-up of other insect-pest populations.

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 picnics 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, and determining other uses compatible with these and 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 been given prime importance, and the use of natural resources has often been decided in relation to short-term advantage when conflict arose. The deleterious effects of this type of development have been recognized and there is now a popular demand for attention to the total long-term needs of the community.

The concept of balance involves equal consideration of the needs of all sections of society, on both regional and State bases, as well as the needs of this and future generations. These needs should be clearly stated as aims.

The intangible values of recreation, aesthetics, and preservation must not be ignored. In addition to actively providing land for these purposes, we must also consider the impact of other land uses upon them. Outstanding natural features should be preserved.

Where several land uses are compatible, land should be available for the most beneficial combination of such uses. 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.

Policy measures should stimulate the best use of partly developed lands and discourage significant changes in natural areas.

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

THE STUDY AREA

Local Government areas

The Coranagamite area occupies 15,000 sq km of the Western District of Victoria. Its southern edge comprises the coastline, from just north of Lorne to west of Port Fairy, while the remainder of the boundary follows those of local government shires except where it passes through the shires of Belfast, Dundas, and Minhamite.

This boundary wholly encloses the shires of Colac, Hampden, Heytesbury, Mortlake, Mount Rouse, Otway, Warrnambool, and Winchelsea. The cities of Colac and Warrnambool, the town of Camperdown, and the boroughs of Koroit and Port Fairy are excluded from the study area.

Roads and cities

Three major road systems traverse the area - the Princes Highway and Hamilton Highway run east--west through the study area and the Great Ocean Road follows the coast between Anglesea and Peterborough. Warrnambool and Colac are the only cities within the area but Geelong, Ballarat, and Hamilton all lie less than 32 km from the boundary.

Physical environment

The area contains considerable diversity of natural environments, each with its own particular combination of physiography, soils, climate, and vegetation. Flat treeless basaltic plains covering much of the area provide a marked contrast to the steep heavily timbered slopes of the Otway Ranges.

The coastal zone differs again from both of these and displays considerable internal variation of environments, including cliffed coastline, precipitous slopes, high as well as low sand dunes, and sweeping beaches.

Land use and tenure

Changes in land use within the study area reflect changes in natural environments. For example, whereas almost all the dry basalt plains support grazing sheep and beef cattle, and to some extent cropping, much of the steep high-rainfall country of the Otway Ranges is used for timber production.

Almost all natural vegetation is concen-

TABLE 1

POPULATION

Local government area	Population at Census 30th June			Average increase or decrease 1961-1971 (% /year)
	1961	1966	1971	
Warrnambool (City)	15,702	17,500	18,684	+1.9
Warrnambool (Shire)	7,610	7,506	6,859	-1.0
Belfast (Shire)	1,917	1,857	1,643	-1.4
Minhamite (Shire)	2,907	2,824	2,503	-1.4
Winchelsea (Shire)	4,584 [A]	4,241	3,998	-1.3 [B]
Otway (Shire)	3,855 [A]	3,888	3,921	+0.2 [B]
Colac (City)	9,252	9,499	9,679	+0.5
Colac (Shire)	7,326 [A]	6,959	6,264	-1.4 [B]
Heytesbury (Shire)	8,196 [A]	8,202	8,208	+0.01 [B]
Hampden (Shire)	9,176	8,773	7,411	-1.9
Mortlake (Shire)	4,627	4,400	4,073	-1.2
Mount Rouse (Shire)	3,056	3,042	2,693	-1.2
Port Fairy (Borough)	2,426	2,579	2,427	0
Koroit (Borough)	1,466	1,416	1,429	-0.3
Camperdown (Town)	3,446	3,540	3,477	+0.1
TOTAL	85,546	86,226	83,269	-0.3

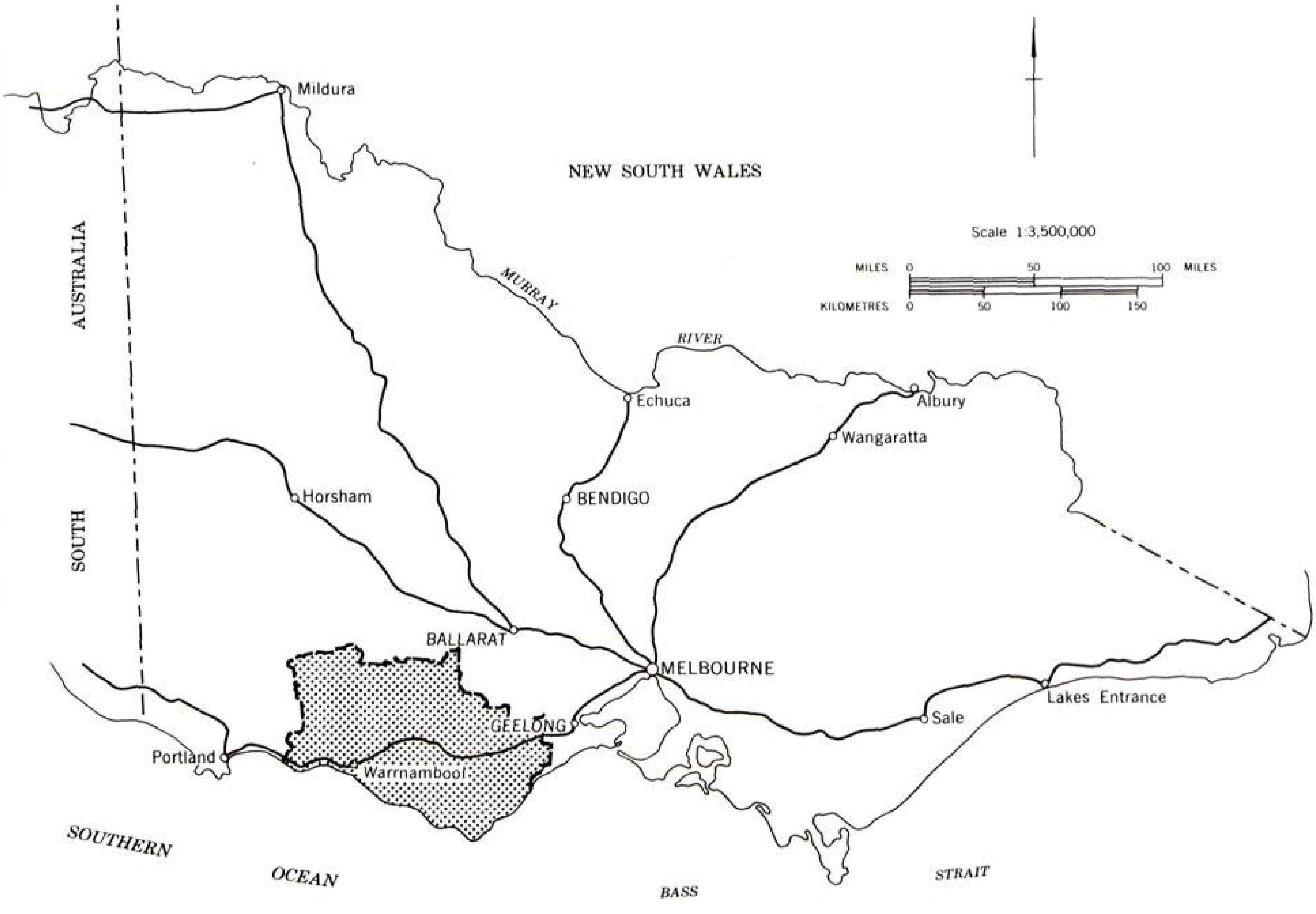
A. Estimate only, due to change in Shire boundary.
B. 1966-1971

Data obtained from *Victorian Year Book*, 1974.

LAND CONSERVATION COUNCIL
VICTORIA

CORANGAMITE STUDY AREA

LOCALITY PLAN



trated on public land in the south-east of the area, on and around the Otway Ranges, where it varies from low heathland to tall mountain forests. This land is used mainly for timber production and is of increasing importance as a source of domestic water. To date a relatively small proportion has been reserved specifically for nature conservation and recreation. Mining and quarrying occur in scattered locations throughout the study area.

The public land is mainly located in the east of the study area and covers about 2270 sq. km (15 %). Much of it is reserved forest and a substantial proportion is Crown land covered by water.

Population

Population has remained fairly static, declining from 83,155 to 82,847 in 10 years (see Table 1). A distinct decline in the population of rural areas during this period reflects, at least in part, the rural recession of the late 1960s. This decline, however, was compensated by an increase in the populations of Warrnambool, Colac, Camperdown and Port Fairy.

HISTORY

The first recorded European sighting of the coastline of the Corangamite area was made in 1800 by Lieutenant Grant in command of the brig 'Lady Nelson'. He named Capes Patten and Otway. In 1802 the Frenchman Nicholas Baudin followed the coastline, naming Cape Desaix (Cape Otway) as well as sighting the Port Fairy--Warrnambool area. Later in the same year Flinders sailed along the Otway coastline, naming Moonlight Head.

The earliest record of exploration of this coast will, however, remain in doubt until the riddle of the legendary 'mahogany ship' is solved. This ancient wreck was first reported lying in the sand dunes some distance from the sea near Tower Hill in 1836 and had apparently been there for a considerable time. It has not been seen since 1880, despite repeated attempts to relocate it.

In the early 1800s sealers and whalers formed temporary settlements at various points, including places now known as Port Faity, Warrnambool, Apollo Bay, and Lorne.

During the early years the sea was the main communication route for the settlements along the coast. Navigation was extremely hazardous and many lives were lost in shipwrecks.

Exploration of the interior of the study area, however, did not occur until the late 1830s. This exploration was not without its share of tragedy also, for the explorers Gellibrand and Hesse disappeared without trace in the dense Otway forests in 1837.

Aborigines

It has been estimated that prior to European settlement the aboriginal population of the Western District was of the order of 2,000--3,000 individuals. These nomadic people were concentrated mainly in open or lightly timbered country in places with permanent water. Aborigines seldom ventured into the Otway forests, although there is evidence of temporary occupations on Cape Otway.

The impact of European settlement on these people was catastrophic, and the effects of disease, liquor, and the general destruction of their way of life, reduced their numbers in the Western District to less than 600 by 1876.

Two reserves (each of 2,592 ha) were set aside for Aborigines, one near Birregurra in 1836 and the other in the Mount Rouse area in 1841. Both of these failed, and the land was made available for settlement in 1848 and 1844 respectively. Another reserve of 1418 ha was created at Framlingham in 1861 and, of this, 198 ha is presently owned by the Framlingham Aboriginal Trust. The reservation of the balance of the area was revoked in 1891, and it is now reserved forest.

Exploration and Settlement

The first permanent settler in the study area was Captain Griffiths, who by 1836 had taken up land at Port Fairy. As well as farming on a small scale, he engaged in whaling.

In 1837, searchers for the missing explorers Gellibrand and Hesse recognized the potential of the inland areas for grazing. Squatters then began moving westwards from Port Phillip to settle areas north and west of the main Otway Range. Glowing reports of "Australia Felix" by Major Mitchell encouraged squatters north of the Murray to follow a similar route south-west from Albury to the Western District, but few penetrated beyond the Pyrenees. The basalt plains around Lake Corangamite in the north of the study area were occupied by squatters arriving mainly from Geelong, and a few from Portland. Most of the men concerned were Tasmanian in origin.

However, it was not until early 1893 that squatters began to take up land on the plains in the study area. These were largely ignored at first. George Russell of Golf Hill, Shelford, an 1836 squatter, wrote in his *Narrative:* "Those persons who were looking out for country to settle on at this time passed over the extensive plains to the westward of the river Leigh and on both sides of the Wardy Yallock as far up as Mount Elephant. The open country was then not considered so suitable for settling down as the timbered country was, and all this fine tract of sheep country was unoccupied by anyone for one or two years after the country beyond Mount Elephant was taken up."

The first to settle were the Manifold brothers, who moved from the Moorabool

Selectors homeward bound from Apollo Bay

River to Lake Purrumbete, and Mackillop and Smith, who took up the run that became Glenormiston. Other squatters followed so quickly that by 1840 most of the basaltic plains of the Western District were occupied. They included George Armitage on the Barwon River at Ingleby, and the Austin brothers on the complex that became Barunah Plains, Barwon Park, and other stations.

Those arriving too late to find free country to suit had to buy land. Neil Black, who arrived from Scotland in 1840, bought Glenormiston. James Ritchie arriving a year later had also, in partnership with James Sceales, to buy into Blackwood (near Penshurst) in 1843. By this time, Burrumbeet had been taken by the well-known Learmonth brothers from Buninyong.

These early squatters endured tremendous hardships, for the only shelter they had were huts or tents and communication was almost non-existent. Apart from perpetual loneliness, and a monotonous diet of mutton, tea, and damper, there was, in addition, the constant threat of attack from hostile Aborigines. However, the efforts of these men were to be rewarded, for within 30--40 years many had accumulated immense fortunes.

During the 1840s some freehold settlement occurred in the study area, particularly around Port Fairy, where, following the potato famine of 1841 in Ireland, many immigrants took up small selections on the fertile land in this area. A little later a small group of German settlers selected land around Penshurst.

The selection era

During the gold rush of 1851--61, the population of the Western District increased six-fold and consequently, towards the end of this period, there was a demand for land, especially from men leaving the diggings. At this time the average size of runs leased by the squatters was 8,000--10,000 ha, and men without land felt that they were entitled to at least some of this. As a result, a number of *Land Acts* were passed during the 1860s providing for selection of relatively small areas for agriculture from the squatters' runs. However, the legislation contained loopholes and, by fair means and foul, the squatters purchased most land made available for selection, thereby ensuring their security of tenure and forcing the selectors to other areas such as the Otway Ranges.

John Gardner, the first settler in the Beech Forest area of the Otways, selected 320 acres in 1884, which he called Ditchley Park. In 1886, 200,000 acres of the Otways were thrown open for selection, and at this time the Government issued a map showing the route of a proposed railway from Colac to Beech

Forest, the promise of which attracted many selectors to the area. In fact during February of 1887, a lands board at Colac handled some 1,500 applications for land. However, the promised railway did not eventuate during the period and its absence, combined with the unbelievable difficulties of clearing the huge trees and dense scrub, resulted in many selections lapsing to the Crown.

Transport and Communications

The coastal and basaltic plains

In the 1850s rough tracks had developed across the open plains occupied by the squatters, linking centres of settlement. These, however, developed into quagmires during winter and horses often had to travel for miles in deep mud. The transport of supplies to squatters by bullock wagons consequently could only occur during the drier months of the year.

It was not until the gold rush that coach services began, and from 1857 a weekly Cobb and Co. service operated from Portland to Geelong. Other coach services operating in the district were the Australian Stage Company and the Western Stage Company. During the 1870s ships carried passengers from Geelong to the Western District ports. However, these forms of transport were to be replaced by railways, for the Geelong to Colac line was officially opened in 1877 and was extended to Camperdown in 1883 and then to Warrnambool and Port Fairy in 1890.

The development of efficient communications and transport routes has affected the pattern of land use.

The Otway Ranges

As early as 1851 two tracks existed in the Otway Ranges. One of these followed the coast from Geelong to Loutit Bay. The other extended from Gerangamete to Cape Otway via Apollo Bay. It was cut by William Roadknight after 6 months' labour.

Conditions on these tracks were appalling and they could only be negotiated on foot or by pack-horses. As late as 1881 G.F. Sydenham, after travelling over Roadknight's track, furnished the following description :

> "For the first few miles the horses averaged about six miles per hour, but from Barramunga to the sea, a distance of 24 miles, the track averaged four feet in width, walled on both sides by impenetrable scrub and undergrowth. Mud was half way up to the horses' belly and often deeper, the trip from Colac to Wild Dog Creek occupying fourteen hours."

This hotel at Ditchley Park, now Beech Forest, was built in 1868. Ditchley Park was burnt out in 1919.

Following selection in the Otways, settlers cut many tracks through the dense forests, but transport posed difficulties. Many of the tracks were practically impassable for most of the year because of mud and fallen trees. The only means of negotiating them was by pack-horses or sledge, and progress was limited to less than 3 km per hour. The only all-weather tracks in the district were a few corduroy roads, which were paved with logs or sleepers. One of these roads extended from Beech Forest to Crowes, a distance of 22 km.

The close of the century, however, saw the beginning of a railway system into the Otways that was to reduce transport problems tremendously. By 1891 the branch line from Birregurra to Forrest was completed, and during February 1902 the Colac to Beech Forest narrow-gauge railway was officially opened. This was extended to Crowes in 1911. Its construction was the major factor in solving the transport problems of this area. It was not until 1962 that it was closed because it was no longer economic, due to improvement of roads in the area.

Rural Production

Pastoral activities

The squatters on the basaltic plains initially grazed sheep, most of which in the early days came from Van Diemens Land. Although these plains provided excellent pasture, there were the problems of killing of stock by the Aborigines and diseases such as scab, footrot, and catarrh. From an early stage shepherds were employed, but obtaining this type of labour for runs was a constant problem. Despite these difficulties, by the 1880s the high-quality wool produced by some runs in the Western District was regarded as equal to the best in the world.

Opening of Colac--Beech Forest railway February 1902

Dairy farms were hewn from the forest.

Up to the 1850s cattle were not regarded as a good investment in this area, but as the demand for beef increased during the gold rush some squatters concentrated exclusively on beef cattle production.

By 1850 most squatters grazed some dairy cattle, producing milk, butter, and cheese mainly for their own use.

With the introduction of the separator in the 1870s, many farmers on suitable land turned to dairying. From 1880 on, much land around Warrnambool and Port Fairy was used primarily for dairying, and butter factories became established.

Land in the Otways was suited to this use and, following construction of the narrow-gauge railway, produce could be transported to markets. A butter factory was established at Beech Forest early this century, but has since closed.

In 1956, the Soldier Settlement Commission began to clear 100,000 acres of the Heytesbury Forest to be developed as dairy farms. Today most of this land has become productive dairying country.

Agriculture

Squatters cultivated some land mainly to grow crops to satisfy their own needs. However, in areas where soils were particularly fertile, friable, and free from stone, the growing of crops especially potatoes was common as early as 1840. This was the case for land around Port Fairy and Warrnambool, where Irish immigrants owned small farms.

With the solution of transport problems of the Otways, potato-growing became widespread around Beech Forest, and from 1917 to 1947 the township held an annual potato show. At one time during the period this district was Victoria's leading "certified potato-seed" area.

Timber production

Practically all of the basalt plains within the study area were treeless. Dense forests, heath, and scrub existed on other geological formations, with probably the best forests in the colony concentrated in the wet Otway Ranges.

As early as 1859, timber-cutters had moved into the Apollo Bay and Loutit Bay districts. They were totally dependent on ships for transport and supplies. Most timber was pit-sawn, dragged to the beach, and floated out to sea, where it was loaded onto ships. The main species cut was blue gum and the main products were piles and railway sleepers for the Melbourne--Geelong and Melbourne--Bendigo railway lines.

Around 1860 the timber industry was at its peak for this period; in 1862 there were more than 1,000 timber-cutters in and around Apollo Bay. However, soon after this date the railway contracts were completed and the industry declined rapidly, until by 1865 there were only 200 men at Apollo Bay.

It was not until about 1870 when surveyors and others made their way inland from the coast that the timber wealth of these forests was realized. In 1873 the first reserve of 193,000 acres of this was excised and in 1879 a further 162,000 acres were made available for selection, reducing the forest reserve to a little over 30,000 acres.

In 1886 the government increased the area available for selection to 200,000 acres. But in 1890 it withdrew those portions unoccupied by the settlers, because of the valuable timber, and in 1899, following the recommendations of a Royal Commission on timber resources

158,000 acres of the Otway forests were permanently reserved.

Following the decline in the timber industry in the 1860s, only small mills continued to operate in the Otways until 1882, when a large mill commenced operations near the mouth of the Elliott River. This mill had several kilometres of tramway and produced millions of cubic metres of timber between 1882 and the 1920s, when it finally closed. At one time it had its own school and football team.

In 1886 the first relatively large inland mill started to operate, on Monday Creek, transporting timber to the railhead at Forrest. This mill was owned by Cowley, Whitelaw, and Henry. Timber was transported through the forest on tramways, the trucks being drawn by horses.

In the 1890s sawmills were established by Hayden and Anderson Mackie and Company. Timber was initially cut at Mount Cowley and ultimately a mill was constructed near Barwon Downs.

By 1902, however, the outlook for the industry changed markedly, for where previously timber had to be carted to Colac or shipped from Apollo Bay, the railway in the ranges now provided an outlet for much larger volumes of produce. The result was a boom in the timber industry. During this period many settlers abandoned their farms to work in the mills, and much cleared land reverted to bracken and scrub.

Timber was the major product of the Otway Ranges during the early days of settlement

Despite the inroads that selectors had made into the timber resources, at one time during this period 29 mills lay within 27 km of Beech Forest. Timber was loaded at Beech Forest, Wyelangta, Crowes, Lavers Hill, and Ferguson. Horse teams were used to haul timber in trucks on tramways to the sidings. During the peak of the timber boom there were 240 km of tramway on the western ridge alone.

However, the boom was short-lived. By 1930 timber supplies had been severely reduced and this, combined with the economic depression of that time, resulted in a decline in the industry. Whereas in 1922 12 mills were working full-time along the Beech Forest--Crowes railway, in 1931 there were only three, all working for limited periods.

In the 1930s, however, the Forests Commission began to increase the timber resources of the area. It purchased much of the abandoned farmland in the Aire Valley at nominal prices, and planting with softwoods commenced in 1930, thus opening the present era of large-scale softwood production.

References

Anon. Cape Otway. *Illustrated Melbourne Post*, 25th November, 1865.

Anon. In the beech forest, Cape Otway Ranges. *Illustrated Australian News*, 1st July, 1895.

Anon. The Black Forest of Victoria. *The Australian Magazine*, 1851. In "Soam Scrapbook". (La Trobe Library Archives: Melbourne, unpublished.)

Anon. The skirts of the Otway Ranges. *Illustrated Australian News*, 16th October, 1886.

Barling, J. The Otways. *Victorian Forester*, 1, 1934.

Bonwick, J. "Western Victoria: its Geography, Geology and Social Condition. The Narrative of an Educational Tour in 1867." Ed. C. E. Sayers. (Griffin Press: Adelaide 1970.)

Brown, P. L. (ed). "The Narrative of George Russell." (Oxford University Press: Melbourne 1935.)

Forests Commission, Victoria. "A Brief Description of the Forest Types, Geology and other Features of the Otway District." (Victorian Government Printer: Melbourne 1934.)

Hebb, I. "The History of Colac and District." (The Hawthorn Pres: Melbourne 1970.)

Henricksen, G. M. "The Big Feller." Ken Jenkin Print: Geelong 1973.)

Kiddle, M. "Men of Yesterday. A Social History of the Western District of Victoria 1834-1890." (Melbourne University Press: Melbourne 1961.)

Koenig, W.L. "The History of the Winchelsea Shire." (Winchelsea Shire Council: Colac 1933.)

Loney, J.K. "Otway Memories." (Ken Jenkin Print: Geelong 1971.)

Loney, J.K. "Wrecks Along the Great Ocean Road." (Ken Jenkin Print: Geelong 1974.)

Loney, J.K., and Morris, E.W. "Twelve Decades. A Short History of Apollo Bay." (Ken Jenkin Print: Geelong 1972.)

Powell, J.M. "The Public Lands of Australia Felix." (Oxford University Press: Melbourne 1970.)

Royal Commission on State Forests and Timber Reserves. "Fifth Progress Report: the Otway Forest 1899." (Victorian Government Printer: Melbourne 1899.)

Ryan, J.M. "The Problems of Land Utilisation in the Otway Region." (M.A. Thesis, University of Melbourne 1962.)

Sayers, C.E. "Of Many Things: History of the Warrnambool Shire." (Griffin Press: Adelaide 1972.)

Thornley, A.A. "Otway Settlement Investigator 9:3." (Ken Jenkin Print: Geelong 1974.)

Victorian Central Planning Authority. "Resources Survey Corangamite Region." (Victorian Government Printer: Melbourne 1957.)

PART II

NATURE OF THE LAND

GEOLOGY

Surface geology

The northern part of the study area consists of a wide basalt plain (see the Geology map) with elevations ranging from 110 to 170 metres above sea level. Numerous scoria cones rise 120 to 150 metres above the plain, which also contains a number of depressions with lakes and Recent sediments. Some of these lakes are large features formed when lava flows blocked the regional drainage, for example Lakes Corangamite and Colac. Others are smaller circular explosion craters surrounded by tuff rings (maars). In places the older Pliocene and Miocene sediments that generally underlie the basalt plain are found at the surface, as at Leslie Manor and Lake Keilambete.

On the northern side of the plain at Chatsworth, Lismore, Mount Bute, and Skipton, small areas of granite or Palaeozoic sediments outcrop within the basalt.

On the southern side of the plain, the valleys of the Curdies and Gellibrand Rivers have cut into the edge of the basalt plain and, south of a line from Warrnambool to Colac, Tertiary sediments (particularly the Port Campbell limestone) outcrop extensively.

In the south-east of the study area is the Otway Range, consisting of arkosic sandstone and shale of Lower Cretaceous age, overlain in places by a thin veneer of Palaeocene, Eocene, and Pliocene sediments.

Stratigraphy

Table 2 outlines the stratigraphy of the Corangamite area. In general the youngest unit, the newer volcanics, lies directly on a basement of Palaeozoic age in the northern part of the area. Southwards, a layer of Cretaceous and Tertiary formations present between the newer volcanics and basalts increases in thickness.

Palaeozoic rocks

Rocks of Palaeozoic age outcrop in isolated areas. These include Devonian granites as well as folded phyllitic shale and siltstone of Ordovician age and quartzitic sandstone and siltstone of probable Lower Devonian age, which are similar to the beds of the Grampians. Similar variations in rock types are found in those oil-search wells that extend to basement.

Otway group

The Otway group, of mainly Lower Cretaceous age, that makes up the Otway Ranges consists (predominantly) of arkosic sandstone and shale with minor thin beds of coal. Bores at Hawkesdale, Moyne Falls, Pretty Hill, and Woolsthorpe have penetrated up to 600 metres of basalts and tuffs with minor lithic sandstone and shale at the base of the Otway group.

These Casterton beds are considered to be Jurassic to Lower Cretaceous in age. A porous quartz sandstone, the Pretty Hill sandstone member up to 600 metres thick, overlies the Casterton beds. This was penetrated in wells at Garvoc and Eumeralla also, but does not outcrop anywhere.

The Otway group wedges out in the subsurface to the north along a line running approximately east--west through Cressy, Camperdown, Woolsthorpe, and Hawkesdale.

Sherbrook group

The Sherbrook group, of Upper Cretaceous age, does not outcrop anywhere, but has been penetrated in a number of wells around Port Campbell and along the coast to Port Fairy. The group includes the marine Belfast mudstone and the Waarre sandstone. This latter formation appears to contain substantial quantities of oil and natural gas. The group remains the most prospective part of the stratigraphic section for petroleum.

Wangerrip group

The Wangerrip group, of Palaeocene age, is found in the southern part of the study area from north of Anglesea to Winchelsea and Deans Marsh and to the coast at Aire River mouth and Rivernook (see the geology map). North of Anglesea and at Deans Marsh, Wensleydale, and Bambra, the group consists of quartz sandstone, conglomerate clay, and brown

Loch Ard Gorge: marine sediments deposited during the Tertiary period.

TABLE 2 : STRATIGRAPHY

AGE	FORMATION	GROUP	LITHOLOGY	THICKNESS (m)
Quaternary	Bridgewater formation		calcareous sands & dune limestone (coastal area)	
	Newer Volcanics — Phase II "later"	Newer volcanics	vesicular basalt, tuffs, scoria	0-
	Newer Volcanics — Phase I "earlier"		olivine basalt	145
Pliocene	Moorabool Viaduct formation (eastern area)		sand, silt, gravel, minor limestone	0-20
	Dorodong sand (western area)		brown micaceous sands	0-40
	Unconformity			
Miocene	Port Campbell limestone	Heytesbury Group	limestone	0-270
	Gellibrand marl		marl	30-340
Oligocene	Clifton formation		limonitic sandy limestone, glauconitic quartz sandstone, limonitic quartz sandstone	0-20
	Unconformity			
Eocene	Marrawataturk member	Wangerrip Group	predominantly marl where present	
	Mepunga member		predominantly sandstone where present	
	Dilwyn formation		quartz sandstone & shale interbedded	0-
Palaeocene	Pember mudstone member		fossiliferous glauconitic clay	700
	Pebble Point formation		conglomeritic quartz sandstone, minor clay	
	Unconformity			
Upper Cretaceous	Curdies formation	Shertrook Group	quartz sandstone with minor shale, brackish formation water	
	Paaratte formation		quartz sandstone, minor shale, saline formation water	0-
	Belfast mudstone		green glauconitic fossiliferous mudstone, minor sandstone	1200
	Flaxmans formation		interbedded shale and sandstone	
	Waarre sandstone		quartz lithic sandstone, minor shale	0-130
Lower Cretaceous	Otway group	Otway Group	lithic felspathic sandstone	0-2800
	Unconformity			
Palaeozoic	Palaeozoic rocks		Devonian granite and quartzitic sandstone, Ordovician phyllitic shale and sandstone with quartz veins	

coal. At the coast from Aire River to Princetown, quartz sandstone with pebbles underlies fossiliferous marine mudstone, indicating that the Palaeocene beds become more marine to the south.

Heytesbury group

The Heytesbury group, of Oligocene--Miocene age, consists of Port Campbell limestone up to 260 metres thick overlying Gellibrand marl up to 400 metres thick. The latter extends over most of the study area, being underneath the basalt as far as Foxhow in the north of the study area.

Pliocene beds

Unconformably overlying the Heytesbury group are thin terrestrial sands, silts, and clays, referred to as the Moorabool Viaduct Formation. There are also wind-laid and beach-sand deposits in the western part of the area - the Dorodong sand.

At this stage the major lakes, Corangamite, Colac, etc., formed at least some of the lake sediments pre-dating the colvanics.

Newer volcanics

The extensive volcanics of the Western District are Pliocene to Recent in age, the earliest eruption being about 5,000,000 years and the latest at Tower Hill being about 5,000 years B.C.

Structure

The Palaeozoic rocks are folded along north--south axes with an average dip of about 50°. They are also extensively faulted.

The Lower Cretaceous rocks are folded along ENE--WSW axes with average dips of about 20°. The beds are also believed to be extensively block-faulted. The Otway Ranges consist broadly of a domal structure, with complexities of folding and faulting on a smaller scale.

The Upper Cretaceous to Eocene rocks are gently folded along ENE--WSW axes with average dips of about 5°.

Younger beds are essentially flat-lying except close to centres of volcanic eruption, where beds in the sides of cones are locally steeper, for example around maars, or in scoria beds around scoria cones.

Geological History

Palaeozoic

During the Ordovician, Silurian, and Devonian periods, sediments were deposited in a complex sedimentary basin called the Tasman Geosyncline. Uplift, folding, and faulting accompanied by the intrusion of granites occurred in the early and late Devonian. A long period of erosion followed in the Permian and Triassic periods. During glaciation in the Permian period, no major folding or igneous activity occurred. By the beginning of the Mesozoic era, the landscape was of low relief and relatively flat.

Mesozoic

Extensive tectonic activity occurred during the Jurassic period, and a down-faulted trough or graben formed in the south of the Australian continent, extending at least from South Australia to East Gippsland. This trough was separated from the sea by a basement ridge located near the edge of the present-day continental shelf. Great thicknesses of felspathic mudstones and sandstones, with minor coal seams, were deposited in this graben under fresh-water or estuarine conditions. These sediments are known as the Otway group, and are up to 4,500 metres thick.

Further tectonic activity at the close of the Lower Cretaceous resulted in the division of this trough into several sedimentary basins, including the Otway Basin. During the Upper Cretaceous, subsidence of the basin continued and, following sinking of the basement ridge in the south, a marine transgression occurred, preceding a regression of the sea and the uplift of the Otway Ranges.

Tertiary sedimentation

Another cycle of marine transgression and regression is recognized for the

Fossilized bones found embedded in Tertiary marine sediments at Curdie.

Otway Basin during the Tertiary period. Extensive deposits of coarse sands, gravels, and some coal were deposited on the edge of the retreating sea in the transgression phase of the cycle during the Palaeocene and Eocene periods. These sediments are called the Wangerrip group. Following their deposition, further uplift of the Otway Ranges took place.

In a continuation of the transgression occurring during the Oligocene period, the upper Wangerrip and Heytesbury sediments were laid down as subsidence of the Otway Basin continued. The marine transgression reached its maximum extent during Lower to Middle Miocene and thick deposits of marls and limestone were laid down.

The final regressive cycle occurred during the Upper Tertiary. Deposition took place on the edge of a retreating sea as uplift occurred. These sediments, called the Moorabool Viaduct Formation, are generally less than 30 metres thick and consist of sands and silts.

Volcanic activity

Towards the end of the Eocene, considerable volcanic activity occurred and the "older basalts" were extruded at the same time as the Wangerrip group was being deposited.

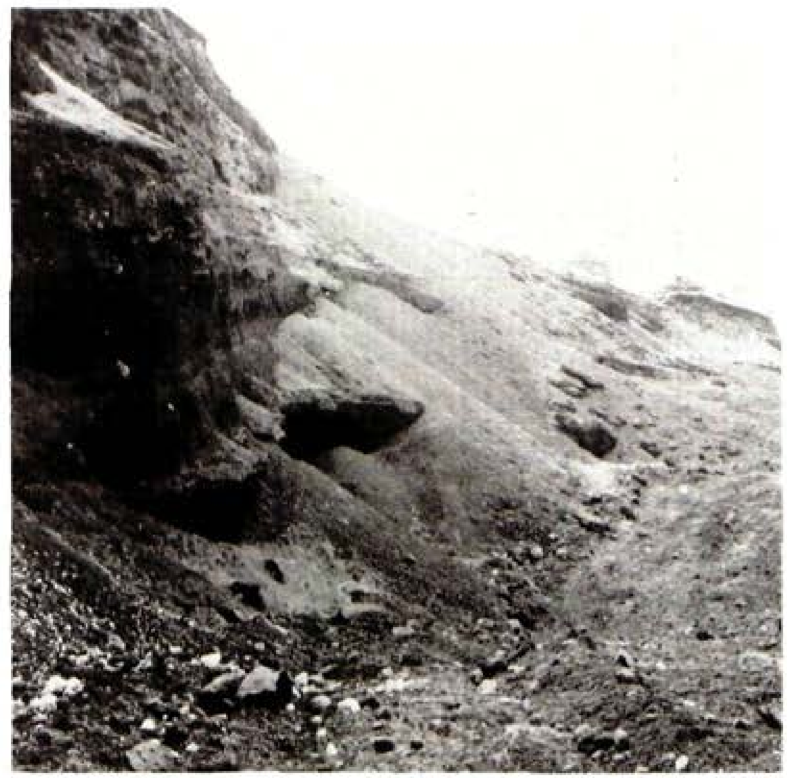
Similar olivine basalts have been encountered in bores in the Otway basin and outcrop near Gellibrand. Some of them may be as young as Lower Miocene.

A second period of volcanic activity, which can be divided into two phases, commenced in the Pliocene following deposition of the Moorabool Viaduct Formation.

The "earlier" newer volcanics of phase I consist of sheets of olivine basalt covering extensive areas. It is generally believed that these lavas erupted from fissured and vents rather than cones. The age of these basalts has been estimated (measured radiometrically) at a little over 4 million years.

The "later" newer volcanics of phase II consist of maars (now crater lakes) and stony rise basalts and scoria cones. These range in age from Pleistocene to Recent. The last known activity occurred at Tower Hill about 5,000 years ago.

The lava flows of the later (stony rise) basalts have an irregular broken surface and the basalt is ropy and vesicular.



Newer volcanics phase I basalt; scoria at Red Rock.

Some interesting lava caves occur in these basalts at several localities.

Quaternary sedimentation

During the Quaternary extensive lakes (such as Lake Corangamite) developed, caused by ponding of valleys by phase I newer volcanics. Black calcareous clays of lacustrine origin have been found beneath the "later" lava flows, indicating the formation of lakes before the final phase of volcanic activity. The distribution of the deposits indicates that these lakes once covered a much larger area than at present. Around their eastern margins, probably during dry periods, wind action built up numerous lunettes. During these dry periods, wind also caused considerable redistribution of siliceous sand, resulting in quite extensive sand sheets in some areas. During the Quaternary, calcareous dunes of the Bridgewater Formation have been built up along parts of the coastline.

References

McAndrew, J., and Marsden, M. (Eds.) "Regional Guide to Victorian Geology." 2nd ed. (School of Geology, University of Melbourne: Melbourne 1973.)

Thompson, B.R. "The Geology and Hydrology of the Corangamite Region." (M.Sc. Thesis, University of Melbourne: Melbourne 1971.)

Wopfner, H., and Douglas, V.G. (Eds.) The Otway Basin of south-eastern Australia. *Geological Surveys of South Australia and Victoria, Special Bulletin 1971.*

Victorian Central Planning Authority. "Resources Survey Corangamite Region." (Victorian Government Printer: Melbourne 1956.)

Abele, C. "Explanatory Notes on Anglesea 1:63,360 Geological Map." (Victoria Mines Department: Melbourne 1968.)

PHYSIOGRAPHY

Four physiographic units are recognized within the study area; the Otway Ranges, coastal plains, volcanic plains, and stony rises. (See physiography map.)

The Otway Ranges

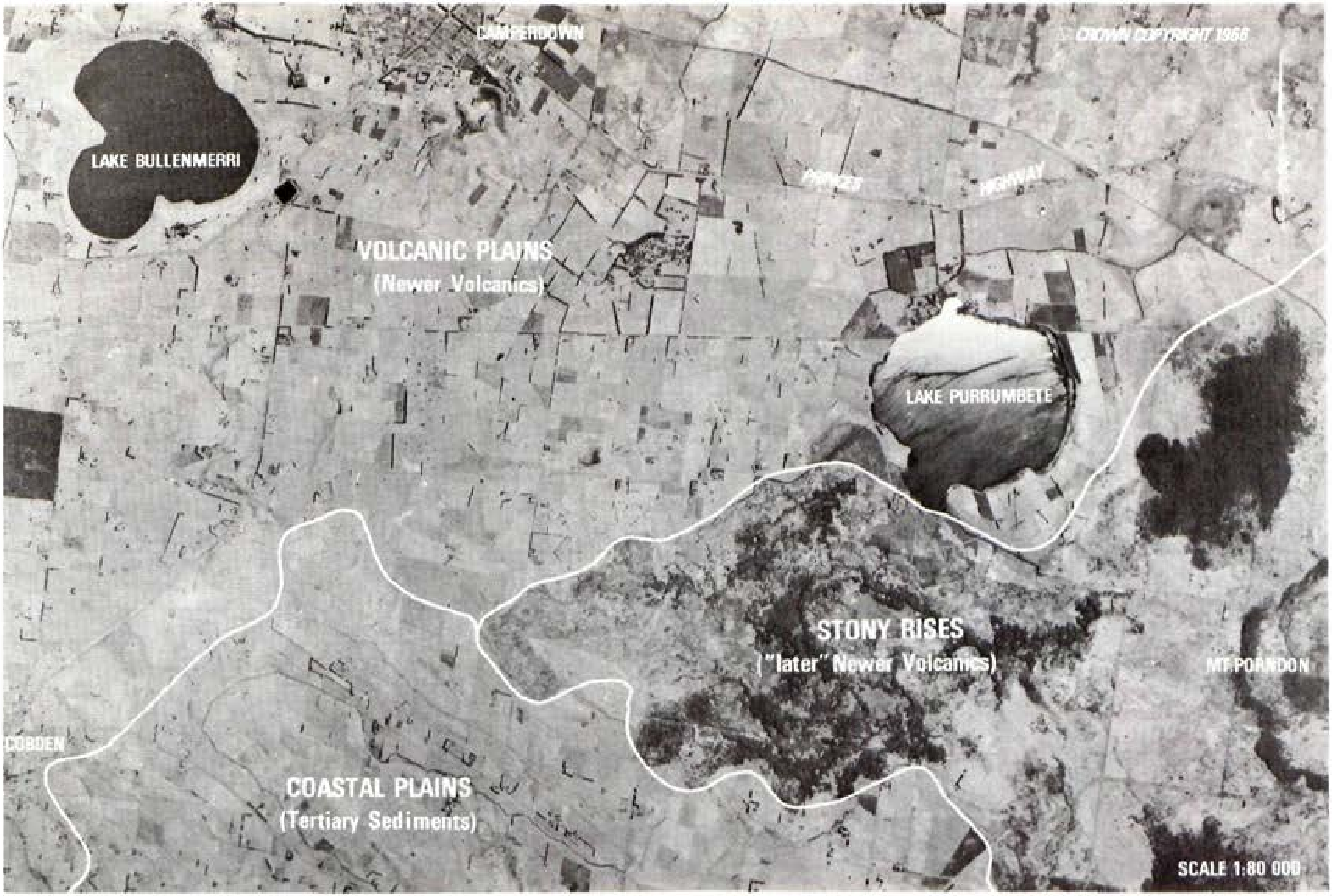
The Otway Ranges are composed of Mesozoic sediments that have been uplifted into a complex domal structure. This range extends for almost 80 km in a generally south-westerly direction from Peters Hill in the east to Olangolah, where it then forks. One branch of the ridge heads in a southerly direction to Cape Otway, while the main ridge continues south-west through Beech Forest to Lavers Hill. Elevation along the main ridge is about 500 m, with the highest point (Mount Cowley) reaching 670 m. In general, the ranges are closely and deeply dissected with the stream pattern generally radial, reflecting the dome-like structural control.

On the northern slopes of the range are the headwaters of the Barwon River in the east and the Gellibrand River in the west. The course of the latter marks the western limit of the Mesozoic sediments in this area. Many short swift-flowing rivers drain the steep southern slopes, including the Painkalac Creek and the Erskine, Cumberland, Wye, Kennet, Barham, and Parker Rivers. Where these streams enter the sea there are often hanging valleys, due to the dominance of marine erosion over stream erosion. Land slips are a feature of the Otway Ranges.

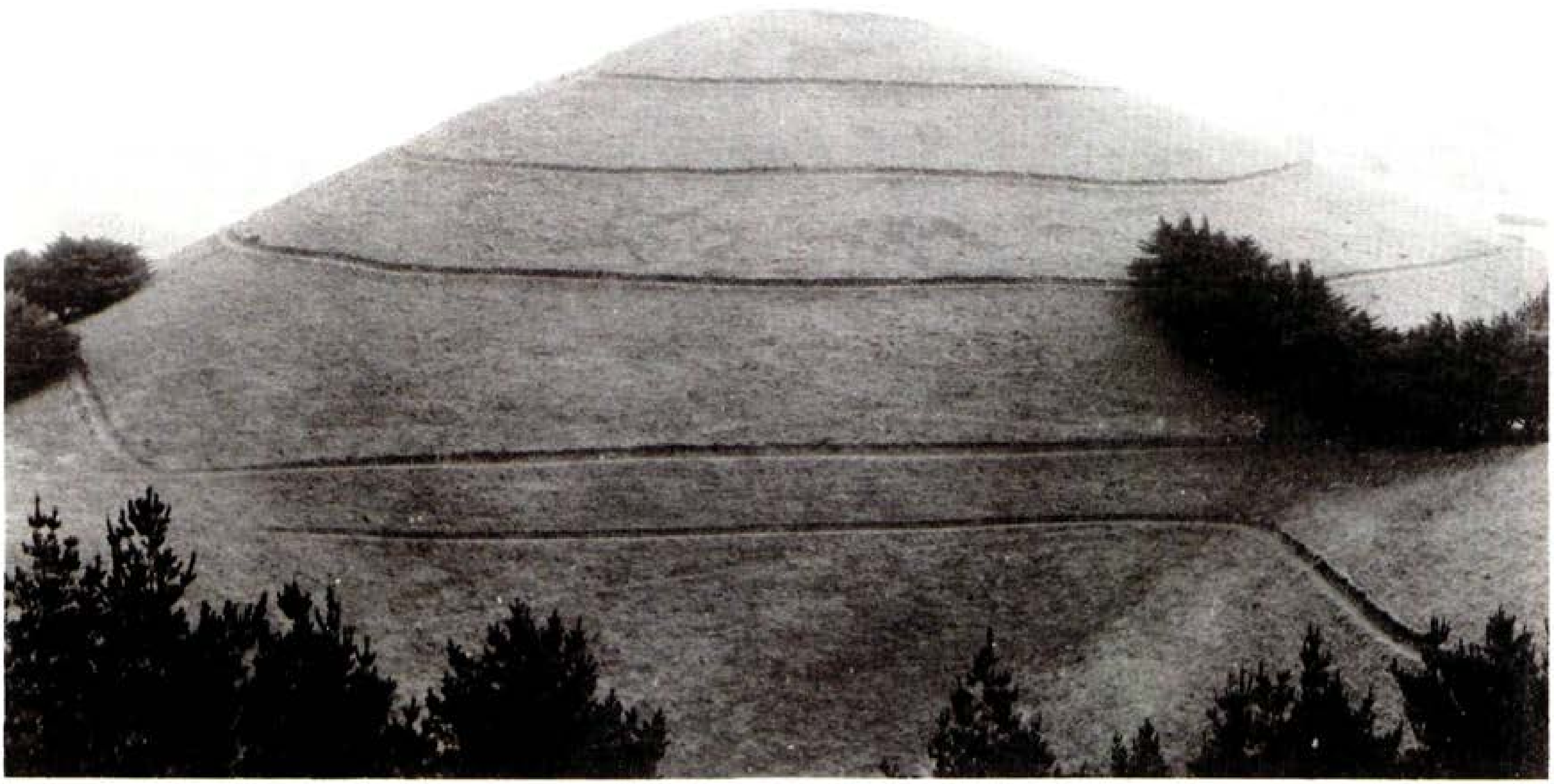
The coastal plains

This upwarped coastal plain consists of flat-lying Cainozoic sediments, and slopes gently to the east, although slopes are steeper towards the Otway Ranges. During the Pliocene this plain was lateritized and then uplifted and dissected. Some areas, particularly around Simpson, contain conspicuous laterite plateau remnants.

Widespread alluvial flats have been formed along the Barwon River upstream of Winchelsea, where tectonic uplift and lava flows east of Winchelsea have modified its original course. In contrast to the mature valley of the Barwon River, Curdies River and its tributaries have incised steep-sided valleys on the plains.



Plains region: Volcanic plains, coastal plains, and stony rises near Camperdown. The lakes are old volcanic craters from which "later" newer volcanics were extruded in the Quaternary. The stony rises are the most recent "later" basalts, originating from a scoria cone (Mt. Porndon) in the east.



Volcanic cone at Mt. Leura. Steep-sided scoria cones in various stages of weathering and erosion are common on the volcanic plains.

The volcanic plains

The largest physiographic unit within the study area is the volcanic plains. These are composed of "newer basalts" and are almost horizontal at an elevation of 150--200 m with only a slight inclination to the south. A large number of volcanic cones, scattered over the plains, rise to heights between 120

Stony Rises near Pomborneit: severely contorted topography, with no defined surface drainage system.

and 180 m above the plains. Although numerous, these cones represent only a small proportion of the total number of points of eruption.

The volcanic plains constitute a surface of physiographic youth characterized by a poorly developed drainage system, as evident from the numerous lakes that have formed.

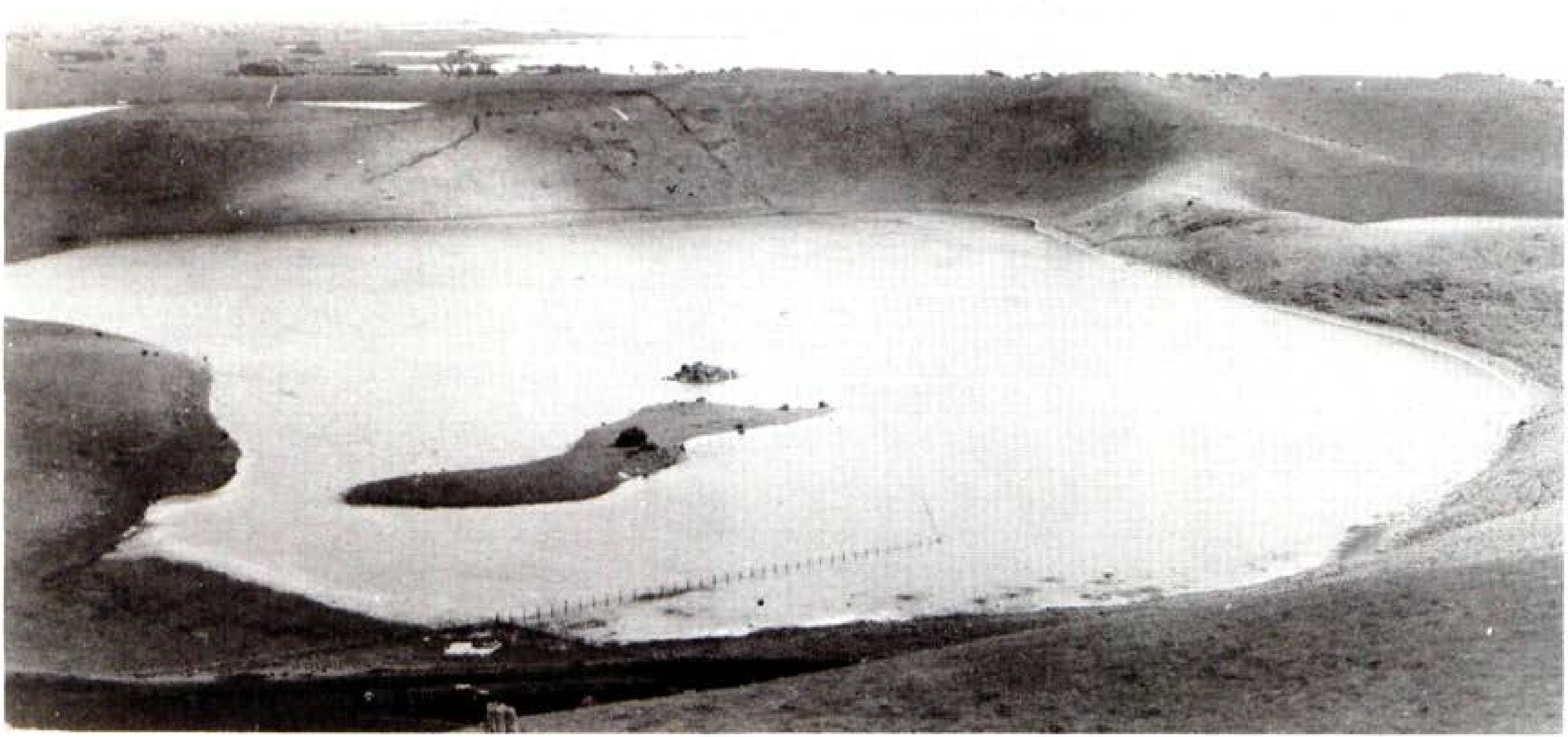
Most of these lakes are brackish or saline. Lake Corangamite is the largest, having a surface area of 230,000 ha.

This lake is surrounded by an extensive sheet of alluvium, indicating that it was much larger at one time.

Two general types of lakes can be distinguished, those occupying depressions in lava flows and those occupying craters and maars in the eruption centres. Lake Corangamite is an example of the former type, while Tower Hill is an example of the latter.

The stony rises

Ridges composed of "later basalts perhaps as young as 6,000 years, are closely associated with scoria cones. These basalts are vesicular, whereas the earlier basalts of the volcanic plains are massive.
Stony rises lie above the general level of the volcanic plains and possess a severely contorted topography of irregular ridges and depressions, with no



Lakes on the volcanic plains may occupy maars (Lake Purdigulluc in the foreground) or depressions in the lava flows (Lake Corangamite in the background).

defined system of surface drainage. This physiographic unit is best developed near Pomborneit, Penshurst, and Mount Eccles.

The coast

Two physiographic sections of the coastline can be recognized. In the section between Lorne and Warrnambool, cliffs are generally being actively eroded; in the section between Warrnambool and the western boundary of the study area, the present coastline is being maintained and in places built up.

On the section of coastline between Warrnambool and Moonlight Head, soft Tertiary sediments are exposed in cliffs that are being actively eroded, as shown by the presence of numerous rock stacks, caves, arches, and tunnels. The harder Cretaceous rocks of the cliffs between Moonlight Head and Lorne resist erosion more effectively.

Between Port Fairy and Warrnambool, recent unconsolidated dunes are being maintained or even extended. This also applies to a small section of the coast near the mouth of the Gellibrand River.

Exposed Tertiary sediments are eroded by the sea along cliffs between Warrnambool and Moonlight Head.

References

Hills, E.S. "The Physiography of Victoria." 4th ed., rev. (Whitcombe and Tombs: Melbourne 1967.)

McAndrew, J., and Marsden, M., (eds.). "Regional Guide to Victorian Geology." 2nd ed. (University of Melbourne: Melbourne 1973.)

Thompson, B.R. "The Geology and Hydrology of the Corangamite Region." (M.Sc. Melbourne 1971.)

Victoria, Central Planning Authority. "Resources Survey Corangamite Region." (Government Printer: Melbourne 1956.)

CLIMATE

Most of the study area has a temperate climate. Summers are warm and dry, and most rain falls in winter. In the south-east, the Otway Ranges exert a marked local effect on rainfall and temperature.

Rainfall

Average annual rainfall is highest on the elevated Otway Ranges, and at Weeaproinah exceeds 1,900 mm. In fact, in wet years more than 2,700 mm per year has been recorded in the Otways. Precipitation is lowest in the north of the study area, falling to 524 mm at Cressy.

In general the bulk of rain falls in April--November, this tendency being more pronounced in the south than the north (see Figure 1).

Temperature

The warmest months of the year are January and February, when average maximum temperatures range from about 20°C on the coast to about 27°C inland. These fall in autumn by about 1--2°C per month along the coast and 3°C per month in the northern parts of the area as well as on the Otway Ranges. In winter, the average maximum temperatures are about 13°C along the coast, but drop as low as 10°C in interior areas and even less on the Otway Range. In August--December, they show a steady rise (see Figure 2).

Extremely hot days can occur in all parts of the area, with record maximum temperatures being above 43°C in all but a few coastal areas and on the Otway Range.

Average minimum temperatures are mainly between 5°C and 7°C in mid-winter along the coast, with an average increase of about 1°C per month. In inland areas and on the Otway Range during mid-winter, they range between 3°C and 4°C, with a monthly increase of between 1°C and 2°C.

Along the coast absolute minimum temperatures under 2°C are rare, whereas at inland localities such temperatures occur 10--15 times in an average year and more frequently than this on the Otway Range. Consequently, frosts are rare on the coast but more common inland, particularly during June and July. Generally, coastal areas have a narrower temperature range than inland localities (see Figure 2).

FIGURE 1

MEAN MONTHLY RAINFALL FOR SELECTED STATIONS

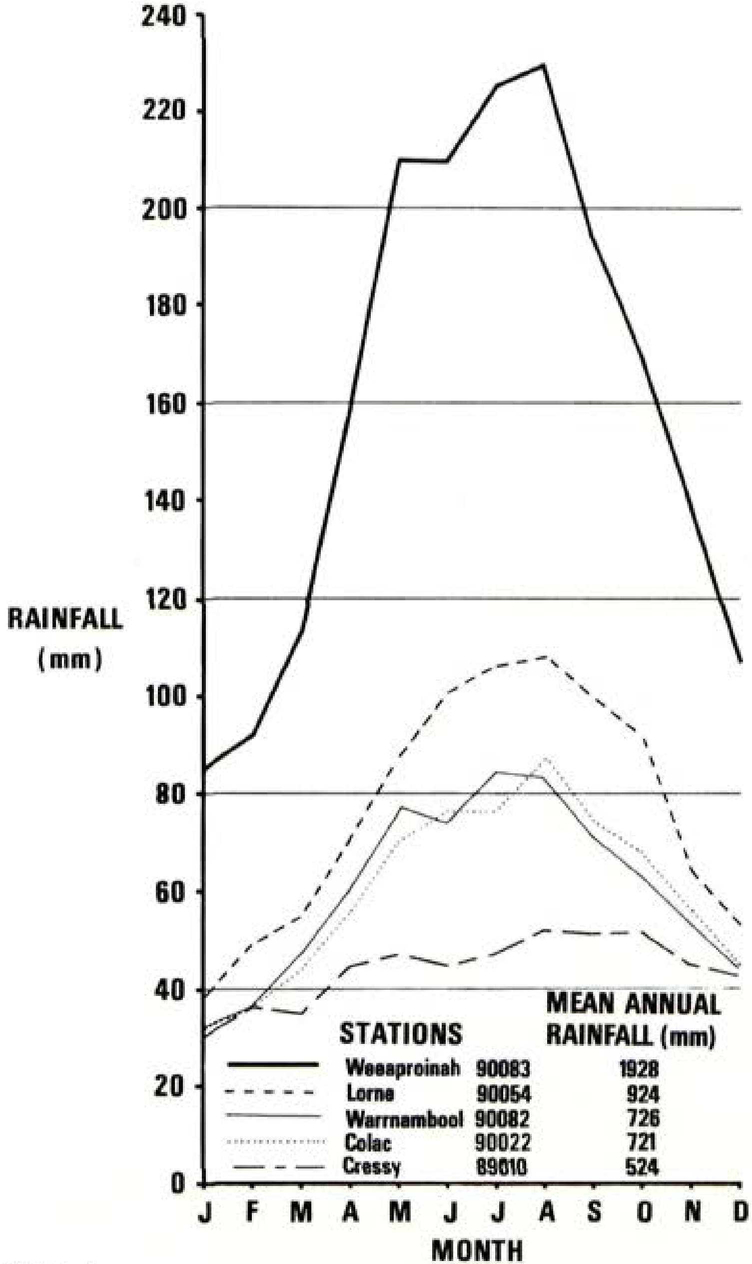
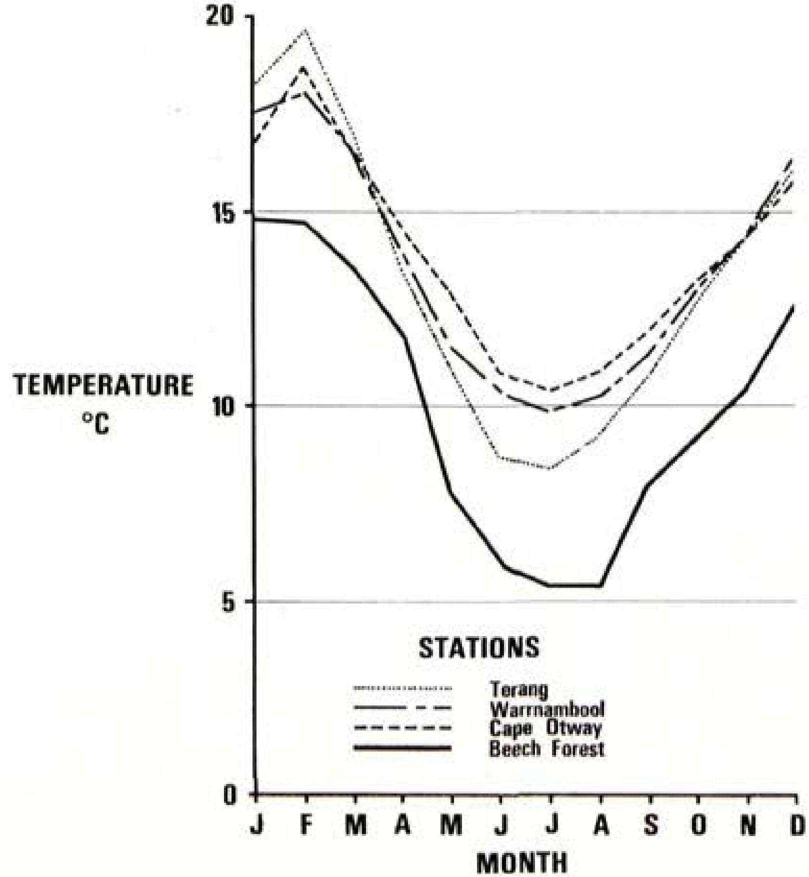


FIGURE 2

MEAN MONTHLY TEMPERATURES FOR SELECTED STATIONS



Evaporation

The average annual evaporation ranges from as low as 750 mm on parts of the Otway Range to as high as 1,150 mm in inland parts of the area. Along the coast it is a little under 1,000 mm.

Average monthly evaporation is as low as 25--30 mm in June and July, but generally exceeds 100 mm between November and March, with monthly totals reaching 125--180 mm in January. Over most of the study area, except for the Otway Range, evaporation normally exceeds rainfall from October to April.

Growing Season

Effective rainfall

Effective rainfall is the amount necessary to initiate and maintain plant growth. The growing season, in terms of effective rainfall, is defined as the number of consecutive months during which the chance of receiving the effective amount equals or exceeds 50%. Effective rainfall is a useful guide to the growth potential of crops and pastures, but probably has less significance for perennials, which can tap reserves of sub-surface moisture.

In terms of effective rainfall, growing season varies considerably over the study area. Colac has a good chance of a growing season from March to November, while in most parts of the Otway Ranges moisture does not normally limit plant growth at any time during the year. This is in contrast to the north of the area, where plant growth is reduced by moisture stress during the months of December, January, and March.

All districts have a better than 70% chance of getting effective rainfall in April, but only the southern half has a better than 50% chance of effective rainfall in March.

Temperature

Plant growth is retarded in a month with an average temperature of less than 10°C and it virtually ceases when the monthly average falls below 5.5°C. In some localities along the coast - for example Cape Otway (see Figure 2) - temperatures are not sufficiently low to retard growth. On parts of the Otway Range - for example Beech Forest - growth is retarded during May to October and actually ceases during June and July. At inland localities, such as Terang, growth is retarded during June, July, and August, but at no time ceases.

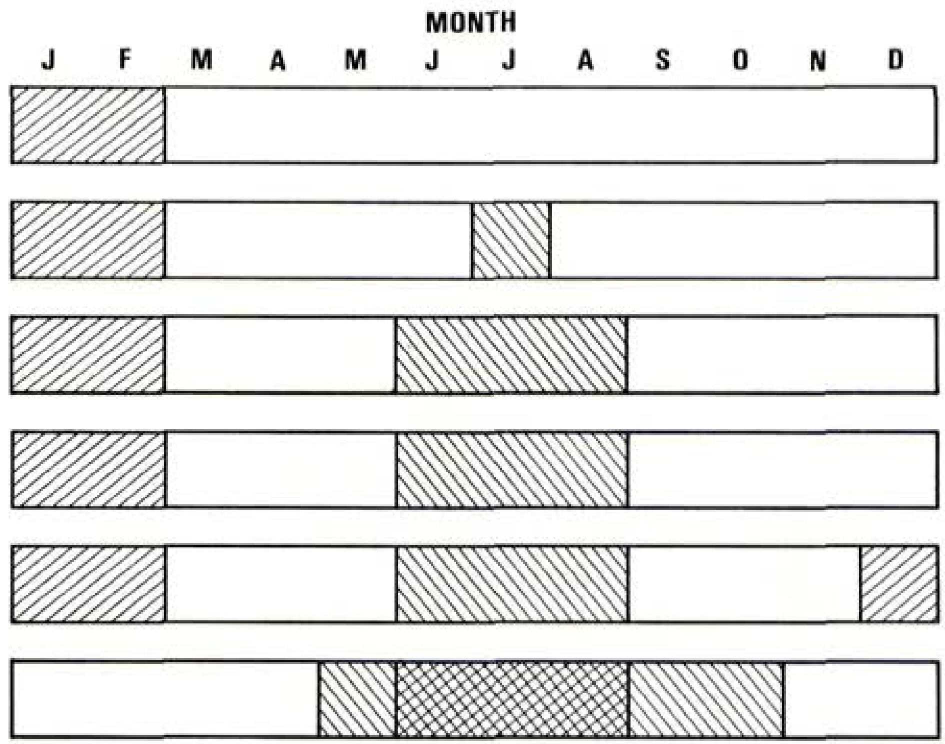
The combined effects of temperature and effective rainfall for certain stations within the study area are shown in Figure 3.

Sunshine

Average annual sunshine ranges from 2,500 hours in the north of the study

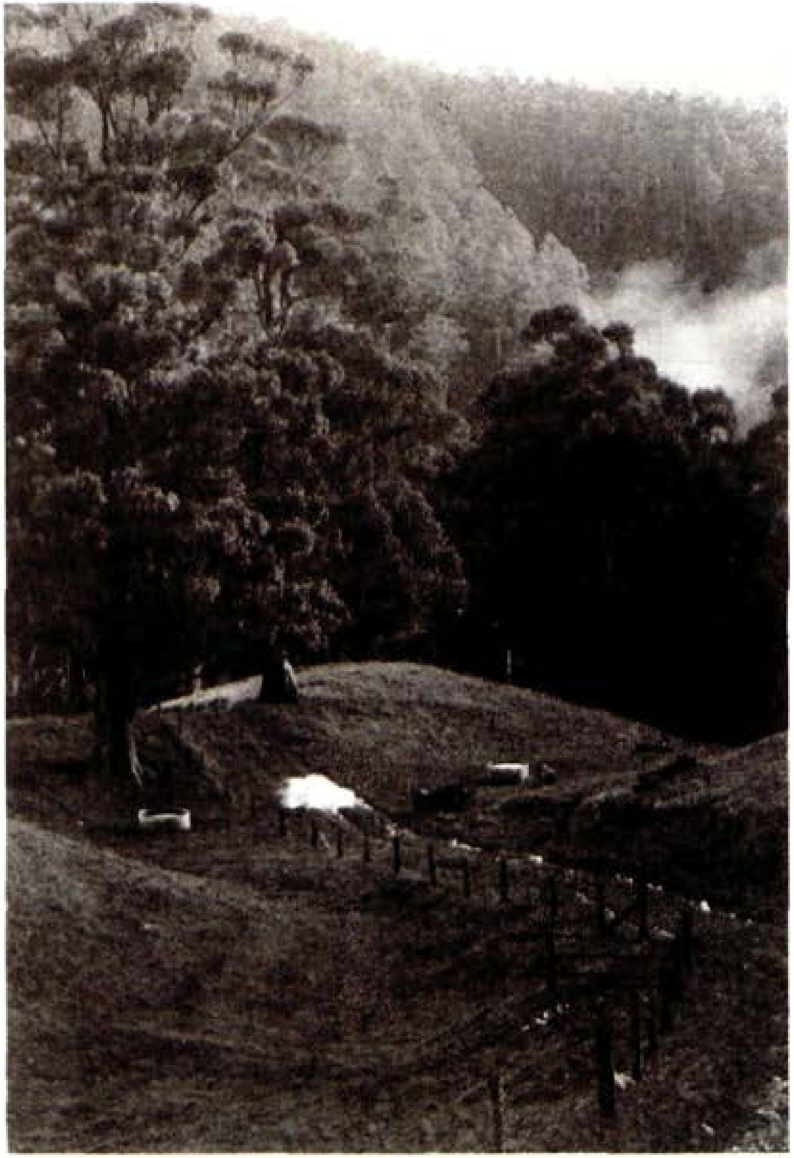
FIG. 3. GROWING SEASON

LOCATION	AV. ANNUAL RAINFALL (mm)	ELEVATION (m)
CAPE OTWAY	879	82
WARRNAMBOOL	726	21
TERANG	786	132
CAMPERDOWN	773	165
COLAC	721	134
BEECH FOREST	1731	518



LEGEND

- Normal growth
- Severely restricted growth due to drought.
- Restricted growth due to temperatures below 10°C
- Severely resricted growth due to temperatures below 5·5°C



Moisture is rarely limiting to plant growth in the Otway Ranges.

area to just under 2,000 hours on the Otways. During January, the month of greatest sunshine, total hours are less than 250 on the Otway Range and along the coast, but almost 300 in the far north. The amount of energy received from the sun at the surface during January ranges from about 550 cals/sq cm/day along the coast to about 620 cals/sq cm/day in the north. During winter, however, figures are considerably less, ranging from 160 cals/sq cm/day to 180 cals/sq cm/day respectively.

While sunshine received during January compares favourably with that in other parts of the continent, the amount received during July is less than half of that normally received over tropical Australia.

Wind

In general, winds in summer blow from the south-west to south-east, with sea breezes having a marked effect on the coastal strip. During winter, winds are basically westerly.

References

Anon. "Rainfall Statistics of Victoria." (Commonwealth Bureau of Meterology: Melbourne 1966.)

Dwyer, L. J. "Climatological Survey of Region 4 - Corangamite Victoria." (Commonwealth Bureau of Meterology: Melbourne 1959.)

Victoria, Central Planning Authority. "Resources Survey of the Corangamite Region." (Government Printer: Melbourne 1956.)

Victoria, Central Planning Authority. "Resources Survey of the Barwon Region." (Government Printer: Melbourne, in press.)

Volum, A. G., and McBeath, N. R. Colac District situation analysis for 1974/75. Victorian Department of Agriculture, Internal Report.

WATER RESOURCES

Localized combinations of climate, physiography and geology, and vegetation strongly influence both surface and groundwater resources. The study area contains considerable quantities of good-quality surface water in the Otway Ranges. Large amounts of saline and brackish surface water form extensive lakes on the basaltic plains. Groundwater is widespread, but quality varies.

Surface Water

Catchments

Lower summer flows are typical for all streams in the study area, although those rising in the Otway Ranges, where up to 50% of the rainfall in the study area occurs, maintain higher flows throughout the year than the remainder.

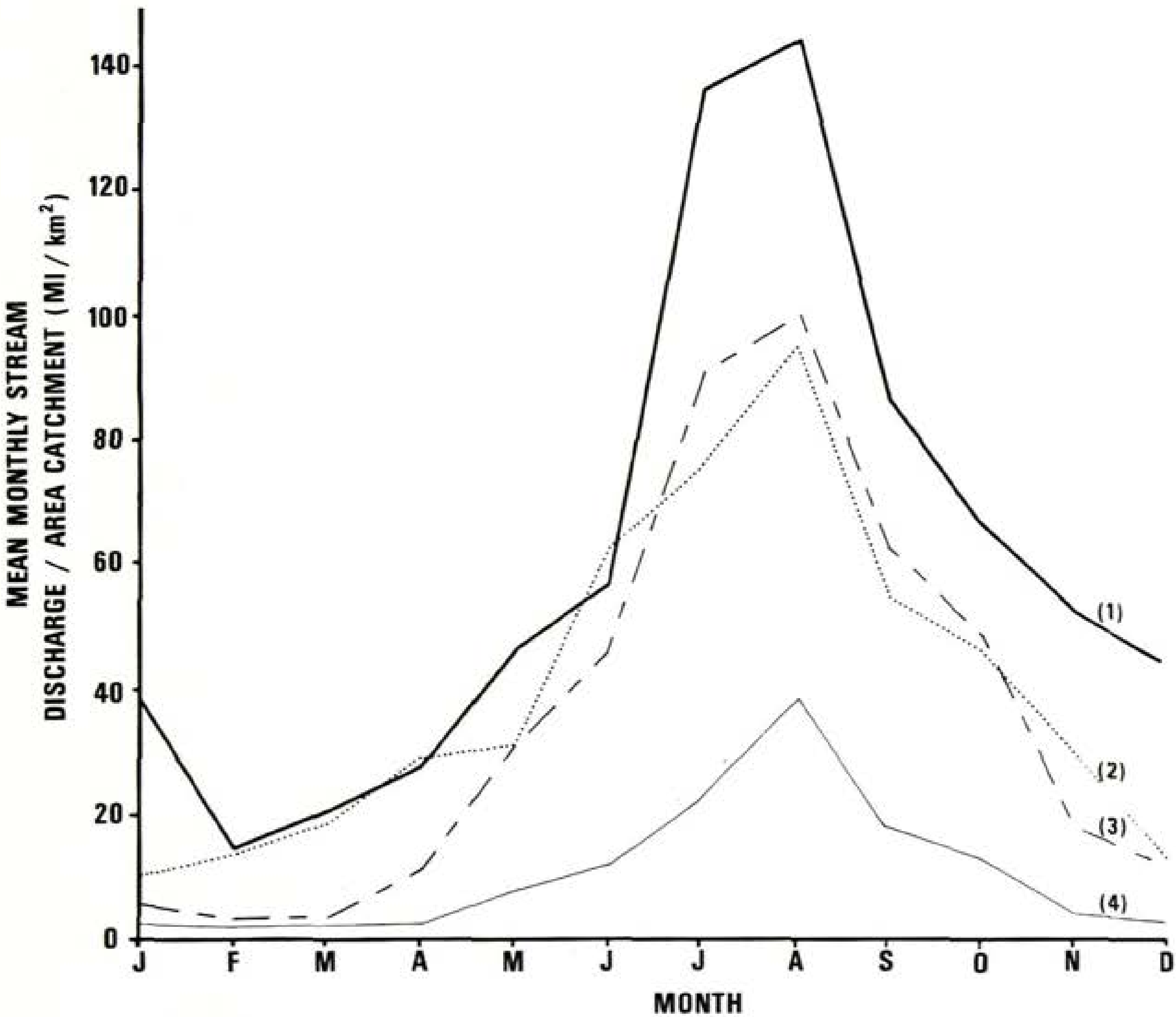
The mean monthly discharge for four small catchments in the study area, shown in Figure 4, illustrates the greater productivity of the Otway catchments.

Flow varies less in streams rising in the Otways than elsewhere in the study area due to the greater reliability of annual rainfall and to the forested nature of the catchments. The magnitude of this variation is illustrated in Appendix III G.

The forests of the Otway Ranges are important in protecting the soil and maintaining its capacity to absorb water. The concentration time of water reaching

Erskine River. Otway Ranges' streams normally maintain a usable flow throughout the year.

FIGURE 4
CATCHMENT PRODUCTIVITY



STREAM CATCHMENT	GAUGE LOCATION	CATCHMENT AREA (km^2)	PERCENTAGE FOREST COVER (Approx.)	MEAN ANNUAL RAINFALL (mm)	MEAN ANNUAL DISCHARGE (Ml / km^2)
(1) Aire River	Beech Forest	25.4	100	1600 – 1800	736
(2) West Barwon River	Forrest	51.8	96	850 – 1500	497
(3) East Barwon River	Forrest (above tunnel)	17.1	98	950 – 1400	436
(4) Cudgee Creek	Cudgee	194	0	780 – 920	129

TABLE 3

MAJOR STREAMS AND TRIBUTARIES

Major stream	Portion in study area	Tributaries
Barwon River	Source to Inverleigh	
Gellibrand River	Whole length	Carlisle River (including Arkins Creek) Lardner's Creek Kennedy's Creek
Curdies River	Whole length	
Hopkins River	From west of Lake Bolac to Warrnambool	Cudgee Creek Mt.Emu Creek (Skipton--Cudgee)
Merri River	Whole length	
Moyne River	Whole length	
Woady Yaloak River	From Narringhal Creek to Cundare Pool	
Aire River	Whole length	

the stream is thus increased and more even flows are maintained throughout the year.

Peak stream flows recorded in the study area are of the order of 33,000 Ml per day on the Barwon River at Winchelsea, the Curdies River at Curdie, and the Hopkins River at Hopkins Falls.

Table 3 sets out the major streams and tributaries in the study area.

Water suitable for domestic use is, in general, available only from those streams with sources in the forested Otway Ranges. The Otway water does have relatively high colour (30--100 units - Platinum Cobalt Scale) and turbidity

(15--30 units - Silica Scale), but bacterial counts in town reticulation systems are generally satisfactory.

The geology and soils of a catchment have an important influence on water quality. For example, erodible sands may cause turbidity if not protected by an adequate vegetation cover.

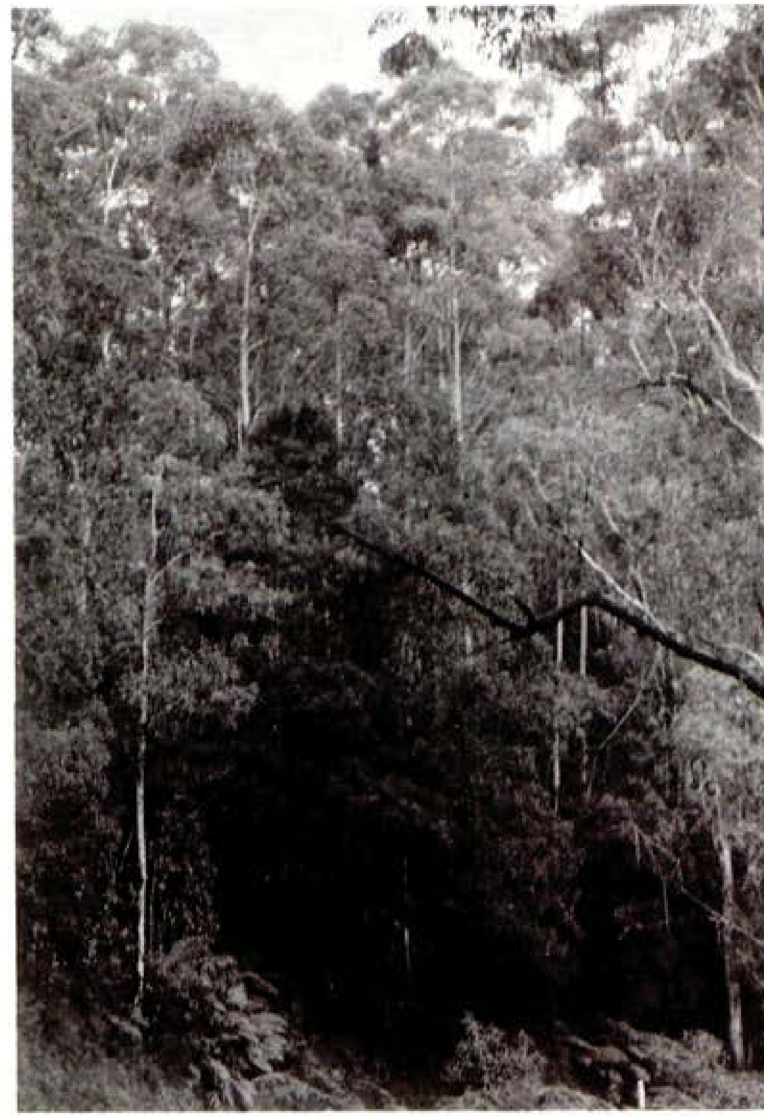
The major catchments capable of supplying domestic water are those of the Gellibrand, Barwon, and Aire Rivers.

Gellibrand River

This very large catchment (± 44,300 ha) contains farmland as well as forests and is the principal source of supply of the Otway Water Supply system, which is currently being expanded with the construction of the South Otway Scheme discussed in Chapter 19, Water Utilization.

Water is presently drawn from the forested sub-catchments of the Arkins Creek, West Gellibrand River, and Olangalah River in the upper reaches. These sub-catchments lie within one of the highest-rainfall regions of the State, with a mean annual rainfall in excess of 1,800 mm. They are closed to public access and produce an even yield of high-quality water.

Water is also drawn from two pumping stations lower down the Gellibrand River. During high flows in winter the water is of poor quality, having excess-



Forested catchments protect water supplies.

Aire River. This catchment has the potential for high-yield water supply.

ive colour and turbidity. Bacterial content rises sufficiently high at times to warrant chlorination for domestic use. This poor quality is probably due to the farmland in the lower catchment and to the considerable numbers of erodible batters and borrow pits formed by road construction works in the area. Treated sewage effluent and partially treated waste from a milk processing plant at Simpson also enter the river system intermittently via Kennedys Creek during wet weather.

The Gellibrand River water is of satisfactory quality during the summer--autumn period and water of acceptable quality can also be obtained at other selected times. Full treatment will eventually be required as the demand increases and the South Otway scheme comes into full operation.

Barwon River

The catchment is predominantly forested in the upper reaches and supplies an even yield of water that does not require treatment for domestic use.

Several farms occupy approximately 4% of the catchment area above the water off-take points.

The upper catchment has two main branches, the East and West Barwon Rivers, and Figure 4 illustrates mean monthly catchment productivity. The only major on-river water storage in the study area is on the West Barwon River near Forrest (see Chapter 19).

Aire River

Being mainly thickly forested, the catchment has the potential for high-yield water supply, as shown in Figure 4.

This water is as yet largely unused, although investigations have shown three sites suitable for water storages in the catchment. The resource thus remains available for development at some future time.

Others

Other streams - such as the Curdies, Hopkins, Merri, and Moyne Rivers and the Mount Emu Creek - are of poorer quality, having a total dissolved solids content of between 1,000 and 4,000 mg per litre.

They are generally suitable for stock use, but require careful management and good drainage conditions if they are to be successfully used for irrigation, especially at the higher salinity levels. Sewage effluent from Terang is discharged after treatment to a small creek that enters Mount Emu Creek.

Lakes

The north-eastern sector of the study area is characterized by the large number of lakes and swamps existing on the volcanic plains. One of these, Lake Corangamite, is the largest in Victoria, having a normal surface area of approximately 23,000 ha. Altogether, the study area contains about 60 lakes, the

Mount Emu Creek during winter. Seasonal flows are very variable.

Curdies River: automatic stream-gauging station.

Table 4

PRINCIPAL LAKES

Lake	Surface area (hectares)	Total dissolved solids (mg/l)
Beeac	607	18,000
Bookaar	435	4,000
Bullen Merri	538	8,600
Colac	2,690	2,950
Colongulac	1,416	12,000
Corangamite	23,000	38,000
Elingamite	324	1,200
Gnarpurt	2,347	25,000
Gnotuk	243	62,700
Linlithgow	992	7,000
Murdeduke	1,255	20,000
Purrumbete	587	1,000
Weeranganuck	518	7,650

principal ones being listed in Table 4.

While the surface run-off and rainfall contribute the major proportion of inflows to many of these lakes, underground seepage and springs supplement inflows and in many cases govern water levels in craters.

Salt accumulates in the majority of the lakes, as they have no natural outlet. Many are highly saline, especially at times of low level, and are unsuitable for consumption by humans or stock. However, they have considerable potential for water-based recreation.

Two sewerage authorities discharge sewage effluent to lakes. The Colac Sewerage Authority discharges to Lake Colac following chlorination and Camperdown Sewerage Authority's effluent is discharged to Lake Colongulac following treatment. In addition, certain industries, for example milk-processing plants and abattoirs discharge trade wastes to these lakes.

In both cases, the quality of the effluent discharged is often not satisfactory. However, all discharges to inland waters are being licensed by the State Rivers and Water Supply Commission Water Pollution Control Section. The quality of the effluents to be discharged will be required to conform to acceptable standards, and the affected authorities and industries are putting works in hand to meet these requirements.

Groundwater

Yields and salinity of groundwater vary considerably throughout the study area, most of the differences being related to geological formations. Thus, while the Wangerrip Group of sediments in general contains large reserves of groundwater, such reserves are generally absent from the Otway Group. The groundwater characteristics of the major geological units - described in Chapter 5 (Geology) and shown on the geology map - are discussed below.

Otway Group (Lower Cretaceous)

This group of sediments is relatively impermeable and in general contains poor reserves of groundwater. However, aquifers containing salt water do occur in the basal sandstone known as the Pretty Hill sandstone, although generally at a depth greater than 1,500 metres below the surface.

Sherbrook Group (Upper Cretaceous)

Commonly this group contains saline water. Its upper formation (the Curdies Formation) is highly permeable and holds fresh to brackish water, but these reserves are seldom tapped, as they usually underlie more recent sands containing good reserves of groundwater.

Wangerrip Group (Palaeocene and Eocene)

The Wangerrip Group includes porous and permeable sands with outcrops, and serves as an intake area along the northern flanks of the Otway Ranges. These sands thicken in the north-east direction along the outcrop under the Gellibrand marl and extend northward under Lakes Colac and Corangamite, grading into deep leads.

Water quality of this group is generally good, ranging from 250 to 350 mg of total dissolved solids per l near the Otway Ranges. However, the level rises to 650 mg per l towards Birregurra and 1,200 mg per l at Cressy.

Heytesbury Group (Oligocene to Miocene)

Fair-quality water can be obtained from the Port Campbell limestone of the coastal plains. This water, however, may be "hard" due to dissolved calcium salts.

Groundwater obtained from other formations of this group is poor and may contain more than 1,200 mg total dissolved solids per l. Thus the quality of water in Gellibrand marl and the Clifton formation (which underlies the basalt and Moorabool Viaduct formation in the northern part of the study area) is generally poor.

Moorabool Viaduct formation (Pliocene to Recent)

Lava flows of the "later" basalts of the stony rises often contain highly permeable zones of interbedded tuffs or pockets of vesicularity. The latter often occur near the top or bottom of a flow, and are caused by the release of gas or vapour from the cooling lava.

Drilling on the stony rises around Mount Warrion has shown that salinity of the water in these basalts increases rapidly down-dip from less than 500 to nearly 10 000 mg per l. In addition to salinity, Thompson (1971) has shown an increase in nitrate content of groundwater of the McVeans Springs on the edge of the rises (see Table 5). He concludes contamination has caused this.

The salinity of Lake Corangamite partly reflects the chloride content of the groundwater flowing through the "later" basalts, but is also due to a general excess of evaporation over precipitation.

The "later" basalts of the stony rises do not have a surface drainage system, and thus act as an efficient intake area. In addition, scoria cones and some tuffs beds have high porosity and also act as intake areas. Consequently a number of perennial springs emanate from the edges of these flows - at Mount Shadwell, Mount Elephant, and Mount Porndon.

The phase I basalts that cover most of the volcanic plains yield very small quantities of brackish water (3,000--

Testing for groundwater, Port Fairy.

Table 5

DISSOLVED SOLIDS IN GROUNDWATER

Year	Total dissolved solids mg/l	Chloride mg/l	Nitrate mg/l
1906	204	59	0.58
1909	159	33	0.70
1924	213	47.5	1.90
1934	272	51	2.50
1969	240	40	37.00

8,000 mg of total solids per l). So, on most of these plains, underground water can only be obtained by drilling through the basalt into the water-bearing Wangerrip Group, which can yield large amounts - in excess of 20 l per sec.

Sand dunes (Quaternary)

The sand dunes along the coast between Peterborough and Port Fairy are a source of good-quality groundwater, as are the dunes (lunettes) near the eastern shore of the lakes. Both contain limited supplies suitable for stock-watering purposes.

References

Bibra, E.E., and Riggs, H.C.W. "Victorian River Gaugings to 1969." (State Rivers and Water Supply Commission: Melbourne 1971.)

Blake, W.J.R. Notes on the geology of the Barwon Downs area. *Mines Department of Victoria, Internal Report*, 1974/29.

Newton, H. "The Corangamite Region. Vol. II - The Underground Water Resources of Victoria." (State Rivers and Water Supply Commission: Melbourne 1954.)

Thompson, B.R. "Geology and Hydrogeology of the Corangamite Region." (M.Sc. Thesis, Melbourne University: Melbourne 1971.)

Victorian Central Planning Authority. "Resources Survey Corangamite Region." (Government Printer: Melbourne 1956.)

SOILS

Interactions between climate, parent materials, topography, and organisms determine the chemical and physical properties of soils. The length of time for which these factors have been acting on the soil is also important.

In some environments one or two factors are obviously dominant. However, soils usually result from quite complex interactions between the features of the environment.

Classification

Most classifications of soil are intrinsic - that is, the features on which the classification is based are selected for their affinity to other soil features and not for their relevance to a particular form of land use. Fortunately the characteristics commonly chosen do happen to be either relevant to a number of forms of land use or corelated with characteristics that are. The classification is therefore useful in assessing the suitability of land for alternative uses.

The classification used in this report is based on that of Northcote (1960). This groups soils into four classes on the basis of texture pattern in the profile as well as the amount of organic matter present. (See Table 6.)

Organic soils contain more than 25% organic matter. Those containing less than this are grouped into three classes on the basis of the texture pattern in the profile: uniform, gradational, and duplex.

Gradational soils become more clayey with depth without any sharp change, but in duplex soils the texture changes suddenly to clay. Additional features such as colour, consistence, structure, and the presence and nature of impeding horizons are also considered.

Land use

In order to determine the suitability of soils for various uses, chemical and physical properties have to be considered, together with climate and topography.

Chemical analyses exist for most soil groupings, but in a few cases chemical properties have been inferred from those of soils developed on similar parent materials in similar climatic regimes outside the study area. Limited physical properties from similar soils outside the study area.

Descriptions

Peats

Although not widespread in the study area, peats do occur in small swamps on the coastal plain in areas with an

Table 6

SOIL GROUPINGS

Principal profile form	Descriptive name	Synonyms
	Peats	Peats
Uniform	Calcareous sands Leached sands Shallow stony soils Red to black soils on limestone Dark clays on basalt Friable soils on volcanic ash Dark saline soils	Regosol Nomopodsol; iron leptopodsol Chocolate soil; brown earth Terra rossa; rendzina Prairie soil; chernozem Red and brown earths Saline soils
Gradational	Friable brown gradational soils Yellowish gradational soils on Mesozoic sediments Reddish and yellowish gradational soils on Cainozoic sediments	Acid brown earth; cryptopodsol Clay leptopodsol
Duplex	Duplex soils	Solodic soils

Cape Otway: calcareous sand dunes covered by Marram grass.

annual rainfall greater than 850 mm. They consist of variably decomposed plant remains and are dark and greasy when wet and friable when dry. In this area, they are extremely acid (with a pH generally below 5) and contain high levels of organic carbon.

Calcareous sands

These calcareous sands occur along the coast, particularly between Port Fairy and Warrnambool and at Cape Otway. They are composed of unconsolidated finely broken shell fragments, and are yellowish brown, friable, and structureless. Nutrient content is low and they are extremely alkaline - the pH may be as high as 9.5, at least at depth.

Marram grass, which can tolerate the extremely dry and alkaline conditions, has been planted on these dunes in a bid to prevent wind erosion.

Leached sands

Widespread in both Tertiary and Quaternary sediments, these soils consist of siliceous sand, with a dark brown accumulation of organic matter at the surface over a grey-white bleached horizon. Profiles are friable and structureless throughout, infertile, and acid.

Applications of phosphorus, potassium, lime, and sometimes copper and molybdenum are necessary before satisfactory pastures can be established.

The most impoverished leached sands in the study area are those that have developed on Palaeocene deposits. Their profiles are white throughout and often contain a layer of coffee rock that impedes drainage, resulting in waterlogging.

Less-impoverished leached sands occur on more recent geological deposits. These soils often have a yellow or orange B horizon, and an impeding layer of coffee rock is uncommon.

Moisture-storage capacity of these soils is low and this property, combined with their inherently low nutrient status, results in a low potential for agricultural development. Annual rainfall on leached sands in the study area varies from 600 mm to about 1,200 mm.

Shallow stony soils

These soils, developed on younger basalt flows, have shallow profiles and basalt boulders are common. They are reddish brown or sometimes black. Texture varies from loam to clay and there is little change with depth. Shallow stony

Cape Otway: manna gum woodland on leached orange sand.

Carlisle Hill: leached sands on Palaeocene deposits, susceptible to erosion.

Shallow stony soils occur on the younger basalt flows.

soils are fertile, generally containing exceptionally high levels of available phosphorus; however, the presence of basalt boulders prevents their cultivation.

Red--black soils on limestone

Red to black soils on limestone have developed on Miocene and Recent dune limestone, particularly along the coast west from Port Campbell. However, they are not widespread in the study area. Profiles are seldom deeper than one metre and are generally uniform but occasionally gradational. Texture varies from sandy loam to sandy clay. Fertility varies with texture, the heavy-textured soils being relatively fertile and the light-textured soils being deficient in many nutrients. Because the profiles are shallow, moisture-storage capacity is low.

Dark clays on basalt

Colour varies from grey to black. Grey clays are developed on basalt north of a line through Camperdown and Colac and are uncommon further south. These soils often underlie a very thin veneer of lighter-textured material and, if the depth of this exceeds 10 cm, profiles are classified as duplex. Black clays on the other hand, are developed in alluvium derived from basalt throughout the study area.

Profiles of dark clays on basalt are coarse-structured and develop marked cracks. Subsoils are alkaline and contain abundant calcium carbonate concretions. Fertility is moderate to high, apart from phosphorus, but moisture availability is low.

Friable soils on volcanic ash

Soils derived from tuff and scoria have settled in the immediate vicinity of eruptive centres. Profiles are generally uniform, but in some cases may be gradational. Friable soils on volcanic ash are brown or reddish brown, well structured, and fertile. The volcanic parent material occurs at a shallow depth. Their most significance occurrence is at Tower Hill, near Koroit, where they are used extensively for onion- and potato-growing.

Dark saline soils

Dark saline soils occur around the edges of some lakes in the area, particularly Lake Corangamite. They are subject to periodic inundation by saline water and consequently contain salt levels that are toxic to most plants. In general, profiles are uniform and heavy-textured, but in some cases may be gradational.

Friable brown gradational soils

These have developed on the Mesozoic sediments of the Otway Ranges in wet gullies or in situations where annual rainfall exceeds 1,200 mm. The upper 20--30 cm of dark organic loams overlie brown, yellowish brown, or reddish brown horizons of slightly heavier texture, extending to depths of up to 2 m.

Profiles are friable and porous and water-holding capacities are high - both features are important in water conservation. Although slightly more fertile than similar soils developed on other parent materials, those on Mesozoic sediments lack various plant nutrients.

Friable brown gradational soils develop on Mesozoic sediments where the annual rainfall exceeds 1,200 mm.

Yellowish gradational soils on Mesozoic sediments

These occur on the Otway Ranges where the annual rainfall is between 900 and 1,200 mm. In general they are characterized by a clay loam A horizon, grading into clay at depth. They are moderately fertile, but are subject to land slips when steep slopes are cleared.

Reddish and yellowish gradational soils on Cainozoic sediments

Such soils developed where annual rainfall exceeds 900 mm. On lateritic plateaux remnants, they are usually reddish with a light-textured B horizon. On Cainozoic sediments that have not been lateritized, they tend to be yellowish rather than red.

Fertility is not as high as that of similar profiles on Mesozoic sediments, and addition of fertilizers (including trace elements) is often a necessary prerequisite for agricultural production.

Duplex soils

Duplex soils are characterized by a light-textured topsoil, which abruptly overlies a clay subsoil of variable colour and structure. Often a shallow bleached horizon lies above the clay. While the A horizon is acid, the B horizon is generally alkaline and the exchange complex characteristically contains high levels of sodium and magnesium.

Within the study area duplex soils vary with changes in parent materials. When developed on basalt the B horizon is often grey, whereas if developed on sedimentary deposits profiles tend to be yellowish or brown, or reddish if formed on lateritized material. These soils are particularly susceptible to deterioration, and gullies and tunnels occur, particularly where they are developed on Tertiary sediments.

References

Gibbons, F.R., and Downes, R.G. "A Study of the Land in South-western Victoria." (Victoria, Soil Conservation Authority: Melbourne 1964.)

Northcote, H. "A Factual Key for the Recognition of Australian Soils." (C.S.I.R.O.--Rellim Technical Publications: Adelaide 1971.)

Victorian Central Planning Authority. "Resources Survey, Corangamite Region." (Government Printer: Melbourne 1956.)

VEGETATION

The structure and floristics of the natural vegetation vary considerably over the study area, reflecting the wide variation of site factors within this area. Tall wet forests grow on the Otway Ranges, while the sands flanking these Ranges, where rainfall and soil fertility are lower, carry shorter drier forests, heaths, and woodlands. These vegetation types contrast with the remnants of natural grassland on the basaltic plains and the low coastal scrub and grassland of the calcareous dunes fringing parts of the coastline.

Importance of vegetation

The composition and structure of natural vegetation are important in planning the use of the land. They integrate and quite sensitively reflect the subtle changes in environmental factors. Because of this - and because it can be readily seen and mapped in the field or from aerial photos - vegetation affords a very convenient method of assessing site factors that by themselves would be hard to measure directly. Morover, 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 constitutes a major part of what we regard as scenery, naturalness, or wilderness.

Classification

Structure

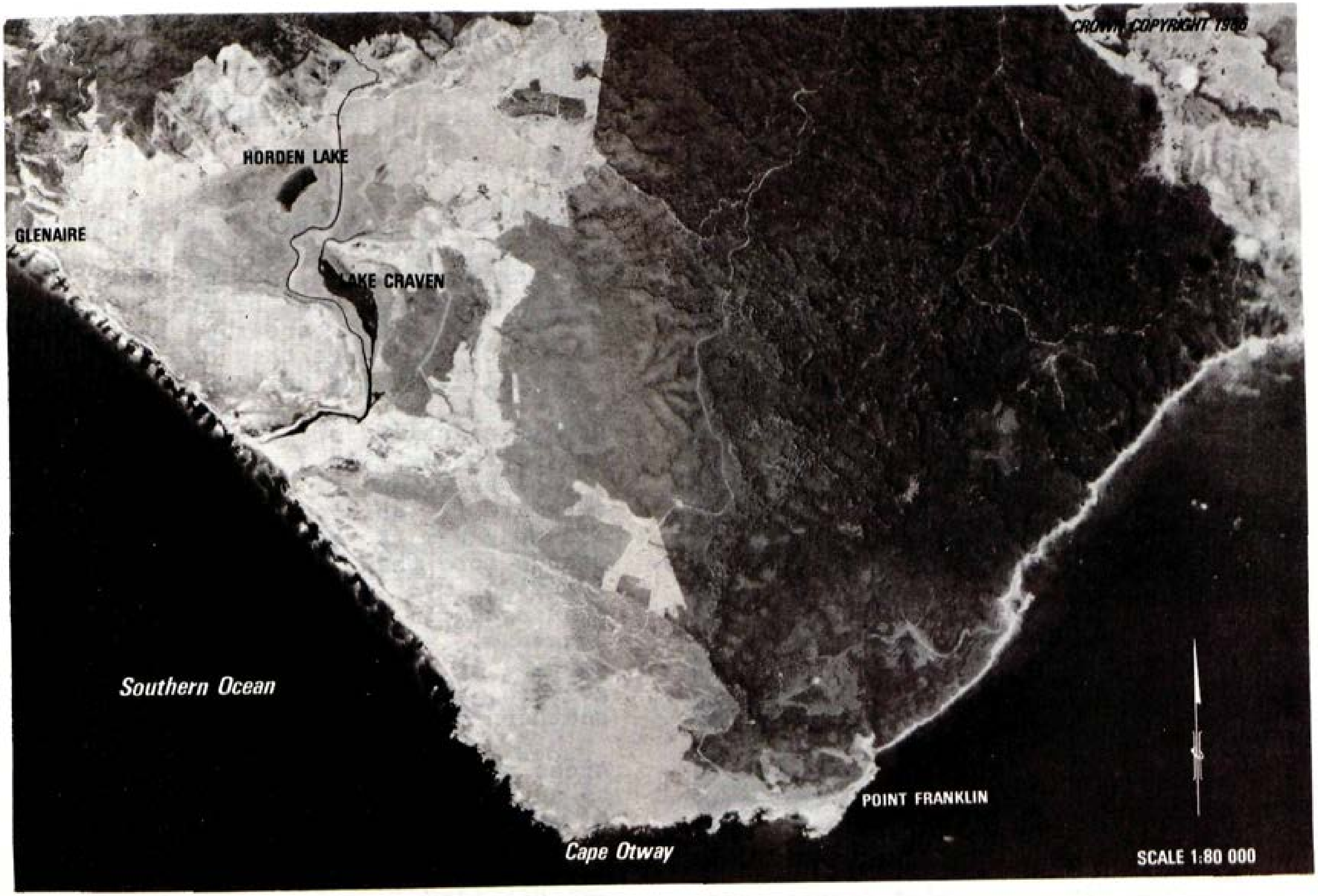
The vegetation has been classified into a number of structural forms, based on the height and form of the tallest stratum and the percentage of projective foliage cover. These are presented in Table 7, and the vegetation map shows their distribution on public land. The classification is based on that developed by Specht, but has been modified to better suit the vegetation of the study area and the data already available. In cases where these variables are not constant over areas large enough to be conveniently mapped at a scale of 1:250,000 some vegetation units have been combined.

Floristics

Within the structural framework, the vegetation has been grouped according to

TABLE 7 : VEGETATION CLASSIFICATION

STRUCTURAL FORM	MAJOR SPECIES OF THE TALLEST STRATUM	ASSOCIATED TREE SPECIES	FORM AND COMMON SPECIES OF THE LOWER STRATA
OPEN FOREST IV	Mountain ash	Messmate	Dense shrubs, tree ferns and small trees: musk daisy-bush, blanket-leaf, silver wattle, satinwood, hazel pomaderris, blackwood, forest wire grass.
	Messmate	Mountain ash	
	Eurabbie	Mountain ash, mess-mate	
	Closed forest in wet gullies	Myrtle beech, satin wood, blackwood	Ferns and mosses
UNSTOCKED	Scrub and closed forest resulting from fires and clearing	Black, varnish wattle, satinwood	
REGROWTH	As for mature stands		
OPEN FOREST III	Messmate	Mountain grey gum	Varies with micro-environment and fire history; generally dense
	Eurabbie	Messmate, mountain grey gum	Tall shrubs, narrow-leaf wattle, blackwood, hop goodenia, dusty daisy-bush, bootlace bush, forest wire grass
	Swamp gum	Messmate, mountain grey gum	
	Brown stringybark	Messmate, manna gum	Dense tall shrubs: hop wattle, narrow-leaf wattle, large-leaf bush pea; hop goodenia, tree everlasting, snowy daisy-bush
OPEN FOREST II	Messmate	Eurabbie, mountain grey gum	Varies with fire history; generally moderately low shrubs; narrow-leaf wattle, prickly mosses, varnish wattle, hop goodenia, large-leaf bush-pea, tree everlasting, snowy daish-bush
	Eurabbie	Messmate, mountain grey gum	
	Brown stringybark	Messmate, narrow-leaf peppermint	Generally low shrubs: silver banksia, prickly mosses, prickly tea-tree, thatch saw-sedge, furze hakea, common heath, common correa
	Messmate	Narrow-leaf peppermint	
	Narrow-leaf peppermint	Messmate, brown stringybark	
	Manna gum	Blackwood	Musk daisy bush, boobialla tree, tree violet; understorey of dense austral bracken obscuring small shrubs and grasses
OPEN FOREST I	Eurabbie	Red ironbark	Varies with fire history; generally dense shrubs; varnish wattle, large-leaf bush-pea, hop goodenia
	Messmate	Brown stringybark	Dense low shrubs; silver banksia, common heath, austral grass-tree, furze hakea, thatch saw-sedge, swamp sheoak.
	Manna gum		Understorey of dense austral bracken obscuring small shrubs and grasses
(Heath or scrub understorey)	Shining peppermint	Brown stringybark	Heath understorey, prickly geebung, swamp sheoak, parrot peas, silver banksia, austral grass-tree, thatch saw-sedge, swamp sheoak, furze hakea.
	Brown stringybark	Shining peppermint	
	Messmate	Brown stringybark	
WOODLAND	Bog gum	Messmate, brown stringybark	Dense scrub understorey: prickly tea-tree, red-fruit saw-sedge, coast beard heath, common heath, snowy bossiaea
(Grassy or open understorey)	Manna gum		Understorey of dense austral bracken obscuring small shrubs and grasses; bursaria
	River red gum		Kangaroo grass, wallaby grass, spear grass, pussy tails
COASTAL scrub	Coast tea-tree, shallow wattle, coast beard heath		Coast everlasting, common boobialla, white correa, sea box, coast twin-leaf, climbing lignum
COMPLEX grassland	Hairy spinifex, coast fescue, marram grass		New Zealand spinach, coast swainson pea, variable groundsel, knobby club rush, sandhill saw-sedge
GRASSLAND	Kangaroo grass, spear grass, wallaby grass, blackwood, tree violet, kangaroo apple		Blue herons bill, pussy-tails, featherheads, blushing bindweed, common everlasting.
PLANTATION Softwood	Mainly radiata pine		
PLANTATION Hardwood	Golden wattle, sugar gum		
CLEARED LAND	Pasture, cultivated, abandoned farmland, recreation grounds, public utilities		



Cape Otway: land clearing and topography are two influences on vegetation pattern.

Open forest IV: a complex forest type with several strata.

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, but are readily recognizable in the field and each unit reflects the operation of a certain set of environmental factors.

Open forest IV

Open forests with heights exceeding 40 m are confined to the Otway Ranges. On the northern slopes they are restricted to areas where annual rainfall is greater than 1,500 mm whereas on the southern slopes of the range they occur where rainfall is as low as 1,200 mm.

Mountain ash (*Eucalyptus regnans*) dominates the wettest sites, but blue gum (*E. globulus* and *E. st-johnii*) and messmate (*E. obliqua*) mixed with mountain grey gum (*E. cypellocarpa*) also form stands more than 40 m in height. Closed forest of myrtle beech (*Nothofagus cunninghamii*), satinwood (*Phebalium squameum*), and blackwood (*Acacia melanoxylon*) is widespread in the moister gullies, particularly those with a southern aspect.

Areas of abandoned farmland, which prior to settlement supported open forest IV of these species, now carry dense scrub of blackwood varnish wattle (*Acacia verniciflua*), satinwood, and austral bracken (*Pteridium esculentum*). The understoreys of these forests consist of several strata of mesophytic plants, including blackwood, blanket-leaf (*Bedfordia salicina*), musk daisy-bush (*Olearia argophylla*), and various ferns and mosses. Under these strata, a deep layer of litter lies above deep friable brown gradational soils.

Open forest III

Open forests with a top height between 28 and 40 m are generally confined to the Mesozoic sediments of the Otway Ranges where rainfall is between 900 mm and 2,000 mm per year. However, they do occur to a limited extent on clayey soils developed in gullies or on Tertiary sediments in areas where annual rainfall exceeds 900 mm. In general they consist of several eucalypt species in mixture and are thus termed mixed-species forests.

For the study area, four broad groupings of these have been recognized. Messmate open forest III is most widespread on the northern flanks of the range, but is replaced by blue gum forests on the southern flanks. Swamp gum (*E. ovata*) open forest III occurs quite extensively on the main Otway ridge between Benwerrin and Mount Sabine, while brown stringybark (*E. baxteri*) is confined to soils developed on Tertiary sediments.

The understorey of these forests varies with fire history, but generally consists of dense tall shrubs such as narrow-leaf wattle (*Acacia mucronata*),

Open forest III: the understorey is less dense than in open forest IV.

Open forest II of messmate and brown stringybark.

blackwood, and bootlace bush (*Pimelea axiflora*).

Open forest II

Open forests with heights between 15 and 28 m are found where the annual rainfall is between 700 mm and 900 mm. Although the species composition resembles that of open forest III, the trees are not as tall and have poorer form.

The structure and composition of the understorey are influenced by type of soil and to some extent by fire history. On the relatively fertile soils developed on the Mesozoic sediments of the Otway Range, the nature of the understorey is influenced by fire history, for if an area has been burnt frequently shrubs are scattered and the understorey is grassy. On the other hand infrequent burning produces a dense understorey of shrubs such as narrow-leaf wattle and large-leaf bush-pea (*Pultenaea daphnoides*).

Open forest II growing on leached sands or duplex soils derived from more recent sedimentary deposits has a xerophytic understorey of shrubs such as silver banksia (*Banksia marginata*), furze hakea (*Hakea ulicina*), and austral grass-tree (*Xanthorrhoea australis*).

Pure stands of manna gum (*E. viminalis*) open forest II are confined to the shallow stony soils developed on Recent basalt flows of the Stony Rises. In this case the understorey consists largely of austral bracken with scattered shrubs such as dogwood (*Cassinia aculeata*), tree violet (*Hymenanthera dentata*), and musk daisy-bush.

Open forest I

Open forest with a top height of less than 15 m occurs on sites where soil moisture availability is low. It thus occurs on sandy soils with a low water-holding capacity, and is generally developed on Tertiary and Quaternary sediments where annual rainfall is less than 700 mm.

A mixture of messmate and brown stringybark - the most widespread type of open forest I in the study area - grades into woodland of these species on poorer sites. On the other hand open forest I of manna gum is restricted to leached sands, and grows on soils developed on Quaternary sands on the Caoe Otway peninsula.

The understoreys of each of these groups differ considerably one from another. In the case of messmate and brown stringybark the understorey comprises heathy species such as common heath (*Epacris impressa*) and austral grass-tree, while under manna gum it consists predominantly of austral bracken. In the case of blue gum it varies with fire shrubs, particularly varnish wattle and large-leaf bush-pea.

Messmate--brown stringybark woodland with heath understorey, Corriemungle.

Woodland with heath or scrub understorey

Vegetation of this type has a top height of less than 15 m and trees are scattered so that projective foliage cover is less than 30%. Woodlands of this group are generally confined to impoverished soils, often with an impeding horizon that leads to waterlogging in winter and drought in summer. Usually only one or two types of eucalypt are present, while the understorey is often particularly rich in species. Various heaths and leguminous, proteaceous, and myrtaceous plants are common.

Woodlands of shining peppermint, (*Eucalyptus nitida*) and brown stringybark

Shining peppermint--manna gum woodland with heath understorey, Bald Hills.

with a heathy understorey are especially widespread on impoverished leached sands derived from Palaeocene deposits on the northern flanks of the Otway Range between Gellibrand and Chapple Vale and on the Bald Hills near Anglesea.

On the other hand, woodland of messmate and bog gum (*E. kitsoniana*) is most widespread on the Cape Otway peninsula. This has an understorey up to 3 m high, consisting of species such as prickly tea-tree (*Leptospermum juniperinum*), showy bossiaea (*Bossiaea cinerea*), and red-fruit sawsedge (*Gahnia sieberana*).

Woodland with grassy or open understorey

Almost all of this type of vegetation within the study area has been developed for agriculture and only remnants have been left. Even where the trees themselves remain, the grassy cover has usually been completely changed by the addition of fertilizers, the grazing of domestic animals, and invasion by exotic plants.

River red gum (*E. camaldulensis*) is confined to dark clay or duplex soils derived from basalt or alluvium, while drooping sheoak (*Casuarina stricta*) is generally confined to duplex soils de-

Heathland, Jamieson Creek.

Coastal complex: primary dunes carry a grassland of marram grass.

rived from Tertiary sediments where the annual rainfall is less than 800 mm.

Coastal complex

This vegetation type occurs on siliceous and calcareous sands along the coastline, particularly between Warrnambool and Port Fairy where the coast is fringed by sand dunes. In general, the most exposed situations such as the frontal dune carry a grassland of marram grass (*Ammophila arenaria*), while the secondary dunes support a scrub of coast tea-tree (*Leptospermum laevigatum*), sallow wattle (*Acacia longifolia* var. *sophorae*), and coast-heath (*Leucopogon parviflorus*).

Grassland

Prior to white settlement, practically all of the volcanic plains in the study area carried natural grassland. Tussocks of kangaroo grass (*Themeda australis*), wallaby grasses (*Danthonia* spp.) and spear grasses (*Stipa* spp.) were interspersed with low herbs such as blue heronsbill (*Erodium crinitum*), pussy-tails (*Ptilotus spathulatus*), and common everlasting (*Helichrysum apiculatum*).

Practically the whole of this area has been developed for agriculture, and only small relics of this type of vegetation remain.

Vascular Plants of Particular Interest in the Study Area

Dark swamp wallaby grass (*Amphibromus recurvatus*) a poorly understood semi-aquatic plant, has a specialized habitat, and thus spasmodic distribution. It has been noted in the northern flanks of the Otway Range and near Port Campbell.

Lax twig-rush (*Baumea laxa*) has been recorded at Long Swamp near Nelson and the Glenelg River areas. It occurs on private property near Mount Richmond and near Portland. There are two small isolated patches near Port Campbell.

Forest boronia (*Boronia muellerii*) appears as an isolated occurrence in the vicinity of Cape Otway, which is the western-most extremity of its range.

Correa reflexa *variety* nummulariifolia *apparently has its only mainland occurrence on the sea-cliffs in the study area.*

Burnettia lizard orchid (*Burnettia cuneata*) is rarely observed and has been recorded under thickets of paperbark on the Carlisle heathland.

Victorian smoke-bush (*Conospermum mitchellii*) has its eastern-most occurrence in Australia in the extreme east of the study area, on the heathlands of the Bald Hills west of Anglesea.

A variety of common correa (*Correa reflexa* var. *nummulariifolia*) is confined in Victoria to the north of the Parker River near Cape Otway.

Slender tree-fern (*Cyathea cunninghamii*) - an uncommon species - occurs in gullies in the Otway Ranges, which is the western-most extremity of its range.

Skirted tree-fern (*Cyathea marcescens*) is Victoria's only endemic fern. Its stronghold is in the Otway Ranges, which is its western-most occurrence.

Binung (*Cyclosorus parasiticus*) has been recorded from two places in Victoria - at Buchan and near Curdie's River near Port Campbell Bay.

Lime fern (*Cyclosorus pennigerus*) occurs in the Lower Glenelg region; the only other records for Victoria are Darlots Creek near Ettrick and the west branch of Sherbrooke River, western Otways.

Short-tailed leopard orchid (*Diuris brevissima*) although widespread, is very uncommon. It has been recorded in the extreme east of the study area.

Swamp diuris (*Diuris palastris*) is becoming rare due to destruction of its habitat. It has been recorded near Port Campbell.

Bog gum, (*Eucalyptus kitsoniana*) a Victorian endemic, is known from only a few isolated occurrences: South Gippsland; Portland--Lower Glenelg; and Cape Otway, where it is locally abundant.

Victorian occurrences of square raspwort (*Haloragis exalata*) are extremely isolated - at Lower Glenelg (near Dartmoor and Moleside Creek), Johnstones Creek, Port Campbell, and Curdie's River.

Everlasting (*Helichrysum rogersiarmum*) is apparently endemic to Victoria, where it is localized to the western part of the Otways, Mount Wellington area, and the Nunniong Plateau.

Wrinkled buttons (*Leptorhynchos gatesii*) a remarkable rare Victorian endemic, is known only from the Lorne district.

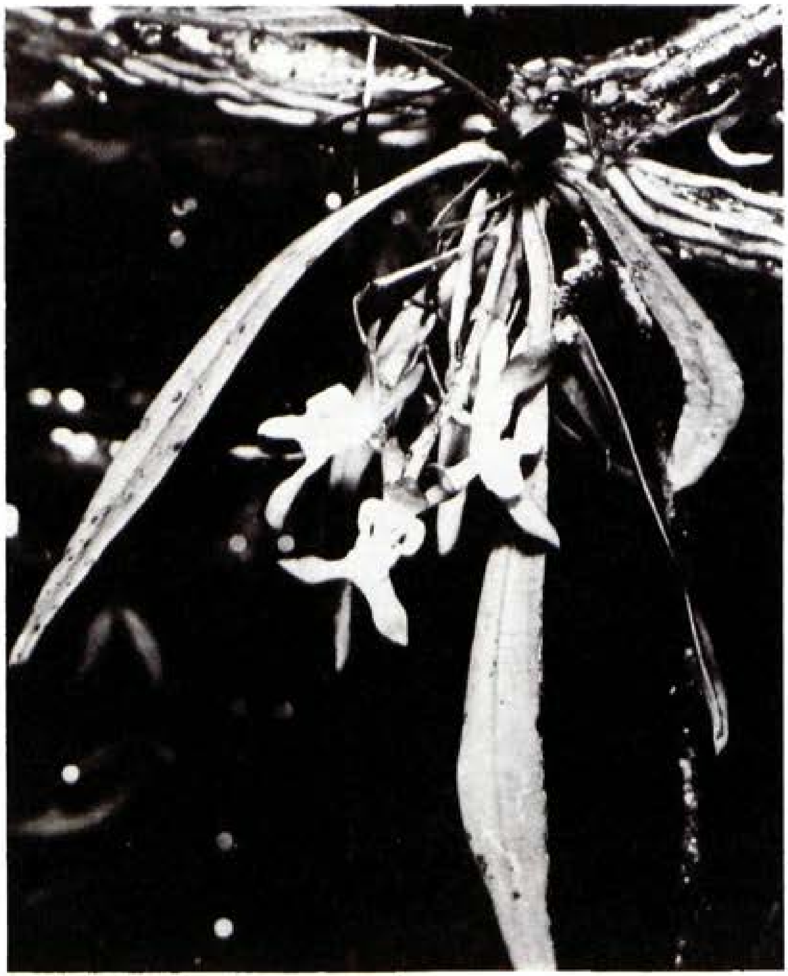
Long clubmoss (*Lycopodium varium*) is an extremely localized species known only from the Victoria Range in the Grampians, Mount Kaye and Genoa Park in East Gippsland, and the Parker River near Cape Otway.

Morning-flag (*Orthrosanthus multiflorus*) has a remarkable isolated Victorian

The skirted tree fern: found in shaded gullies along Parker River, Cape Otway block.

occurrence at Port Campbell. It also occurs at Cape Nelson.

The typical satinwood (*Phebalum squameum*) species is widespread in Tasmania, but in Victoria is confined to the Otway Ranges, where it is locally common. The variety *coriaceum* is known from Macalister River sources and Mount Elizabeth in eastern Victoria.



Gunn's orchid occurs as an epiphyte in the Aire River and Cape Otway blocks.

The endemic Victorian variety of common flat-pea (*Platylobium obtusangulum* var. *spinulosum*) is rare in heathland in the extreme east of the study area (the type locality).

In Victoria, the midge orchid (*Prasophyllum beaugleholei*) is localized and rare, known only from far south-western and north-eastern Victoria as well as near Barongarook on the northern flank of the Otway Ranges.

A widespread but rare plant, the yellow leek-orchid (*Prasophyllum flavum*), has been recorded on Cape Otway.

The leafy greenhood (*Pterostylis cucullata*), except for an isolated record from south-eastern South Australia, is confined to south-western Victoria, where most of the records are from private property. It has been recorded in the study area near Peterborough.

Gunn's orchid (*Sarcochilus australis*), an uncommon epiphitic orchid, occurs in fern gullies in the Otway Ranges, which is the western-most extremity of its range.

Small-fruit fanflower (*Scaevola albida*) has been recorded near Glenaire; otherwise in Victoria it occurs only in the far south-west and far east.

Pointed rice-grass (*Tetrarrhena acuminata*) is localized and rare in Victoria. It has been recorded in swampy areas in the Carlisle heathland.

Metallic sun orchid (*Thelymitra epipactoides*), a localized and rare orchid, has been collected near Port Campbell. It was once abundant near Warrnambool, but this land has now been cleared.

Blotched sun orchid (*Thelymitra fuscolutea*), an unusual and striking plant, is locally common in the extreme east of the study area.

Epiphytic ferns and orchids are found in deep moist gullies.

Normally, veined sun orchid (*Thelymitra vernosa*) occurs in alpine or sub-alpine bogs, but it has been recorded in swampy areas in the Carlisle heathland.

Fork-fern (*Tmesipteris* sp.), an apparently undescribed species, is known from New Zealand and some islands and two localities on the Australian mainland - near Moe, and the Parker River area in the Otway Ranges.

References

Churchill, D.M., and de Corona, A. "The Distribution of Victorian Plants." (Dominion Press: North Blackburn 1972.)

Cowley, R.D. The Otway forest land use report. *Forest Commission of Victoria, Internal Report*, 1971.

Frankenberg, Judith. "Nature Conservation in Victoria - a Survey." Ed. J.S. Turner. (Victorian National Parks Association: Melbourne 1971.)

Specht, R.L. Vegetation. In "The Australian Environment." Ed. G.W. Leeper. Fourth ed. (C.S.I.R.O. and Melbourne University Press: Melbourne 1970.)

Willis, J.H. "A Handbook of Plants in Victoria." Vol. I and II. (Melbourne University Press: Melbourne 1970; 1972.)

FAUNA

The study area has an unusual fauna, which attracts interest as much for the species it lacks as for those it contains. The forests of the Otway Ranges have apparently been separated from the eastern highlands for a long time and have been populated by species capable of bridging the habitat barriers. Their fauna represent an intermediary between the rich eastern Victorian wet-forest fauna and the sparser Tasmanian wet-forest fauna.

Habitats

More than 350 native vertebrate species have been recorded as regularly occurring within the study area. This is more than half the total number of vertebrate species recorded in Victoria. They include more than 240 birds, about 40 native mammals, 20 reptiles, 50 fishes (including some marine species), and about 15 amphibians.

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

Thus, a classification of habitats based on vegetation structure appears to be the most meaningful approach to assessing the distribution of animals within an area the size of Corangamite.

The vegetative classification presented in Chapter 10 has been simplified in order to identify broad habitat types. In addition, several aquatic habitats that support fauna have been added.

Habitat types are presented as follows:

- Wet open and closed forest
- Dry open forest
- Grassy woodland
- Heathy woodland and dry coastal complex
- Pasture
- Marine waters
- Coastline
- Inland flowing waters
- Inland standing waters

Wet open and closed forest

Closed wet forest occurs in small patches (mainly along south-eastern slopes of gullies between 180 and 250 m altitude) and is usually surrounded by wet open forest, which grows on all slopes of the Otway Range (generally between altitudes of 150 and 600 m in the south and 300 m in the north).

Open forest III and IV as well as closed forest are included in this habitat grouping. The tall trees, dense shrub layers, and the frequently occurring moist ferny gullies provide habitats for a diverse fauna.

Dry open forest

This habitat type includes open forest I and II, and usually occurs between 75 and 220 m altitude. It is restricted to a narrow belt around the lower slopes of the Otway Range except in the north near Aireys Inlet, where it is more extensive.

The shrub understorey varies from mid-dense to sparse depending on fire history. In the northern section of the Otway Range, red ironbark, red stringybark, broad-leaf peppermint, and small areas of narrow-leaf peppermint grow as open forests 12--18 m in height. Red ironbark is an important source of winter food for nectar-eating wildlife. It flowers over winter, producing large flows of nectar, but little pollen. The

One of the many stream environments in the study area; here the stream is surrounded by a wet closed forest of myrtle beech.

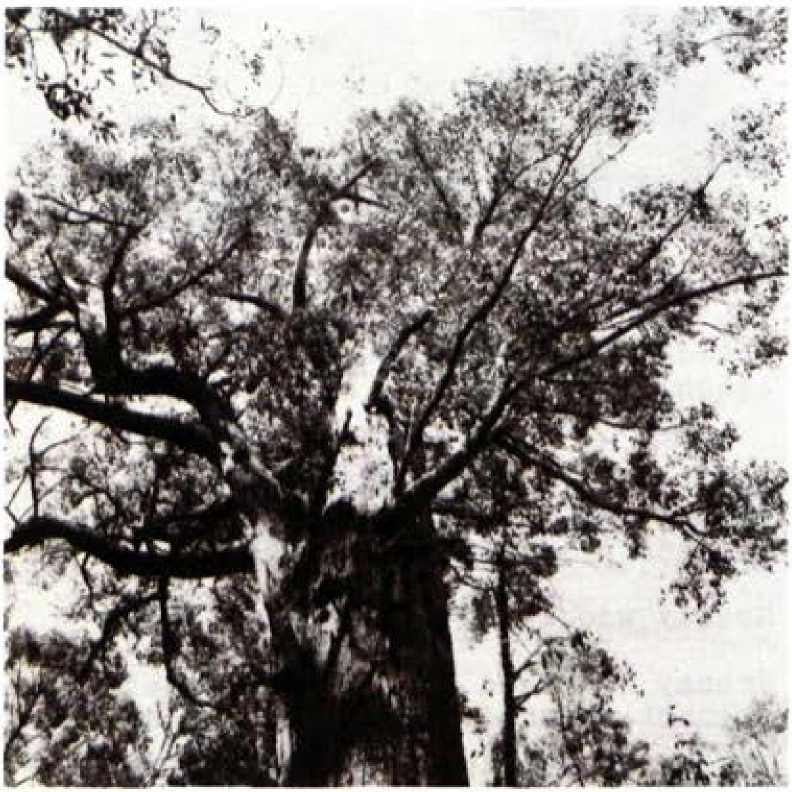
remaining three tree species flower in spring and summer, but are considered to be poor producers of pollen and nectar.

Grassy woodland

Grassy woodland occurs as a vegetation remnant on the volcanic plains and stony rises, where it grades into dry open forest.

Its value to wildlife in the study area is high. River red gums flower over autumn and winter and produce large quantities of nectar and pollen. Manna gums flower over late summer and autumn and produce medium quantities. Both of these gums are important food trees for koalas and, when over-mature, contain an abundance of open hollows in their trunks and branches.

The native trees and shrubs in these woodlands produce small dry seeds and have mid-dense foliage, suitable for bird-nest protection. In the early days of European settlement, the grassy stratum was probably an important grazing area for large macropods and provided cover for other ground-dwelling animals.



Over-mature trees, with hollows and dead branches, provide habitat for arboreal species.

Heathy woodland and dry coastal complex

The heaths and those woodlands with heathy understoreys are considered as one broad habitat type. They occur along the coastal scarp and on poorly drained sandy soils on the top of it, and on elevated, flat, sandy areas that extend inland along the Gellibrand River catchment. Another extensive inland area occurs west of Aireys Inlet.

The scrub fringing the coastal wetlands and heathy forests of the riparian and water-logged habitats that occur in dry open forest are also included.

An important feature is a dense to mid-dense stratum of low shrubs, which provides ample shelter for small ground-dwelling animals as well as nesting cover and feeding areas for small birds. The trees and shrubs in these communities produce quantities of small dry seeds, pollen, and nectar throughout the year.

The woodlands with understoreys of heath species, which are often more than 2 m tall, are widespread on the Cape Otway peninsula, while the vegetation forming the coastal complex reaches varying degrees of development on different parts of the coast.

Pasture

More than 75% of the Corangamite study area is now farmlands. They cover nearly the entire northern and north-western portions of the study area as well as a large part of the southern portion (which was originally timbered).

The pastures that now cover the volcanic plains still contain grazed relics of the original grass communities. However, many introduced annual grasses, forbs, and sown species now form short grasslands.

The perennial Toowoomba canary-grass is widespread, and forms a dense, tall, tussock grass community, especially along roadsides.

Marine waters

This habitat comprises the waters extending seaward from the coastline habitat. Those adjoining the study area support commercial marine fishes, oceanic birds, and mammals.

Coastline

The Otway peninsula extends into the Indian Ocean in the temperate latitudes of 39° South. It has a coastline of about 200 km, which for half of this distance is mainly a steep scarp, or

These coastal cliffs provide habitats that are uncommon in Victoria.

cliff face. There are only a few sections where beaches and dunes have formed. Narrow, sandy beaches usually occur in bays between the ocean and coastal scarp. Cliffs of soft sandstone are found along much of the southern coastline.

Several small islets occur close to the coastline and one island, Lady Julia Percy, lies some 10 km off Port Fairy. These islands have rocky cliffs around

Isolated and inaccessible, Lady Julia Percy Island provides an ideal habitat for marine species.

much of their margins, and support grasslands on their plateau-like tops.

The plant communities and animals that occur on the dunes and coastal scarps are discussed in the section on coastal complex.

Inland flowing waters

All flowing surface waters are considered parts of this habitat. These include estuaries, streams, and rivers, together with their margins of sand, gravel, or mud and associated vegetation.

The southern coastline of the Corangamite study area contains several small river estuaries, which collectively have a total surface area of approximately 400 ha. The five largest are located at the mouths of the Moyne, Hopkins, Curdies, Gellibrand, and Aire Rivers.

These estuaries have small openings to the ocean by way of steep-sided valleys through coastal ridges of aeolian calcarenite. All of them, with the exception of the Hopkins River estuary, are shallow lagoons, with flat sand or mud bottoms and brackish waters. Large amounts of suspended organic matter and mineral nutrients often accumulate and result in relatively high production of plants and animals.

Reed-beds of cumbungi and cane grass, to 2 m tall, are still extensive on the estuaries at Princetown (Gellibrand River) and at the Aire River. Margins of swamp-weed, rushes, and woolly tea-tree scrub occur, or were once common, along most of the estuaries.

The river systems in the area drain catchments of four types of country. In the western section, the Moyne River, Hopkins River, and Mount Emu Creek drain large areas of the volcanic plains.

Their catchments are at relatively low altitudes, average 60 km in length, and have gentle gradients. The Curdies, Gellibrand, and Barwon Rivers drain the low plateau country in the centre of the study area, and their catchments average

50 km in length.

The waters in these areas are slow-flowing, warmer, and less oxygenated than those at higher altitudes. Aquatic plants such as swamp lily, knotweeds, water milfoil, and some sedges grow on their margins. Silt, sand, and weed bottoms are usually present.

In the Otway Range, usually between 150 and 600 m in altitude, there are many shallow, fast-flowing streams with clear, cool, fresh waters. These streams normally have rock bottoms, but heavy siltation may occur subsequent to soil disturbance by logging or clearing in the catchments. Temperate rainforest and wet open forest shade these streams, and blue-green algae is the main aquatic vegetation.

Inland standing waters

The volcanic plains contain approximately 50 lakes and 40 large areas of swampy depressions. In addition, five small reservoirs are located in the Otway Range as well as some farm ponds and fire dams. Together these water bodies encompass a wide range of salinities, temperatures, bottom characteristics, and depths; consequently they provide a diversity of aquatic habitats.

Many of the lakes in the volcanic plains are saline, with some attaining salinities much greater than that of sea water. In contrast, some volcanic lakes and the reservoirs in the Otway Range have fresh water.

Some mud flats and salt-marsh vegetation occur around the foreshores of the saline lakes. The low swampy depressions on much of the volcanic plain support tussock grasses, rush-fields, and pastures. Reed fields of cumbungi, cane grass, and rushes are found in shallow margins of fresh-water lakes.

Birds

More than 240 bird species have recently been recorded as regularly occurring within the study area; 154 of these are recorded as breeding or as likely breeding. Appendix 6A lists these species by common name and provides information regarding habitat affinities, breeding, and feeding.

The following general description on birds is confined to eight habitat types. Most emphasis is placed on birds in the habitats still remaining in public ownership.

Wet open and closed forest

Some 38 kinds of birds regularly occur in these forests; the majority of these breed within this habitat and utilize the variety of nesting structures it provides.

In terms of species, the important families include parrots--cockatoos (four

Rufous fantail, an inhabitant of wet open forest.

species), eagles--goshawks (three), Australian warblers (four), old-world flycatchers (three), whistlers--shrike thrushes (three), and honeyeaters (four). In addition, fifteen families are each represented by either one or two species.

The birds occurring in this habitat rely heavily on insect populations for subsistence. More than 70% include substantial quantities of insects in their diets. Foods such as seeds, fruits, and roots are also utilized by the parrot--cockatoo family. The four honeyeater species take nectar as well as insects, and the six predatory bird species generally consume other vertebrate animals.

The species composition of birds in this habitat is similar to that in the more extensive wet open forests in the eastern half of the State. However, the small areas of wet open forests still remaining in the Otway Range appear to be the Victorian stronghold of the grey goshawk and the forest raven. While the goshawk is occasionally reported from other areas of the State, in Victoria

The Australian ground thrush normally nests in a fork of a tree.

the forest raven has been reported only in the Otway Range and on Wilsons Promontory.

In a State-wide context, the wet forests of the Otway Range are of considerable importance to those birds with primary affinities for this type of vegetation, because the Otway region contains its only substantial representation in the western half of Victoria. Birds particularly well adapted to survival in this habitat include the grey goshawk, Australian ground thrush, pink robin, rose robin, rufous fantail, olive whistler, satin bower-bird, and forest raven.

Noticeable by their absence in the Otways are the superb lyrebird and pilot bird, both of which are widespread in other wet open forests of the State.

Dry open forests

The most extensive area of this habitat in the study area is located at the north-eastern end of the Otway Range.

Fifty-five species of birds are recorded as regularly occurring in these forests. The two best-represented families, with seven species in each, are the parrot--cockatoo and the honeyeater families. Some species of both of these groups probably only utilize the forests during times when the eucalypts are flowering. Other families that are moderately well represented include the Australian warbler family (five species), the whistler--shrike thrush family (four), and the flower-pecker family (five).

At least four species are relatively restricted to the areas of dry open forests in the Corangamite study area. These include the painted quail, white-throated nightjar, rainbow bee-eater, and spotted quail thrush.

A gang gang cockatoo eating the seeds from a planted sugar gum.

Grassy woodland

The most extensive and continuous area of this plant formation now occurs mainly on private land in the Stony Rises south-west of Lake Corangamite. Other small scattered remnants of the habitat occur on the volcanic plains creek and river frontages and as planted farm windbreaks.

Individually these small areas may not be ecologically viable, but collectively they are important to the continued success of many bird species in the study area. They provide shelter, protection, roosts, nesting sites, and food for both migratory and resident birds. In Appendix 6 the number of species present is probably underestimated, because some of the migratory birds that stop only briefly in these areas may not be included.

More than 60 species are recorded as occurring in these woodlands. The parrot--cockatoo family is particularly well represented, with 11 species being present during either all or some portion of each year. Most of the cuckoos recorded in the study area also occur there at times. The Australian warbler family is represented by seven species, the flower-pecker family by four, and honeyeater family by six.

The species composition in this habitat apparently comprises a mixture of: birds adapted to living in open grassland situations (e.g., yellow-rumped thornbill and white-fronted chat); birds that more typically inhabit open forest (e.g., golden whistler and olive-backed oriole); nomadic birds that follow the eucalypt flowering seasons (e.g., lorikeets and honeyeaters); and birds that utilize it year-round as their primary habitat (e.g., eastern rosella, noisy miner, and grey butcher-bird.

Heathy woodland and dry coastal complex

Some 55 bird species regularly use these habitats in the study area. Most of them nest in the study area, utilizing mainly the low shrubs and trees.

Their habits are quite varied, reflecting the diversity of plant components that make up the habitats. The Australian warbler family is represented by ten species, which exhibit habits that range from the ground-dwelling (mainly coastal scrub) rufous bristle-bird to the canopy-dwelling (heathy woodland) striated thornbill.

The honeyeater family (eight species) is also well represented in this habitat - the local survival of two (the singing and tawny-crowned honeyeaters) probably depends on adequate areas of this vegetation remaining.

Six species of parrots and cockatoos occur in these communities. The rare ground parrot possibly still occurs in the inland heath areas along the south-

The southern emu-wren is restricted to grassy woodlands.

western edge of the Otway Range, and the king parrot was observed during recent surveys in coastal scrub near the mouth of the Parker River.

Four species from each of the eagle--goshawk and falcon--kestrel families occasionally hunt over these communities. However, the importance to these two families of this habitat relative to other adjacent habitats is unknown.

In addition to the above-mentioned five, 16 other families are each represented by up to three species. Among these species, the rare (in Victoria) beautiful firetail appears to be restricted to the coastal heath areas, and the powerful owl has recently been reported from near Narigal in an isolated riparian area of dense shrubs.

Many of these birds include substantial quantities of insects in their diets. The relatively large number of honeyeater species also suggests that nectar is seasonally available. Some of these species are particularly well adapted to feeding on nectar from some of the characteristic flowers occurring in this habitat. For example, the eastern spine-bill utilizes the nectar from the tubular flowers of the pink-heath, and the crescent honeyeater utilizes banksia flowers.

The distribution of a considerable number of species is restricted to these habitats in the study area. They include the ground parrot, southern emu-wren, singing honeyeater, tawny-crowned honeyeater, little wattle bird, and beautiful firetail. The rufous bristle-bird, which elsewhere in its range is restricted to this habitat, is found in the Otways in the dense undergrowth of the wet open forests as well.

Pastures

The tussock grasslands that originally grew across the volcanic plains are virtually gone and have been replaced by pastures and crop lands.

More than 80 species of birds regularly occur in the open pasture lands and associated dense vegetation remaining

Table 8

BREEDING AREAS OF INTERCONTINENTAL BIRDS THAT MIGRATE TO THE STUDY AREA

Occurrence in study area	Breeding areas			
	Arctic	Antarctic & sub-Antarctic	Eurasia (mainly Japan & Siberia)	New Zealand
Inland waters (margins)	Pectoral sand-piper, red-necked stint	-	Japanese snipe, eastern curlew, greenshank, sharp-tailed sandpiper, curlew sandpiper	Double-banded dotterel
Coastal and offshore islands	Grey plover, eastern golden plover, turnstone, whimbrel, knot, pectoral sand-piper, red-necked stint, sanderling, bar-tailed godwit	Crested penguin	Japanese snipe, eastern curlew, common sandpiper, grey-tailed tattler, sharp-tailed sandpiper, curlew sandpiper	Double-banded dotterel, white-fronted tern
Marine	Arctic skua	Crested penguin, wandering albatross, giant petrel, black-browed albatross, Cape petrel, medium- and thin-billed prions, grey petrel, dove prion, southern skua	-	White-fronted tern, fluttering shearwater
Aerial	-	-	Spine-tailed swift, fork-tailed swift	-

along creeks and roads and around suburban gardens. The open nature of the land makes it suitable for hunting by such predaceous birds as the eagles--goshawks (eight species) and the falcons--kestrels (four species).

Some members of the parrot--cockatoo family also forage in the pastures for roots and bulbs, while others are occasionally seen in the denser vegetation associated with the pastures. Six honeyeater species also occur in this habitat, some being regularly seen in suburban gardens.

Species that are particularly well adapted to survival in the open habitat now existing in the study area include galahs, corellas, some quails and larks, Australian pipits, yellow-rumped thornbills, white-fronted chats, jacky winters, house sparrows, goldfinches, greenfinches, starlings, and white-backed magpies.

At least two species, the plain wanderer and the brolga, formerly occurred in substantial numbers in the tussock grasslands. Today these two are rarely reported and concern is expressed about their local survival in the area.

Marine waters

The 28 species that inhabit offshore waters belong mainly to the petrel--mutton-bird family (nine species) and to the gull--tern family (six species). The albatross and cormorant families are each represented by three species, and the penguin and skua families by two. Represented by single species are the storm petrel, diving petrel, and gannet families.

Thirteen of these species are intercontinental migrants from the Arctic, the Antarctic, Eurasia, and New Zealand (see Table 8). Only nine species are recorded as breeding in the study area, the majority of which utilize the coastline habitat for nesting purposes. Most of these species eat mainly fish, cephalopods, and crustaceans.

Coastline

Forty-six bird species occur regularly along the beaches and cliffs and on offshore rocks and islands in the study area. Important among these are 18 species of intercontinental migrants, which inhabit the areas during their non-breeding seasons. Nine of these breed in Arctic regions, six in Eurasia, two in New Zealand, and one on sub-Antarctic islands (see Table 8).

The beaches and offshore rocks and islands in the Port Fairy area are of particular importance to these migrants, although most would also be expected to occur elsewhere along the coast.

Approximately half of the 46 species utilize this habitat for nesting as well as for resting and feeding. The nesting species on Lady Julia Percy Island include little penguins, short-tailed shearwaters, fairy prions, diving petrels, sooty oystercatchers, swamp harriers, peregrine falcons, nankeen kestrels, welcome swallows, white-fronted chats, skylarks, Australian pipits, house sparrows, and starlings.

The coastal cliffs along the mainland provide suitable nesting areas for peregrine falcons. In view of the world-wide population decline of this species, its continued survival in Victoria is of particular significance.

Short-tailed shearwaters (mutton birds), members of the marine community, nest in burrows and feed on fish and crustaceans.

Other beach-nesting species include hooded and red-capped dotterels, pied and sooty oystercatchers, silver gulls, and crested terns. Most of these have been reported as nesting in the Port Fairy area, and also probably nest elsewhere along the coast. The black-faced cormorant nests on offshore islets in the Bay of Islands, this being the only known breeding area in Victoria.

In addition to being an important area for intercontinental migrants and for some breeding species, this habitat is also significant for supporting the rare orange-bellied parrot along its inland margins (dunes and associated vegetation). The Little River near Port Fairy formerly supported substantial numbers of this species, although reports in recent years suggest that the numbers are decreasing.

Inland waters

Seventy-five species of birds are listed as regularly inhabiting inland aquatic environments in the study area. The best-represented families there (in terms of numbers of species) are: ducks--geese--swans (13 species); herons--egrets--bitterns (8); rails--crakes--waterhens (8); plovers--dotterels (7); and curlews--sandpipers--snipes (6).

The aquatic habitat can be divided into a number of feeding zones, each of which supports a characteristic group of aquatic birds.

The heavily vegetated swamp areas provide food for night herons, bitterns, rails, crakes, and waterhens. Along sparsely vegetated margins of water, such birds as plovers, dotterels, snipe, sandpipers, stilts, wagtails, sparrows, and magpie-lark forage by either probing into the mud for invertebrates or catching them as they move across the exposed beaches.

The shallow waters of lakes, rivers, and estuaries support both emergent and submergent vegetation as well as a variety of aquatic insects, crustaceans, molluscs, and small fish. Pelicans feed on fish and crustaceans in these waters by immersing their long necks and bills beneath the water surface. Herons, egrets, spoon-bills, and ibis feed by wading in the shallows and catching small aquatic animals. Many of the ducks and the black swan feed in this zone, utilizing a variety of feeding methods.

The open deeper waters support populations of fish and crustaceans swimming at various depths below the suface. Birds such as cormorants, grebes, and some ducks dive and swim below the surface of the water to feed upon these organisms. Other birds utilizing these deeper waters are blue-billed and white-eyed ducks and coots, which dive to feed upon submergent plants and bottom-dwelling molluscs and crustaceans.
The lake region in the volcanic plains represents one of the most important water-bird areas in south-western Victoria. The swamps and lake margins in this region provide nesting areas for many of the water-birds, although the nesting habitat has been seriously reduced in extent by clearing down to the margins of the lakes and by draining many of the swamps.

The privately owned Vaughan Island on Lake Corangamite supports one of the few breeding colonies of pelicans in Victoria, as well as thousands of breeding straw-necked ibis and some breeding swans and white ibis.

Pelicans and straw-necked ibis intermingle on Vaughan Island, Lake Corangamite.

The mud flats associated with many of these lakes also provide foraging areas during the non-breeding season for eight species of intercontinental migrants, of which two breed in the Arctic, five in Eurasia, and one in New Zealand. It is likely that the extensive changes to this lake region since European settlement have considerably reduced most of the water-bird populations.

The esturaries in the coastal region also contribute significantly to the water-bird habitat in the study area. Such areas as those occurring near the mouths of the Aire and Gellibrand Rivers at times support large numbers of swans, ducks, egrets, swamp-hens, and various species of shore birds.

Mammals

Some 35 terrestrial and aboreal species and 10 bat species have been recorded within the boundaries of the study area this century and one species of seal has a major breeding colony on an offshore island. Appendix 6B lists the mammals.

Several rare species are present. The Otway Ranges is a stronghold for the tiger cat, which is now rare. The quoll which is very rare and now possbly extinct in Victoria, was recorded in considerable numbers among the rocks and stone walls of the stony rises about 40 years ago. The Corangamite area is also important for swamp antechinus, Gunns bandicoot, potoroo, broad-toothed rat,

The broad-toothed rat primarily inhabits wet open and closed forests.

and smokey mouse, all of which are uncommon or rare throughout their Victorian ranges.

Wet open forest and closed forest

The diverse structural aspects of this habitat and its relative remoteness have contributed to a large existing faunal complement comprising a relatively large number of species, some of which are abundant. Seventeen species of ground or arboreal mammals have been recorded in this habitat, and for eight of these (tiger cat, swainsons antechinus, long-nosed bandicoot, black wallaby, ring-tailed possum, yellow-bellied glider, bush rat, and broad-toothed rat) it is the primary habitat.

Of the five small ground-foraging species, the most common is the bush rat.

The brown antechinus is fairly common and occurs throughout most types of wet forest, but not in closed forest. Swainsons antechinus is widespread but uncommon and prefers moist, shaded areas with low ground vegetation cover.

The two other native species are rodents and both appear to be quite rare. Broad-toothed rats have an unusual distribution and their habitat requirements are difficult to specify. Smokey mice have been recorded in the Otway Range only twice, and both times were found in wet open forest.

Of the six medium-sized ground mammals recorded in this habitat, three are carnivorous, two insectivorous, and one herbivorous.

The one herbivorous mammal is the introduced rabbit, which does not occur deep in wet forests but is restricted to the margins of roads and farms. Echidnas are apparently quite common throughout,

The tiger cat is found primarily in wet open and closed forests.

although they might be expected to prefer drier habitats. Long-nosed bandicoots also occur throughout the habitat, but appear to be most common in the areas with a dense ground cover and open overstorey canopies.

The only native mammal carnivore of this habitat is the tiger cat, a rare species that seems to be surviving adequately in

Sugar gliders are widespread in wet open and closed forests.

the wet forests. Foxes and cats are widespread and fairly common.

The only large animal present, the black wallaby, is common and widespread throughout the area.

Common ring-tailed possums, sugar gliders, and feather-tailed gliders are widespread. The first of these occurs commonly, but the other two are uncommon. Yellow-bellied gliders have an unusual habitat preference. Their range is largely restricted to specific types of wet forest: they have a particular preference for areas with manna gum and the southern blue gums, and appear to avoid messmate and mountain ash.

Dry open forest

Although the dry open forest fauna essentially resembles that of the wet open forest, some differences warrant its discussion as a separate type. While 18 species have been recorded in this habitat, it does not appear to be the primary one for many species.

The community is characterized by a general decrease in the number of small mammals. Those present include bush rats, brown antechinus, swainsons antechinus, and house mouse.

The distribution and abundance of the small ground species are determined by local conditions - such as shrub structure, which tends to vary. The brown antechinus occurs throughout, except in the most open grassy savannah-type areas. Both bush rats and swainsons antechinus only occur in areas with dense shrub cover. House mice were only recorded among dry open grassy vegetation.

Of the larger ground mammals, long-nosed bandicoots and tiger cats are probably restricted to areas with thick ground vegetation. Echidnas, rabbits, cats, and foxes are all widespread.

Black wallabies are generally restricted to thicker ground cover and shrub understorey. Grey kangaroos (which do not occur in wet open forests) are fairly common in dry open forests, particularly those with a grassy understorey.

Koalas and brush-tailed possums are rarely encountered in wet open forest but do occur in some dry open forests.

Grassy woodland

Little is known of the composition of the original volcanic plains grassy woodland, and the fauna of the stony rises has probably altered considerably.

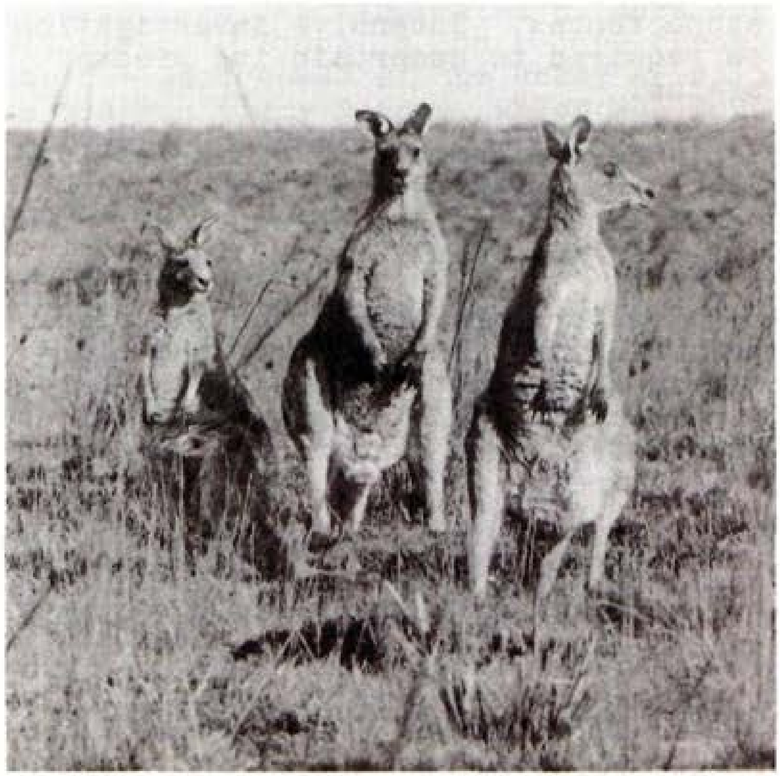
The stony rises have extensive areas of rocks, some cliffs, and small caverns. These present a unique habitat, and some corresponding unique features characterize the fauna.

The discussion of woodland mammal communities is restricted to the community on the stony rises, since this woodland is the only extensive area left. All other grassy woodlands - such as roadside reserves and red gum woodlands near streams - now largely support brush-tailed possums and provide roosting sites for bats. Approximately 16 mammals have been recorded in grassy woodlands, which form the primary habitat for the quoll and brush-tailed possum.

The most surprising feature of the stony rise fauna is the apparent lack of the brown antechinus, while its usually rarer and certainly more specialized relative swainsons antechinus is comparatively common.

The dense areas of bracken that occur in some areas support both swainsons antechinus and bush rats.

Other small mammal species recorded in the stony rises include the swamp rat,



Grey kangaroos are found in grassy woodlands, grasslands, and dry open forests.

which is probably restricted to moist areas of bracken and shrubs such as tea-tree. The introduced black rat is commonly associated with rubbish dumps and human habitation.

Among approximately six medium-sized ground-dwelling mammals, the most significant past (and perhaps present) resident is the quoll. It was common in the stony rises in the 1930s, where it was reported as inhabiting rock piles and stone fences. Intensive investigation is required to ascertain its present status.

Echidnas are common and widespread, as are foxes, rabbits, and cats. Long-nosed bandicoots are present, but are uncommon and fairly restricted.

Both eastern grey kangaroos and black wallabies are fairly common and widespread throughout the area. The latter is prevalent in thick ground scrub, and the eastern grey kangaroo in more open grassy areas.

Brush-tailed possums are widespread and common, koalas have been introduced at Pirron Yallock, and sugar and feather-tailed gliders are probably widespread.

Heathy woodlands and coastal complex

Twenty-three mammal species have been recorded in these habitats, which form the primary habitat for six of them: the swamp antechinus, white-footed dunnart, short-nosed bandicoot, potoroo, red-necked wallaby, and swamp rat.

Eight of the mammals are small ground-dwellers. The swamp rat occurs in almost all of the different heath woodland types but in few other vegetation forms, and thus is the most characteristic mammal of the heath fauna. White-footed dunnarts belong in the same category, but are relatively uncommon and the exact limits of their distribution within heath types is uncertain.

In contrast to these two widespread species, the swamp antechinus is restricted to the coastal escarpments that support a tussock grass and shrub vegetation, and is seldom found outside this habitat. Bush rats are common in heathy woodland and coastal scrub but they avoid low heath. Brown antechinus has a similar distribution, which excludes the low coastal heaths and grassy scarps but includes all the woodland. Swainsons antechinus is only found in dense heath in moist areas, such as near creeks or swamps.

Broad-toothed rats are rare and their habitat preferences are not well known. They appear to prefer very dense ground-level vegetation such as some low heath forms and the tussock grassland of coastal escarpments.

The introduced house mouse is common in some coastal areas and is usually associated with discarded rubbish.

The primary habitat of the potoroo is the heathy woodlands and coastal complex.

A further eight are medium-sized ground-dwellers. Both short-nosed bandicoots and potaroos are restricted to heath-like communities. The former occur abundantly throughout these habitats, while potoroos have a distribution limited to heathy woodland. Echidnas, foxes, and cats have a wide and apparently unrestricted distribution. Long-nosed bandicoots and possibly tiger cats are restricted to dense heath in moist areas, which generally adjoin forests. Rabbits occur in some areas but usually near clearings, farmland, or roadsides.

Heathy woodlands support three large ground-dwelling mammals: eastern grey kangaroos, red-necked wallabies, and black wallabies.

In the study area, red-necked wallabies only occur in heathy vegetation or the adjacent dry forest. They are probably widespread, although records of their distribution are patchy. Eastern grey kangaroos and black wallabies are widespread.

Common ring-tailed possums, sugar gliders, and feather-tailed gliders are widespread. There is one record (from the far west coast of the study area) of an eastern pigmy possum, which was found in heathy woodland.

Pastures

The faunal community discussed in this section is that of the western and northern farmlands of the volcanic plains.

Approximately eight mammal species inhabit grasslands, which is the primary habitat for four of them: the fat-tailed dunnart, Gunns bandicoot, hare, and house mouse. With the exception of the house mouse, these species are restricted to grassland.

Only two small ground mammals are present. Fat-tailed dunnarts are wide-spread but uncommon. They prefer areas with some cover such as rocks and logs, but nevertheless often occur in barren areas. House mice are common and similarly widespread, and they prefer areas with some cover.

Of the five medium-sized ground mammals that occur in grassland, only one, Gunns bandicoot, is a native. This species was once common throughout the northern two-thirds of the study area but is now restricted to an area in the extreme west. Grassland in the study area is vital for the species' long-term survival prospects in Victoria. Hares, cats, and foxes are all widespread and common. Rabbits are also widespread, but usually require some cover such as bushes and rocks.

The general lack of trees has caused a decrease in the arboreal fauna. The

Fat-tailed dunnarts are widespread but uncommon in the pastures of the study area.

The Australian fur seal has a major breeding colony on Lady Julia Percy Island.

only species that occurs throughout the area, associated with the few trees that remain, is the brush-tailed possum.

Marine waters

Several whales and seals have been reported in the ocean near the study area, but the area has little relevance for all but one species, the Australian fur seal. This seal has a major breeding colony on Lady Julia Percy Island and often comes ashore on the coast of the mainland.

Inland waters

Two species are associated with non-marine aquatic habitats. The platypus inhabits streams and fresh-water lakes throughout the study area and is common in most areas. Eastern water rats occur in a wide variety of aquatic systems, from mountain streams to estuaries. They are generally common and wide-spread, although there are no documented records from the inland saline lakes.

Reptiles

Appendix 6C lists the 22 reptile species recorded in, or thought to occur in, the study area. These constitute 15 genera and five families.

Two major communities of reptiles in the area can be distinguished as having separate distributions. One occurs in the Otway Range and surrounding foot-hills. The other, an inland community, is found on the volcanic plains. These two reptile communities largely correspond to the reptile faunas of the cool temperate and the warm temperate bassian zoogeographic subregions outlined by Rawlinson (1971). Both of them comprise species that occupy similar habitats in other areas of Victoria.

Unlike the mammal fauna of the Otway Range, which lacks several significant species, the reptile communities resemble those found in other comparable areas such as the eastern Victorian highlands. Evidently the ecological barriers that prevented several mammal and bird species from colonizing the Otway Ranges were not sufficient to isolate the Otways from the cool temperate reptile fauna.

The ability of reptiles to maintain preferred body temperatures is the most important factor, particularly in temperate regions, influencing their habitat requirements.

Two major behavioural mechanisms are recognized. The heliothermic reptile absorbs infra-red radiation from the sun to elevate its body temperature, and retires to shade to reduce it. The thigmothermic reptile rarely comes out into the sun, but maintains its body temperature by moving into areas with suitable ambient temperatures.

The study area contains representatives

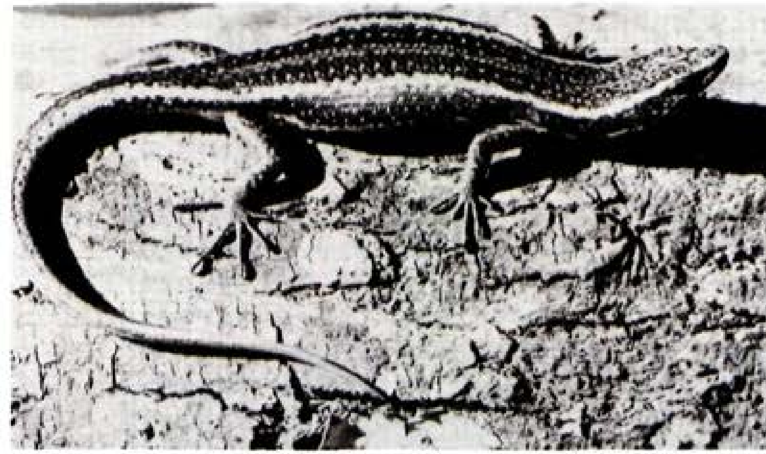
of both behavioural types.

Wet open forest and closed forest

The denseness of this vegetation produces low ambient temperatures, which are unsuitable for most reptile species. Only three species occur widely in undisturbed open forest, and their life styles are adapted to this habitat.

McCoys skink and weasel skink, both small thigmotherms, forage in moist litter on the forest floor. Spencers skink, which is a small heliotherm, copes with the lack of sunlight penetra-

McCoys skink, being a thigmotherm, needs to occupy areas of suitable ambient temperature within the wet open and closed forests of the study area.



Spencer's skink, a heliotherm, needs to climb above the thick undergrowth of wet forests to bask in the sun.

tion by climbing above the thick undergrowth and basking high on dead trees.

Four other reptiles can colonize clearings in wet open forests, and often become very common. They take advantage of the sunlight and plentiful supply of food in such clearings. These four species, all heliotherms, include the garden skink and one undescribed skink species *(Leiolopisma sp. nov.)*, both of which are small insectivourous lizards. The other two species are the water skink and the tiger snake.

Dry open forest

This forest allows greater sunlight penetration to the ground than does wet open forest. However, it has less litter and moisture on the forest floor. These factors result in a change in the reptile fauna.

The weasel skink and the one undescribed skink do not occur in this forest type, and McCoys skink is restricted to areas of deep litter. Spencers skink, which depends on tall dead trees, only inhabits some areas of dry open forest.

Three of the species that inhabit clearings in wet open forest - the garden skink, water skink, and tiger snake - are all common and widespread in this habitat. Two heliotherms, the copperhead and southern blue-tongue, are also both common. Copperheads are most common in moist areas where frogs are plentiful, but southern blue-tongues are widespread. One other medium-sized heliothermic species, the tree dragon, may occur in some of the more open forms of this forest type.

Grassy woodland

This habitat allows greater sunlight penetration and has less litter depth than dry open forest.

Garden skinks are common and widespread. Another small heliothermic lizard, the grass skink, is found in moist, grassed areas. Bougainvilles skink is the only thigmothermic reptile usually found in grassy woodland. This small species burrows in loose soil and litter. The tree dragon is found throughout these woodlands and the southern blue-tongue is widespread and common.

The white-lipped snake, a small harmless species, is most often found associated with grassy areas. Tiger snakes are very common in the rock piles, specially in the stony rises.

Heathy woodland and dry coastal complex

The only small skink species present is the garden skink. It is common and widespread throughout all heath types. Two medium-sized heliothermic skinks occur in some heath types: Whites skink is found in the more open forms of heath and usually those without a tree cover; and the mourning skink, a rare species, is only found in heath or cane grass swamps. Tree dragons are found in heath that has a woodland tree cover and southern blue-tongues are very common and are found throughout.

Copperheads are common, particularly near swamps; white-lipped snakes are found in open heaths, but usually away from swamps; and tiger snakes are common and widespread.

Coastal complex

The garden skink, grass skink, and three-lined skink, all small heliothermic lizards occupy this habitat. Garden skinks tend to be restricted to scrub vegetation. The other two are most com-

com in the coastal tussock grassland. Whites skink, a medium-sized heliothermic lizard, is common along most of the coastline, especially in rocky areas, although it is often found on bare sand dunes. In this area, the southern blue-tongue and copperhead and tiger snakes are all common and widespread. The white-lipped snake is relatively uncommon and is restricted to coastal tussock grassland. The bearded dragon has been recorded on grassy sand dunes near Port Fairy.

Pastures

Two small heliothermic skinks, the grass skink and the three-lined skink, are widespread and fairly common. Their abundance varies according to local conditions and to cover, which is provided by basalt rocks, farm rubbish, and fence posts. Bougainvilles skink is the only small thigmothermic skink found in these grasslands. It shelters under rocks and burrows through grass and loose soil. Three medium-sized lizards - the spinifex lizard, marbled gecko, and Whites skink - are also found on open, grassy plains and they use rocks and debris for shelter. The first two are thigmothermic and the latter is heliothermic.

Common blue-tongues probably occur throughout grassland, and bearded dragons may be present on the western and northern edges of the study area.
Four snake species are found on the grassy plains. White-lipped snakes are

A log charred by fire no longer provides shelter for reptiles.

restricted to cooler and moister areas. Brown snakes, although they have not been recorded in the study area, and the little whip snake, a small nocturnal snake, are probably widespread. Tiger snakes are particularly common in wet areas.

Amphibians

Fourteen frogs occur in the study area. Of these, five species and two sub-species are considered to be Southern Bassian, one species is Eastern Bassian, three are Eyrean, and three are wide-ranging, (see Appendix 6E).

Although none of these frogs is restricted to it, the Corangamite area does provide suitable habitat that supports large populations of some of these species.

For descriptive purposes, the distribution of amphibians in the study area is discussed in relation to three geographic regions: the Otway Range, coastal plains, and volcanic plains.

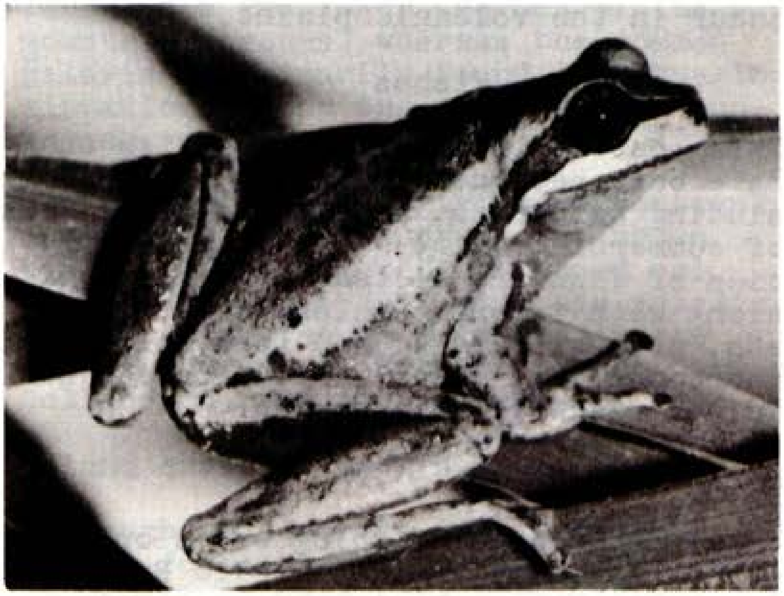
Otway Range

This region includes the wet and dry forests. The aquatic habitats are primarily mountain streams and small dams with permanent fresh water. High rainfall, fog, and cool temperatures make much of the terrestrial vegetation continually moist. *Geocrinia victoriana* is the only frog restricted to this region in the study area. Another four species are widespread throughout the area. These are *G. laevis*, *Limnodynastes peroni*, *Litoria ewingi*, and *Ranidella signifera*.

Coastal plains

This region mainly includes the terrestrial habitats of heathy woodland, pastures, and grassy woodlands. The main aquatic situations are the lowland rivers and their associated swampy margins.

Twelve species of frogs have been recorded as occupying this region, including the four widespread species discussed above. The ranges of the two subspecies of *Limnodynastes dumerili* extend into the study area in this region. *L. dumerili variegatus* extends into the study area from the west and *L. dumerili insularis* from the east. Also restricted to this region in the study area are *Litoria verreauxi verreauxi*, *Neobatrachus picctus*, and *Pseudophryne semimarmorata*. Two species - *Limnodynastes tasmaniensis* (southern call race) and *Litoria aurea raniformis* - occur in this region as well as in the volcanic plains.



Litoria ewingi *is widespread throughout the Otway Range.*

Volcanic plains

The terrestrial habitat in this region is largely grassland with some trees. Agricultural settlement has led to the construction of farm dams, which have probably benefited populations of those frogs requiring more permanent water. Frogs have been reported from most of the fresh-water lakes, but they do not live in or near the saline lakes.

Most of the amphibians in this region are Eyrean in zoogeographic affinity. These include *Pseudophryne bibroni* and *Ranidella parinsignifera*. Four widespread species and the last two species mentioned under the coastal plains also occur in the volcanic plains.

Fishes

This section includes all the fish that have been recorded in inland waters, including estuaries, and those marine fish of commercial value. Fifty-eight species of fish are listed in Appendix 6D, along with information on their habitats, status, feeding and food relations, and commercial value. Distribution of inland fishes is also shown.

Marine habitats

Commercial marine fishing boats operate out of Anglesea, Lorne, Apollo Bay, Port Campbell, Warrnambool, and Port Fairy. By weight, the most important species taken are snoek and gummy shark.

Along the coastline, amateur surf and rock fishing produces Australian salmon, sweep, parrot fish, flathead, and yellow-tail king fish. It should be noted that fish of coastal waters, although occurring outside dry-land areas, may be influenced considerably by drainage from these areas. Thus, land-use decisions may affect coastal fisheries by altering discharge volumes of fresh water, by elevating water temperatures, or by increasing pollutant and nutrient levels.

Inland flowing waters

Wide-ranging species such as King George whiting and yellow-eye mullet utilize estuaries in the study area as nursery and feeding areas. The short-finned eel, pouched lamprey, common galaxias, grayling, and rainbow trout may also use estuaries during spawning migrations. Amateur fishing in the estuaries of the study area yields bream, salmon, sea mullet, red mullet, estuary perch, snapper, mulloway, river garfish, tupong, and King George whiting. The estuary perch is thought to be decreasing in numbers, but still occurs in estuaries of such streams as Painkalac Creek and the Barham, Aire, Gellibrand, Curdies, Hopkins, and Moyne Rivers.

The lowland sections of some rivers support both amateur and commercial fishing. The Woady Yaloak River supplies brown trout and blackfish. Rainbow trout are taken in the Curdies River.

Sport fishing, especially for brown trout and redfin, occurs in Mount Emu Creek, Merri River, and the Hopkins River. Eels are taken commercially from the Eumeralla and Merri Rivers.

The grayling, a native species, was common in many Victorian coastal streams last century. In the study area it was once common in the Gellibrand River, in Skenes Creek until about 1920, and in the St. Georges River until about 1950, and probably still occurs in the larger more stable river systems, such as the Gellibrand and Barwon Rivers. It is now considered to be rare, with only small numbers being reported from some eastern Victorian coastal streams.

Another small native fish, the dwarf galaxia, has a distribution in the study area restricted to a few coastal streams. One of its main strongholds in western Victoria is the Eumeralla River on the western boundary of the study area. Its typical habitat includes swamps, backwaters, and slow-flowing streams.

The wide-ranging blackfish is still locally common (particularly in sections of the Gellibrand River), but apparently has suffered a recent general decline in numbers. It was common in the lower reaches of the Calder River in 1929, but today appears to be absent.

The mountain streams of the Otway Range represent those flowing waters of the study area least affected by European settlement. Although logging in the catchments has probably resulted in some alteration of stream characteristics, a unique and largely native fauna still persists.

In particular, the streams of the south-eastern slopes are unique for their populations of four native galaxiid species. The Parker River contains all four of these species and most of the other permanent mountain streams contain at least two or three species. Cox's mountain galaxia and the ornate mountain galaxia are mainly restricted to the upper reaches of the mountain streams. The spotted mountain galaxia occurs in the middle and lower reaches of the mountain streams, whereas the common galaxia is primarily found in estuarine situations along the edge of the mountains.

The only introduced fish to extensively invade the Otway Range is the brown trout. The native short-finned eel, blackfish, and ornate mountain galaxia coexist with the brown trout in the middle and upper sections of the Barwon, Gellibrand, and Aire Rivers.

Inland standing waters

Although no discrete fish component exists for either fresh or saline lakes in the study area, the diversity of species tends to decrease with increasing salinity.

Invertebrates

Invertebrates make up approximately 95% of the total fauna of the study area. They include worms, molluscs, and arthropods. Collectively they form a vital part of the ecosystem, forming the major elements in most food, break-down, and decay chains in both terrestrial and aquatic environments. They also play a major part in the fertilization, degradation, and break-down of plants.

However, lack of information means that this report can only draw attention to the group and mention a few species of special interest. Discussed below are a few land planarians, molluscs, and arthropods.

Wet open and closed forest

These forests contain a wide range of niches for invertebrates. Tall trees, dense understoreys, and thick litter layers provide habitats. The more obvious insects that occur here include butterflies of the families Satyridae and Lycaenidae. Mayflies (Ephemeroptera) caddisflies (Trichoptera), and stone-flies (Plecoptera) are often found, as they require the cool water of mountain streams.

Other insects occurring in this habitat are sucking insects such as cicadas (Cicadidae), scale insects (Coccidae), stick insects (Phasmatidae), and leaf beetles (Chrysomelidae).

The moist litter and fallen logs support a wide variety of cryptozoic fauna. These include the carnivorous snails *Victaphanta compacta, Strangesta gawleri,* and *Prolesephanta dyeri*, which are all rare and localized.

Among the many small endodontid snails are several species largely confined to the area. These forests also contain large populations of the bush leech, the land nemerteon, and several species land planarian. Of particular significance is *Geoplana warragalensis*, a rare species of planarian in Victoria recorded in the Otways wet open forest.

Victaphanta compacta (*the Otways black snail): one of the rare carnivorous snails found in the wet open and closed forests of the study area.*

Dry open forest

The relatively warm and dry environment here results in a prolific insect population. Moths and butterflies (Lepidop- beetles (Coleoptera), termites (Isoptera), grasshoppers (Orthoptera), cockroaches (Blattodea), bugs (Hemiptera), flies (Diptera), and ants, bees, and wasps (Hymenoptera) are all well represented. These forests also contain over 10 species of land planarians.

Grassy woodland

Like dry open forests, this habitat type supports a large insect population that includes representatives of most families mentioned above, although species diversity is reduced.

Heathy woodland

Few insects are specifically confined to this habitat - most also occur in others. Ants and ant lions (Myrmeleontidae) are found in sandy soils.

Pastures

A number of insects occur, particularly crickets and grasshoppers (Orthoptera). Land planarians are of the typical plains species of yellow-dominant form.

Inland flowing waters

Several fresh-water snails and limpets have been recorded. *Velusinio ambiguus* and *Hyridella drapeta* are fresh-water mussels commonly encountered in inland creeks and rivers. Yabbies occur in most streams.

Inland standing waters

The numerous lakes of the study area provide a series of aquatic habitats ranging from fresh water to extremely saline. Of special interest is a large population of operculate molluscs (*Coxiella striata*), which lives in Lake Corangamite and some other saline lakes. Other saline waters, such as Lake Gnotuk, have very sparse populations of *Potamopyrgus nigra* and a few oligochaetes. while *Lymnaea tomentosa* and *Bulinus* sp. are found in fresh-water lakes such as Lake Colac.

References

Bayly, I.A.E., and Williams, W.D. "Inland Waters and their Ecology." (Longman: Australia 1973.)

Brook, A.J. "Anurans of the Corangamite Study Area." Report to the Land Conservation Council, 1974.

Cayley, N.W. "What Bird is That?" (Angus and Robertson: Sydney 1931.)

Chessman, B.C., and Williams, W.D. Distribution of fish in inland saline waters in Victoria, Australia. *Australian Journal of Marine and Freshwater Research*, 1974, 25, 67-72.

C.S.I.R.O. An index of Australian bird names. *C.S.I.R.O. Division of Wildlife Research, Technical Paper* No. 20, 1969.

Emison, W.B., Porter, J.W., Norris, K.C., and Apps, G.J. Ecological distribution of the vertebrate animals in the volcanic plains - Otway Range area of Victoria. *Fisheries and Wildlife Papers, Victoria,* No. 6, 1975.

Fleay, D. The rare dasyures (native cats). *Victorian Naturalist,* 1932-33, 49, 63.

Frankenburg, R.S. "Studies on the Evolution of Galaxiid Fishes with Particular Reference to the Australian Fauna." (Ph.D. Thesis, University of Melbourne, 1969.)

Lake, J.S. "Freshwater Fishes and Rivers of Australia." (Nelson: Melbourne 1971.)

Littlejohn, K.J. Amphibians. *Victorian Yearbook* 1971, 85, 1-11.

Littlejohn, M.J., and Martin, A.A. The Crinia Laevis complex (anura: Leptodactylidae) in south-eastern Australia. *Australian Journal of Zoology,* 1964, 12, 70-83.

McVicar, J., and McFarland, R. "Report on the Animals of the Corangamite Study Area, from the Collections and Archives of the National Museum of Victoria." Report to the Land Conservation Council, 1974.

Rawlinson, P.A. Reptiles. *Victorian Yearbook,* 1971, 85, 11-36.

Renowden, J. "An Ecological Survey of the Freshwater Fish of the Otway District." (B.Sc. Hons. Thesis, University of Melbourne, 1968.

Ride, W.D.L. "A guide to the Native Mammals of Australia." (Oxford University Press: Melbourne 1970.)

Rogan, P.L., and Turnbridge, B.R. "Guide to Angling." (Victorian Fisheries and Wildlife Division of the Ministry for Conservation: Melbourne, in press.)

Sanders, K.J. Fish of the estuaries. *Victoria's Resources,* 1973, 15, 3.

Troughton, E. "Furred Animals of Australia." (Angus and Robertson: Sydney 1941.)

Turnbridge, B.R. The elusive grayling. *Freshwater Fisheries Newsletter* No.2, 1972.

Wheeler, R. "A Handlist of the Birds of Victoria." (V.O.R.G; Melbourne University Press: Melbourne 1967.)

Williams, R.J. Vegetation regions of Australia. In "Atlas of Australian Resources". (Department of National Development: Canberra 1955.)

(Various papers of interest may also be found in issues of *The Australian Bird Watcher, The Bird Observer,* and *Geelong Naturalist.*)

PART III

LAND USE

HAZARDS

Prior to European settlement of Australia, many ecosystems were relatively stable. Changes did occur as a result of normal geological processes, but these were long-term.

The impact of Man has resulted in the disturbance of the stability of many environmental variables comprising natural ecosystems. Some of these changes aimed at improving the environment for Man have, through lack of understanding, resulted in deterioration of the land.

This chapter discusses the known hazards associated with various land uses in the study area.

Soil Deterioration

In their natural condition, soil and vegetation are usually in a state of ecological balance. However, this balance can be upset by human activities such as cultivation, grazing, burning, extraction of timber, construction of roads, tracks, dams, and buildings, or trampling by people. The result of these activities can be soil erosion by either wind or water, or accumulation of salts to concentrations toxic to plants in the surface layers of soil.

Soil deterioration involves the community in losses of production. Although soil is being formed all the time from the weathering of parent rock, the process is such a long-term one that any loss of soil from productive land can be considered to be a permanent loss. As well as this, soil erosion causes siltation and water-quality problems in streams and reservoirs.

Soils vary in both the extent to which they can withstand disturbance and the manner in which they deteriorate following disturbance.

Water erosion

The porous friable soils of the Otway Range are generally resistant to gully and tunnel erosion. However, steep acres that have been recently cultivated for cropping or cleared for some forest operations are susceptible to sheeting and rilling. Landslips are common throughout most of the Otway Ranges. In 1956, a massive landslip damned the east branch of the Barwon River, forming Lake

Elizabeth. The severity and frequency of landslips has been increased by cultural developments.

Landslips - prone to occur in the steep, high-rainfall areas of the Otway ranges.

Landslips and rockfalls are a hazard to traffic along the Great Ocean Road and along many of the minor roads through the ranges. The steeper slopes that are cleared for agriculture are very prone to landslips and evidence of this can be seen in the stock terracettes covering the hills near Apollo Bay.

On the Tertiary sediments, slumping of soils is localized to laterite plateaux surrounding the Barwon River and its tributaries upstream from Winchelsea and in the Heytesbury district. In these cases, landslips often occur halfway down slopes and possibly coincide with

Stock terracettes are formed as cattle gradually cause mass movement of friable soils on steep slopes.

the emergence of springs below the lateritic cappings.

However, in contrast to the Mesozoic sediments of the Otway Ranges, slumping is not the most serious problem for the soils developed on Tertiary sediments. Almost every cleared drainage line in the moderately to severely undulating parts of this coastal Tertiary plain is susceptible to gully and tunnel erosion. The areas most highly prone to such erosion are the tributaries of the Barwon River upstream from Winchelsea, the Heytesbury settlement near Jancourt, and the Glen Thompson area in the north-west of the study area. In these areas it is not uncommon to find gullies up to 15 metres deep.

The sandy country in the Heytesbury district is prone to incipient sheet erosion when used for agriculture.

Some areas of public land in this sandy country have been used for surface stripping of sand and gravel and, unless reclamation has been implemented, severe sheeting and rilling can result. Examples of this can be seen at Barongarook, Carlisle, and Gellibrand and in the Bald Hills near Anglesea.

Wind erosion

In the study area, wind erosion is only a serious problem on a few sand dunes at river mouths of the Otway Ranges and at Peterborough. These dunes are at or near popular beaches and so receive heavy trampling in the summer months. Once unstable, they become a hazard to nearby buildings and roads.

Soils on Tertiary sediments are subject to erosion.

Stabilization is achieved by the tedious vegetative establishment of marram grass. A rather novel problem associated with wind erosion in the study area arises when Lake Corangamite retreats after successive dry years: *Coccinella* shells blown from the dry lake bed cover surrounding paddocks and block roads.

Salting

The accumulation of toxic levels of salts in the surface layers of the soil is commonly a problem of dryland farming

Marram grass, introduced from Europe, is very effective in dune stabilization.

where the hydrologic balance has been upset by clearing of deep-rooted natural vegetation. Salting occurs to some extent in the study area, particularly on soils developed on Tertiary sediments where annual rainfall is less than 800 mm. It is a significant problem on Quaternary sediments around Lough Calvert, which drains the salt-lake system to the north of Colac.

Fire

The accumulation of fuels in the forests of the study area combines with hot, dry summers to produce a high fire danger. There is evidence that wildfire, probably resulting from lightning and the hunting techniques of Aborigines, has been a significant factor in the evolution of the forest plant communities. In fact many of these communities probably depend on fires for their survival.

In the early days of European settlement extensive areas of productive forests were destroyed by fire associated with land-clearing operations. In latter years, damaging fires were recorded in 1919, 1920, 1926, 1933, 1934, 1936, and 1938. In 1939, fires burnt 87,000 hectares of forest in the study area and there were enormous losses of other property. During the last 10 years, 233 forest fires have occurred in the study area - more than 30% of them originated on adjoining private property, and 13% were attributable to forest visitors.

The fire hazard

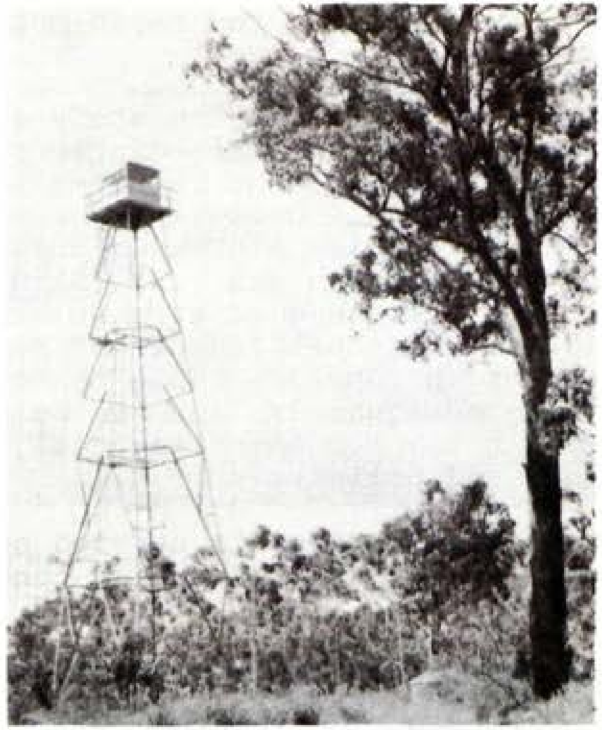
From the aspect of fire hazard, three broad forest vegetative types may be identified.

The mountain forest type that occupies the higher elevations of the Otway Range comprises mountain ash, messmate, and gums with a dense understorey. Rainfall is high, and in some years the forest remains damp throughout. However, the favourable growing conditions lead to heavy fuel accumulation and in dry years an extremely high fire danger results.

The foothill forests occupying both the northern and southern slopes of the Range consist of stringybark and peppermint with an understorey of low scrub species. The rainfall, of the order of 750 mm per year, falls mainly in winter and spring. The eucalypts spread prolific quantities of leaf and bark material, which dries out in summer. Consequently fire hazard is very high.

The lowland forests and woodlands occupy areas west of the main Otway Range and

Woodlands present a high fire danger.



Early detection is an essential feature of adequate fire control. Fire tower, Peter's Hill.

along the coastal strip. They comprise stunted eucalypts, along with heaths, grasstree, and scrub species. This vegetation burns readily and fire hazard is very high, particularly adjoining the much-frequented coastal resorts such as Lorne.

Successful control of wildfire depends on early and effective initial attack. The keys to success involve early detection, good access, and rapid mobilization of men and equipment.

Seven lookout towers in the study area are manned during the fire-danger period and aircraft are used as required to supplement them. A network of access roads and tracks is maintained throughout the area and men and fire-fighting equipment are located at strategic centres. During the fire-danger period, crews maintain constant radio contact with their headquarters and are held on stand-by, ready for immediate call, at week-ends and holidays.

Fuel-reduction burning is carried out in the study area under prescribed conditions that will support low-intensity fire, thereby reducing fuels with little permanent damage to the forest. Such burning is confined to the foothill and lowland forest, as the species of the mountain forest are sensitive and subject to damage, even in a mild fire.

Prevention of wildfires is partially achieved by adequate patrols and education.

Flooding

Stream floods occur with some regularity within the study area, but are seldom violent. However, due to the flat gradients and indirect outfalls to the sea of some streams, coastal areas may be subjected to inundation for prolonged periods.

Flash flooding is typical of streams with headwaters in the Otway Ranges, particularly those on the southern slopes with steeper gradients and direct access to the sea. However, such floods cause little damage to property.

Floods along the Barwon River valley cause inconvenience at times to individual landholders.

Lakes

Usually lakes have sufficient freeboard within their natural banks to accommodate all but abnormally heavy series of inflows. Lake floodings within the study area are therefore infrequent.

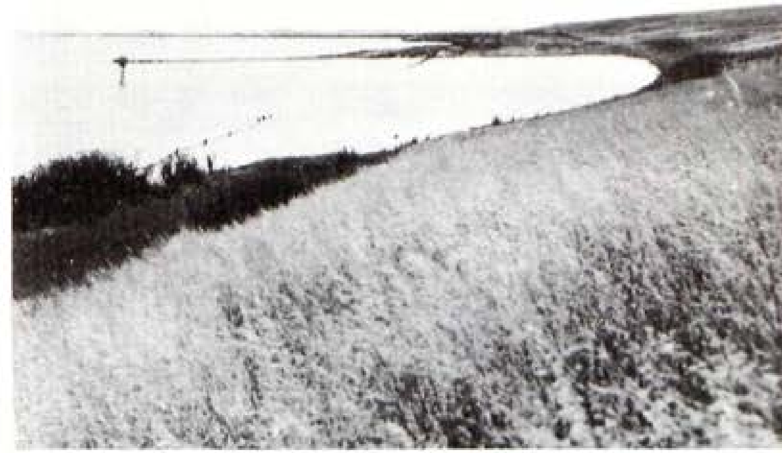
Prior to the 1950s flood period, the last serious lake floodings were reported in the 1870s. However, many thousands of hectares of public and private land were inundated between 1952 and 1960 around the margins of Lakes Corangamite, Gnarpurt, Murdeduke, and Colac, and Lough Calvert. Artificial drainage works have now substantially removed the likelihood of similar floods occurring again.

Lakes Corangamite and Gnarpurt

Lake Corangamite lies in a basin of internal drainage having no natural surface outlet to the sea. This basin has a total area of approximately 3,289 km^2, of which some 2,331 km^2 is within the study area. It contains a number of well-defined sub-catchments. The Woady Yaloak River is the most important, as it drains an area of 1,166 km^2, comprising the north-eastern sector of the basin above Cressy.

Lake Corangamite itself is about 32 km long and from 3 to 11 km wide, normally occupying an area of around 23,000 ha. Between about 1890 and 1950, the surface area is believed to have been about this order. This fluctuated between winter and summer and from year to year, without, apparently, causing any significant inconvenience.

Lake Gnarpurt, situated to the north-west of its larger neighbour, is separated from it by a narrow strip of land. It has a "normal" area of about 2,347 hectares, but under drought conditions



The creeping lakes problem: Lake Corangamite, August 1953.

this is much reduced. In very wet years such as 1952, 1956, and 1960, Lake Gnarpurt overflows into Lake Corangamite.

Prior to 1952, a number of small lakes and swamps lay immediately north-east of Lake Corangamite. These comprised Lake Martin, which lay to the north of the Woady Yaloak River, and a number of other salt lakes to the south. The combined areas of these lakes and swamps under more or less "normal" conditions is believed to have been about 1,740 hectares.

From 1951 to 1956 the level of Lake Corangamite rose 4.4 metres, resulting in the amalgamation of Lakes Corangamite, Gnarpurt, and Martin into one body, thus

Valuable grazing land lost through wave erosion: Lake Corangamite, 1958.

flooding many thousands of hectares of privately owned land. Several roads were cut and homes flooded or isolated. Wave action caused severe erosion of good grazing land.

The first Inquiry on this creeping lake problem was placed before the Parliamentary Public Works Committee in October 1955, and the Final Report, issued in December 1956, recommended a scheme to divert almost the entire flow of the Woady Yaloak River to the Barwon River.

As a result of the findings of this Inquiry, the State Rivers and Water Supply Commission constructed a major diversion channel from the Woady Yaloak River to the Warambine Creek, which flows into the Barwon River.

In order to maintain a constant flow in the diversion channel and to prevent flood flows entering Lake Corangamite, a regulating storage with a capacity of 87,000 Ml was completed in the Cundare Pool in 1959. A 1,200-mm-diameter pipe also connected Lakes Gnarpurt and Corangamite through the narrow strip of land separating them to permit control of the level of Lake Gnarpurt. Despite several wet seasons since their completion, these works have proved successful.

Lake Murdeduke

The normal area of this lake is now about 1,255 hectares, with a depth of 314 m and a water level with a reduced level (R.L.) of 280 ft. (Imperial units are used for reduced levels because a new datum is to be introduced; R.L. will then be expressed only in metric units.) Very little, if any, private land is flooded at this level. Natural inflow is from the Mia Mia, Barunah, and Mount Hesse Creeks. The lake rose quickly in 1952, when it received water that overflowed from the northern end of Lough Calvert, and poured down the Mount Hesse Creek. Local information suggests that this had happened previously in 1875.

By 1956, Lake Murdeduke had risen to R.L. 289 ft (6 m deep), the surface area then being about 1,860 hectares. Available information indicates that some 575 hectares of private land was submerged, practically all in two large properties. In 1958-59 overflow from Lough Calvert was controlled and the natural flow of the upper reaches of Mount Hesse Creek was diverted into the Woady Yaloak channel.

The lake then gradually receded to its present level. During the winters of

Prevention of flooding: The Woady Yaloak diversion channel outfall.

1960 and 1974 the lake rose to about R.L. 283 ft, but the danger of serious flooding seems to have been removed.

Lake Colac and Lough Calvert

Lake Colac is relatively large, having an area of approximately 2,690 hectares. It has a drainage basin of approximately 23,000 hectares, the main contributor being the Barongarook Creek, which enters the lake at the southern end. The natural overflow from Lake Colac is at the north-eastern end, where a depression runs some 7 km to Lough Calvert.

Lough Calvert consists of a chain of lakes and swamps approximately 16 km long to the east of the Colac--Cressy Road, with an area of approximately 2,100 hectares.

Following very high rainfall in 1951 and 1952, Lake Colac filled and overflowed into Lough Calvert. This led to the flooding of approximately 6,070 hectares of privately owned land. Seven farms were vacated and another 100 or so seriously affected. Floodwaters were 2.5 m deep in some places.

Water that overflowed from Lough Calvert reached Lake Murdeduke, as explained previously.

The Lough Calvert Drainage Trust was constituted in 1953 to construct and manage drainage works to remove surplus water. A low-level outfall channel was constructed from the Lough to the Salt Lake depression, which connects to the Birregurra Creek near Warncoort and thence to the Barwon River east of Birregurra. This outfall was subsequently improved and extended through the Lough itself, and by 1958 the problem had been largely resolved.

The Lough Calvert Drainage Trust is also responsible for the regulation of water from Lake Colac when the level exceeds

Flat areas are subject to waterlogging.

R.L. 385.50 ft. Releases are approved by the State Rivers and Water Supply Commission and are carried out between May and September, which is off-irrigation season on the Barwon River. This is necessary, as the water has a salinity of 2,000 to 3,000 mg per l at that time and is thus unsuitable for continuous irrigation. Salinity in the Barwon River below the junction of the Birregurra Creek is monitored when diversions are taking place, and the releases regulated to avoid exceeding 1,000 mg per l.

Resumption of freehold land

In 1966, the *Lake Corangamite Act* No. 7381 was passed by Parliament relating to the surrender to the Crown of certain lands inundated by or adjacent to Lakes Corangamite, Gnarpurt, and Murdeduke.

The Act provided for owners of land in these areas that lay below R.L. 380 ft (Corangamite), R.L. 389 ft (Gnarpurt), and R.L. 283 ft (Murdeduke) to elect within a period of 2 years to surrender such land to the Crown. Land that adjoined these lands and that had been eroded by wave action could also be surrendered.

Compensation was paid to land-owners surrendering land in accordance with a sliding scale based on a percentage of the value of undeveloped land that was not subject to flooding. The minimum compensation payable was $50 per acre.

The Cundare Pool was being used to deliberately impound water; the Parliamentary Public Works Committee therefore recommended in 1964 that the necessary steps be taken to enable the State Rivers and Water Supply Commission to acquire all alienated lands in that area below the full supply level of R.L. 391 ft, together with a flood easement on the marginal lands below R.L. 392.5 ft.

The area involved totalled 2,230 hectares, of which 150 hectares had already been acquired by the Commission and about 200 hectares would be flood easement.

All resumptions have now been finalized and the bulk of the land is leased for grazing under licence, in many cases to the original owners.

Fungi

Cinnamon fungus

The soil-inhabiting cinnamon fungus *(Phytophthora cinnamomi)* attacks the small feeder roots of a wide variety of native trees and shrubs, making it difficult for them to absorb water and nutrients from the soil. There is evidence that this pathogen was introduced into the study area relatively recently.

The symptoms of damage appear in the foliage of trees and shrubs and strongly resemble those produced by drought and nutritional disorders. The fungus is spread by the transfer of infected soil and by running water. It attacks plants most vigorously in warm moist soils.

Once the soil has been infected, the fungus cannot be eliminated without incurring great expense and jeopardizing the survival of the existing flora. To date the only successes have been recorded in nurseries, where small amounts of soil can be treated with soil fumigants.

Cinnamon fungus, recently introduced into the area, has the potential to kill significant areas of eucalypt forest.

This fungus was first noted in the study area in 1972 in the foothill forests, particularly around Wormbete and Angahook. It has the potential to kill significant areas of eucalypt forest.

Other fungi

The needle-cast fungus *Sclerophoma pitophylla* does affect radiata pine within the study area, but is not a serious problem.

Pest Plants

Many factors govern the growth and density of infestation of noxious weeds, but rainfall, soil type, and land utilization have the greatest influence.

There are 93 weeds proclaimed as noxious under the *Vermin and Noxious Weeds Act* for the State of Victoria and legal provisions require control measures to be carried out. A survey conducted in 1970 revealed that 60 of these are growing in the study area. Appendix 5 indicates the weed species and the number of parishes in each block of the study area where they are found.

Most species of noxious weeds only infest areas that have suffered some soil disturbance. Weed species have thus become plentiful along roads, in grazed areas, or at sites of old sawmills,

Table 9

HABITATS OF THE MAIN NOXIOUS WEEDS IN THE CORANGAMITE AREA

Habitat	Black berry	Bone-seed	Ragwort	Box thorn	Spear, shore, & variegated Thistles
Undisturbed native vegetation		*			
Disturbed native vegetation (by logging, grazing, and recreational usage)	*	*	*	*	*
Native vegetation cleared for timber, mining, or agriculture	*		*	*	*
Roadside easements	*	*	*	*	*
River frontages	*			*	
Coastal foreshores		*		*	

camps, and farms. They are of concern because they may compete with desirable species, impede access, or possess undesirable properties such as thorns, prickles, or toxicity.

The principal weeds in this area are the perennials, of which blackberry, ragwort, boneseed, and boxthorn are the most prevalent.

In the Otway Ranges and foothills extending west to Warrnambool, ragwort, blackberries, tutsan, and boneseed are well established. Table 9 shows their habitats.

Ragwort *(Senecio jacobaea L.)*

This pasture weed is poisonous to stock, but sheep are less affected than other animals and can be grazed lightly on it.

It is a prolific seed-producer and is spread by wind, water, and grazing stock. Root pieces can be spread by inadequate cultivation. When new areas of bushland are cleared for sowing pasture, the seed germinates and, if the plant is allowed to become established, eradication and control is costly.

Blackberry (*Rubus fruticosus* L. agg.)

Blackberry is widespread throughout the study area, but is more prolific in the Otway Ranges. It grows along waterways and roadsides, and on neglected farms, and is persistent.

It is difficult to eradicate, especially where access is difficult. Its persistence is due to its efficient reproduction and to the prickly growth that discourages stock from eating or trampling the plant.

Boneseed (*Chrysanthemoides monilifera* L.)

This weed poses more an environmental problem than an agricultural one, as it has the ability to compete with and eventually kill out native shrubs and flora. In agricultural situations the plant rarely survives, as stock will graze and trample it and cultivation will kill young plants. However, it presents a critical ecological problem. It is becoming established on public land along the coast and in the east of the study area.

Boxthorn (*Lycium ferocissimum* Miers)

In the early days of settlement, this plant was grown for wind breaks and used as fences. The seed is spread by birds, which eat the fruit. It grows in agricultural situations and, if left unattended, will cover large areas of ground and provide excellent shelter for rabbits. Boxthorn is chiefly found on fencelines, badly managed farms, and public lands throughout the study area.

Other weeds of agricultural importance throughout the study area include variegated thistle, shore thistle, Paterson's curse, horehound, spear thistle, ox-eye daisy, Cape tulip, and soursob.

Vermin

Animals declared vermin under the *Vermin and Noxious Weeds Act* found in the study area are rabbits, foxes, hares, and feral dogs. Feral cats are not covered by the Act, but do constitute pest animals in this area. The degree of infestation, type of damage, and methods of control for each of these animals vary for different environments.

Rabbits

The rabbit is found throughout the whole study area, but to a lesser degree in the timbered Otway Ranges.

On farmlands the rabbit, if control measures are not maintained, competes with stock for food and taints pasture to the stage where stock will not eat it. Public lands such as coastal foreshore reserves and other areas set aside for public use can be denuded of all native growth and suffer serious soil erosion.

The coastal margins, consisting of sand dunes and cliffs, and the stony rises are two areas where methods of control such as bait poisoning with 1080 and fumigation must be consistently and vigilantly carried out to maintain control of the rabbit population.

The flat undulating volcanic and coastal plains support heavy infestations. However, control is much easier here as all recognized methods of destruction can be used. The myxoma virus continues to assist in reducing the rabbit population throughout the study area.

Foxes

The fox is common in the region and lives in all types of habitat. It is not as serious a predator of lambs in fat-lamb-raising districts of the region as was previously thought, but can be a threat to smaller native fauna and birds where carrion sheep are not so readily available. Some landholders carry out control work by poisoning, but the population is reduced mainly by shooters and by secondary poisoning when rabbit poisoning is being carried out.

Hares

This animal usually inhabits the undulating plains country and only becomes a problem when a large colony forms. As the hare has only one litter a year and the young are easy prey for animal predators, it takes a number of years to form a colony. For several years in this study area the hare population has not reached the number where crop and young tree damage has been prevalent. Control is chiefly carried out by shooting.

Feral dogs

The feral dog is uncommon in the study area and stock losses caused by this animal are very low. Its main food comprises large native animals such as the wallaby.

The hydatid tapeworm is a common parasite in these dogs but their significance as sources of infestation for humans and domesticated livestock is unknown.

Feral cats

These animals are relatively common throughout the study area. They occur in a wide variety of habitats and pose a threat to the smaller native animals and birds.

Insects

Sirex

Sirex noctilio, a European wood wasp that attacks coniferous trees, was first detected on private property in the study area in 1967. Outbreaks have continued and currently present a threat to the softwood plantations near Beech Forest and Bambra.

Control by destruction of infected trees has had limited success because usually the insect has completed its life cycle before external signs on the trees reveal its presence. By that time the insects have emerged and laid eggs in other trees. However, an extensive campaign to breed and release insects parasitic on *Sirex* has been under way for a number of years, and their successful establishment has been effected in most areas of known *Sirex* infestation on private property within the study area.

Phasmatids

A plague of the phasmatid insect *Didymuria violescens* has built up in the mountain ash forests east of Melbourne since 1961. In some areas it has threatened destruction of that species. However, no serious phasmatid infestations have occurred in the mountain ash forests in the Otways.

Other insects

Various insects are minor hazards in the study area. These include bark beetles, cup moth, gum-leaf skeletonizer, and the blue-gum moth.

References

Coman, B.J., and Brunner, H. Predators on trial. *Vermin and Noxious Weeds Destruction Board Pamphlet* No. 45, 1973.

Cope, F. Catchment salting in Victoria. *Soil Conservation Authority, Victoria, Bulletin* T.S.L., 1958.

Downes, R.G. Land management problems following disturbance of the hydrological balance of environments in Victoria, Australia. *Proceedings of the 7th Technical Meeting I.U.C.N. Athens*, 1958.

Downes, R.G. The ecology and prevention of soil erosion. Biogeography and ecology in Australia. *Monographiae Biologicae*, 1959, VIII, 472-86.

Mitchell, A. Conservation of coastal dunes. *Victoria's Resources*, 1971, 13, 15-20.

State Rivers and Water Supply Commission. The Lake Corangamite problem. *State Rivers and Water Supply Commission Progress Report*, Nos. 1-3, 1961; 1962; 1963.

NATURE CONSERVATION

Conservation is concerned with Man's relation to his environment. It was described in Chapter 2 as being the wise or balanced use of resources to provide for his physical and spiritual needs, both now and in the future.

This chapter discusses those aspects of conservation concerned with the native species, communities, and landscapes of the area, which are commonly grouped under the collective heading 'nature conservation'. The following chapters consider other aspects, related to the production of food, fibre, and minerals. In some cases these activities also depend upon native species.

Ecology

Irrespective of their particular interest, all conservationists are basically concerned with environments and their use. The environment has both spiritual attributes, such as inspiring landscapes and remoteness, and physical attributes such as topography, timber, and minerals.

Its character is due to the integration of factors such as climate, soil, and vegetation, which have been discussed in the preceding chapters. Knowledge and understanding of these and of their interactions are essential for conservation.

Ecologists have developed terms and concepts that, although only convenient working abstractions, clarify our thinking and enable us to describe and discuss the otherwise incredibly complex web of interactions.

The ecosystem - the unit of study - is applicable on many scales; the whole world may be regarded as an ecosystem, as can a lake, a forest, or a small part of the soil beneath the floor of the forest. Each ecosystem contains four interacting parts: the inorganic materials, producers (green plants), consumers (chiefly animals), and decomposers (chiefly bacteria and fungi).

Biological communities

Biological community is the term given to any naturally occurring group of different organisms whose members:

(1) inhabit a common environment

(ii) interact either directly or indirectly with each other (especially through food chains)

(iii) are relatively independent of other groups

Some communities form more readily recognizable entities than others - for example the flora and fauna of a pond - but in fact no community is ever a

A pond could be studied as one ecosystem, but its boundaries are arbitrary. It is not biologically isolated from surrounding ecosystems.

closed system, since interactions, movement of animals, and transfers of energy continuously take place across any arbitrarily defined boundary.

Stability

Each community has evolved within its particular environment, and so together the species form a dynamic but fairly stable system. Undisturbed, the community represents the best combination and relative abundance of the available plant and animal species that can continue to live and compete with each other in the prevailing soil, topographic, hydrological, and climatic conditions.

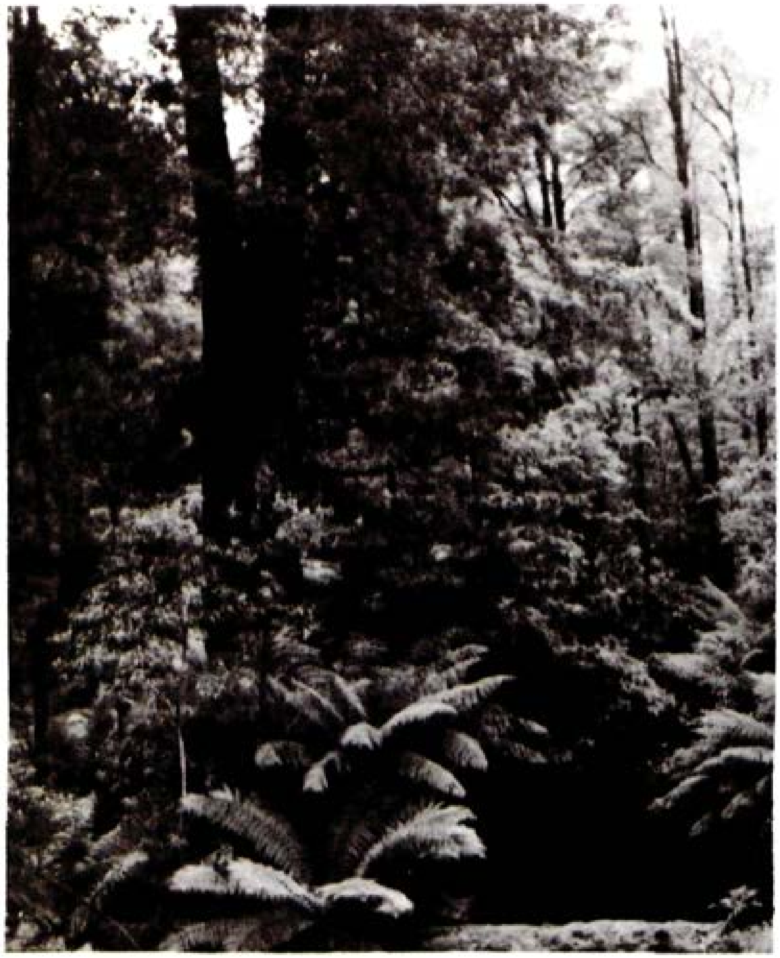
Different systems have varying degrees of stability. The more stable often tend to be those containing the greater variety. In some of the most vulnerable, stability depends on some particular set of circumstances such as specialized vegetation; others may have inherent topographic, soil, or hydrological weaknesses.

The influence of Man

Man is an important part of most world ecosystems. He is only one of many species, but his dense and rapidly growing centres of population and his ability to manipulate other species and parts of his physical environment make him very influential. He has affected - either directly or indirectly - all

Remnants of a manna gum woodland near Bellbrae. Man's influence is evident from the fences and bare ground due to grazing.

parts of this study area. Pressure of grazing by rabbits and domestic stock and the invasion by exotic weeds have changed the original pastures. Timber harvesting has changed much of the virgin forest, while the fire regime has been drastically altered. The network of access tracks is such that few, if any, parts of the area are further than 5 km from the nearest vehicle track.



Wet closed forest of myrtle beech, one of the most complex and stable communities in the study area.

Despite these pervading effects, it is convenient and generally accepted to distinguish between artificial systems (such as urban areas and farms) in which Man's influence is obvious, and "natural" ones (such as eucalpyt forests) which it is not so obvious.

Man must provide himself with adequate supplies of food and fibre, many of which he can best obtain from artificial systems such as wheat fields and pine plantations. He must manage such systems in a way that permits the combination of introduced plants and animal species to maintain general stability within the soil, topographic, hydrological, and climatic systems, just as the original natural combination did.

Certain other of Man's needs can best be provided by natural systems. Awareness of this is causing a rapidly growing demand, here as elsewhere, for land to be set aside and managed specifically to preserve the natural or native fauna, flora, and landscapes.

Conservation Needs

Some of the types of land required to satisfy the needs of nature conservation are discussed below. Each has value for our edification, inspiration, and recreation. Each requires different levels of management and manipulation. Their naturalness can vary considerably, being greatest in large areas used for reference and least in those intensively managed to preserve some endangered species or the remnant of a former landscape, and in areas that people are encouraged to visit for education and recreation.

None necessarily requires a monopoly of the land. Often they are compatible with each other or with commercially productive uses.

Areas for reference

Viable and relatively undisturbed examples of all land types (differing in land forms, soils, or biological communities) need to be set aside as reference areas to which those concerned with changing and managing land for either productive or aesthetic uses can refer when trying to solve the resultant problems.

As with references and standards used in other fields, these areas must not be tampered with, and natural processes should be allowed to continue undisturbed. Access should be restricted to competent observers carrying out approved work, and no experimental manipulation should be permitted.

Continued studies of natural features and their dynamics increase our knowledge of the ecological laws and processes on which Man's survival may ultimately depend. Reference areas act as standards against which the progress and effect of human alteration and utilization of the land can be measured. They will also provide a valuable gene pool of wildlife species. Such material is already being used, and will be increasingly used, to produce genetically strong domesticated species.

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

Few, if any, areas suitable for reference remain in some land types, such as those of the volcanic plains. Conscious effort must be made to retain reference areas of other land types currently being developed, for example some of the open forest types being converted to softwood plantations or to agricultural uses.

Park areas

Other examples of each of the major land types and their biological communities are also required for less restrictive inspirational, educational, cultural, and recreational purposes.

Several categories of park are needed. Large parks containing outstanding natural features and diverse land types are of nation-wide significance. These have visitor density restricted to a generally low level in order to impair their naturalness as little as possible (although limited areas such as information centres may be intensively used). They may contain areas of wilderness suitable for solitude, inspiration, and primitive unconfined forms of recreation.

On the other hand, smaller parks are of particular importance to regional populations. Higher densities of visitors are permitted and so the naturalness correspondingly declines. However, these parks still provide opportunities for contact between Man and nature, and serve the important function of reducing the pressure of visitors on more restricted parks.

Education areas

Education in the components and functioning of ecosystems is an important step in the conservation of natural resources. It is becoming an increasingly important feature of school curricula at primary and secondary levels, and with other groups concerned with nature appreciation.

The study of ecosystems is indispensably linked with field studies. Obviously some aspects of this type of education can take place in areas primarily used for production of, say, hardwood timber. Other aspects can only be dealt with in areas where the flora and fauna have been preserved in their natural state. However, nature is to be observed, felt, heard, smelled, and collected, and in some circumstances laboratory facilities and associated accommodation are needed so successive groups can undertake long-term studies. As these activities may not always be compatible with full preservation, some land will need to be set aside especially for education.

Endemic and endangered species

Every living thing is a unique assortment of biological characteristics, evolved over millions of years. Each offers a potential enrichment of human knowledge limited only by our capacity to appreciate and understand. The loss of any species therefore erodes the quality of the human environment. Many people feel that Man also has a moral responsibility to avoid endangering species.

It may be possible to ensure the continued survival of all species in zoological and botanical gardens, but only protection in their natural environment will permit a full understanding of the species and their interaction with the physical and biological factors that surround them.

Species endemic in the study area and endangered species must receive high priority for preservation.

Special values

Particular areas of land are often needed to preserve distinctive natural values.

The occurrence of a species near the limits of its distribution is of unusual scientific interest. A number of both plant and animal species mentioned in Chapters 10 and 11 reach these limits within the study area.

Some animal species, for instance the colony of Australian fur seal on Lady Julia Percy Island, favour certain areas as breeding localities. Other areas are favoured as stop-over places for nomadic or migratory animals. Some of these - such as the coast between Peterborough and Port Fairy - are discussed in the block descriptions.

Some areas provide particularly good examples of a geological feature or process, for instance the Mesozoic fossils that are exposed on cliffs at the Devils Kitchen near Princetown.

In scientific work, plant and animal names must be applied with precision, for the validity of much research work hinges on the accurate identification of the materials involved. The type specimen, chosen by an author when naming a new species, fixes the application of that name and is basic to correct identification. The locality at which the type specimen was collected is therefore of considerable importance, and protection from destruction or degradation should be approved for such areas.

In other natural sciences, type sections or materials are used to define, for example, soils or stratigraphic units.

Small areas

A host of smaller areas can contribute to nature conservation. They include narrow reserves along coasts, streams, and roads and remnants of the natural vegetative cover that have survived on areas originally set aside for purposes such as gravel, water, cemetery, and camping reserves.

Since these small areas of public land often still bear, perhaps in a modified form, their original vegetation, they make a contribution to regional character out of all proportion to their size. (An example of a small area containing a valuable relic of natural vegetation is the *Themeda* grassland in the small area of reserved forest north of Hexham.) They are often the only refuge for many of the remaining native animals.

In the past many of these small areas have not been properly administered, and they have not been as secure against alienation or despoliation as they ought to have been. Further, their recreation potential has not been fully realized - access is often difficult and they have not been well known to the public.

Appropriate management and rights of access to them are essential.

Productive areas

Some native species are valued for direct use. Game-shooting, a popular form of recreation, depends on the reliable supply of native ducks and quail. Much of the native flora provides honey, and wood is obtained from many species, mainly eucalypts.

Viability of Areas

The viability and effectiveness of nature conservation areas depend on a number of factors, including the size of the area, the type of community or ecosystem we wish to conserve, and the degree to which we can manage the area and control influences that tend to upset the natural balance.

Large consolidated reserves have less perimeter relative to their area than small or irregular ones and so tend to be better-buffered against the effect of intrusive factors. Generally the conservation of birds and mammals will require larger areas than those required for the maintenance of plants, insects, or amphibians. Communities that exist in more variable climatic zones - prone to drought, floods, or fire - usually require larger areas (or more examples) set aside to ensure survival.

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

Choosing areas

In addition to consideration of viability, many other factors influence the selection of areas for nature conservation.

Land is a limited resource, and good planning requires compatible uses to be grouped together on one area if possible. Where possible, a single reserve should cover a number of land types.

The migratory and nomadic existence of some animals requires corridors of habitat - linking, for example, breeding and feeding grounds.

Such corridors may be left intentionally through areas used for agriculture or softwood production, and they may even be used for a number of other purposes such as hardwood production.

In many cases few alternatives are available, as only remnants of the natural systems remain. Where they exist, areas with natural boundaries such as watersheds should be selected, as they are usually easier to manage and maintain.

Retention of vegetation along streams retains some nature conservation values when native forest is cleared for agriculture or softwood production. The retained strips must, however, be sufficiently wide to remain viable in the long term.

It is likely that, in practice, a balanced system of nature conservation will include a few fairly large areas (more than 20,000 ha) in which the major communities and land types are represented, supplemented by a greater number of smaller areas that are more intensively managed for a particular purpose.

References

Barwick G. "The Preservation of Diversity." (Australian Conservation Foundation: Melbourne 1971.)

Dasmann, R.H. "Environmental Conservation." (Wiley: New York 1968.)

Downes, R.G. Conservation and the community. *Victoria's Resources*, 1966, 8, 66-9.

Frankenberg, Judith. "Nature Conservation in Victoria: a Survey." Ed. J.S. Turner. (Victorian National Parks Association: Melbourne 1971.)

RECREATION

The term recreation as used here refers to the enjoyable activities that people undertake when they are not at work. It takes a multitude of forms, depending on individual preferences, but currently interest in activities orientated towards the enjoyment of outdoor surroundings is increasing. These activities involve various degrees of exertion and challenge, both physical and mental.

The many outstanding natural features of the study area - in particular the cliffs, rock platforms, and surf beaches on the coast, the Otway Range with its waterfalls, rugged terrain, and varied vegetation, and the undulating pastoral landscape of the hinterland - give it a very high capability for outdoor recreation. Its recreation value is enhanced by its proximity to the major population centres of Melbourne and Geelong and its location on the interstate coastal route linking Adelaide and Melbourne.

Outdoor recreation in the study area tends to be concentrated on public land, as it provides a variety of natural and semi-natural environments well suited to cater for a wide range of activities, and access is relatively unrestricted. Opportunities for outdoor recreation also exist on freehold land, often complementary to those on public land.

Factors Affecting Demand

A number of factors collectively influence the demand for outdoor recreation although the precise effects of each have not been fully determined.

Population

Population growth in Melbourne and Geelong, and to some extent in Warrnambool, Hamilton, and Colac, influences the demand for recreation in the study area. Melbourne's population is expected to increase from 2.5 to over 4 million by the year 2000. Geelong is considered a major growth centre in Victoria, and its population is expected to exceed 200,000 by the year 2000. These factors will vastly increase recreation pressures on public land, particularly in the eastern section of the study area, which is already attracting many visitors from Melbourne and Geelong.

Disposable income

Most forms of recreation require financial outlays for specialized equipment, travel, and accommodation. It has become evident from a number of overseas studies that people tend to spend an increasing proportion of disposable income on recreation as their real and disposable incomes rise.

There is also a trend of increasing affluence in the community, and a greater participation in outdoor recreation can be expected to accompany this increased affluence.

Mobility

The ability of people to reach many recreational sites in the study area depends on the motor car for transport, since access by public transport is extremely limited. As car ownership in the community increases, the frequency of recreation trips also increases. The amount of future recreation traffic within the study area can therefore be expected to expand considerably over present levels.

Accessibility

Parts of the coast in the study area receive very heavy recreational usage and this is in a large part due to the presence of a good-quality road along the coast. In general, areas with good access are used more heavily than those without. As access is improved, particularly in the Otway Ranges, recreational pressures on an increasing number of areas will grow.

Leisure time

As productivity rises in the economy, leisure time increases. Although there is some tendency for people to use some of this time in other employment, it is likely that the time available for recreation will increase also.

Due to the uniform pattern of the work schedule, recreation pressures on public land coincide with weekends, public holidays, and annual holidays. Recent trends towards flexible working hours - such as three-day weekends - may lead to more long-distance recreation trips extending further into the study area from the cities.

Education

Studies have shown a relation between the level of education and participation in outdoor recreation. Education curricula now incorporate a wider range of environmental studies that enhance environmental awareness and require access to tracts of natural bushland and geological or botanical sites close to schools.

Recreational Activities

There is a wide diversity of recreation activities, and the requirements for land types, degree of human intervention, size, and location of recreation areas vary. Some types are compatible with other land uses, while in other

Table 10

INCREASE IN CAMPING AND CARAVANNING

Location		Total number of people using park					Increase per year %
		Summer	Autumn	Winter	Spring	Total	
Lorne	1963	6,000	1,000	200	800	8,000	
(5 parks)	1973	14,000	3,000	700	2,300	20,000	10
Warrnambool	1963	600	350	5	20	975	
(1 park only)	1973	1,800	700	15	60	2,575	11
Killarney	1963	120	40	-	-	160	
	1973	160	40	-	-	200	2

cases strong conflicts occur. Some activities have requirements that confine them to limited parts of the study area.

Individuals seldom confine themselves to one form of recreation. They usually participate in a number of activities during the course of a year and often combine several activities during the one outing. Public land in the study area provides a wide range of recreation opportunities and therefore appeals to a large proportion of the community.

Few quantitive data relating to recreational use of the study area are available. However, the increasing popularity of the coastal holiday resorts is indicated by estimates of the numbers using coastal camping parks (see Table 10). The population of Lorne probably increases from the normal 1,000 to 22--25,000 in the January school holidays. The City of Warrnambool, with 1,105 camping sites, eight motels, and numerous flats and holiday homes, may double its population - from 20,000 to 40,000 - during the summer holiday season.

The influx of holiday-makers to the seaside in the summer months is accompanied by increased usage of public land in the hinterland of the study area.

The National Parks Service believes that 40,000 people currently visit the Port Campbell National Park each year, compared with the estimated number of visitors in 1972 to parks outside the study area and closer to Melbourne:

Kinglake National Park	98,000
Ferntree Gully National Park	110,000
Sherbrooke Forest Park	150,000
You Yangs Forest Park	96,000

Some recreation activities occurring in the study area and estimates of their popularity are outlined below.

Pleasure driving

As car ownership in the community rises, and tourist roads and facilities in the study area improve, driving for pleasure is likely to become increasingly popular. Trips most often involve family groups and extend from half to one day. Day trippers are attracted to good roads with scenic value or historic interest, and their excursions often include picnicking in pleasant surroundings.

The eastern end of the Otway Range as well as the coast is becoming increasingly popular for pleasure drives from Geelong and Melbourne, and the remainder of the Otway Range has potential for this use. On a fine Sunday or public

There is scope for most forms of recreation within the study area.

Maits Rest, Great Ocean Road, provides a suitable resting place for motorists.

holiday, numbers of day trippers in the east of the study area and similar areas further east have been estimated to be 150,000.

Surveys by the Forests Commission during January 1973 showed that Erskine Falls were visited by an average of 69 cars per day, the highest daily record being 129 on the Australia Day holiday and lowest being 33 on a week day. Some idea of the relative level of use in the Otways compared with areas closer to Melbourne is given by surveys by the Australian Road Research Board on isolated Sundays in January 1970:

Sherbrooke Forest	202 cars
Kinglake National Park	413 cars
Lerderderg Gorge	167 cars
You Yangs	320 cars

It is difficult to know how representative of the "typical" situation such figures are, since weather, and events such as car rallies and club picnics, cause large variations.

Driving for pleasure and picnicking are not confined to the coastal or Otway Range areas, and often cover those used primarily for agricultural production in the hinterland.

Picnicking

Picnic facilities are provided throughout the study area, particularly in parts of the Otway Ranges and along the coast. The location of these is shown on the recreation map. Picnicking often occurs in conjunction with pleasure driving and may in fact be the main object of the trip. Picnic sites usually coincide with areas of recreational interest such as the Erskine Falls and Maits Rest reserve.

Car rallies

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

All-terrain vehicles

These vehicles, which are capable of off-road movement, include trail bikes, dune buggies, and four-wheel-drive vehicles, and drivers seem to seek the challenge to their driving skill posed by remoteness and ruggedness.

This form of recreation is coming into growing conflict with other land uses. It may cause damage to the environment and destruction of essential four-wheel-drive fire-access tracks. The value of remote areas to others seeking recreation may be reduced by noise pollution.

Isolated coastlines provide opportunity for solitude.

The use of vehicles registered under the *Motor Car Act* 1958 on public land is permitted only on roads formed for the passage of vehicles having four or more wheels. However, the *Land Conservation (Vehicles Control) Act* provides for the declaration of 'free-access areas' where the use of properly registered vehicles (under the *Motor Car Act* 1958 or the *Recreation Vehicles Act* 1973) off roads is not an offence. The need for provision of land for motorized recreation is becoming greater.

Bushwalking

The Otway Range and adjacent coastline provide the main attractions for bushwalking in the study area. Bushwalking is often combined with other activities such as climbing, canoeing, surfing, and various aspects of nature study. Two broad categories with differing requirements can be identified: short walks for pleasure or interest along walking tracks, and longer walks involving overnight camping.

Day walks are confined mainly to the coast and Otway Range, in particular the Lorne area and Angahook Forest Park in the extreme east of the study area. There is also interest in walks around extinct volcanic cones such as Tower Hill and Mount Elephant.

Longer walks involving overnight camping require larger areas of bushland and often include agricultural land. Overnight bushwalking is increasing in popularity, particularly in the Cape Otway--Aire River area and along the Cumberland River. Walking clubs have estimated that 2,500 walkers visited the study area during 1975.

Orienteering

This sport is increasing rapidly in popularity. However, at this stage it is not practised to any great extent in the study area. The most suitable land types for orienteering are flat to undulating terrain with forest cover but minimal undergrowth. In the study area this would include the undulating to hilly zone of natural vegetation or alternatively some softwood plantations. Adequate car-parking facilities should be ensured at the assembly point for competitors and their families.

Camping and caravanning

The study area contains a number of developed camping and caravan parks throughout, mainly in coastal areas and adjacent to inland lakes. Use of these parks is confined mainly to the summer. Table 10 gives estimates of numbers of people using a sample of municipal camping parks in each of the four seasons for 1963 and 1973. Coastal resorts such as Lorne have been experiencing annual increases of 10--12% in the number of campers and caravanners, and this rate must be expected to continue. These increases in holiday campers will significantly affect the usage of public land in the areas close to holiday resorts.

Hunting and fishing

The major form of hunting in the study area is duck-shooting. Popular localities for this sport are shown on the recreation map and include Lake Murdeduke, Lake Colac, Lake Linlithgow, and the Cundare Pool. Most streams in the Otway Range provide good fishing, as do a number of rivers on the coastal and basalt plains. These include the Barwon, Curdies, Hopkins, and Merri Rivers as well as Mount Emu Creek. Popular lakes for fishing include Lakes Bullenmerri, Purrumbete, and Colac and the Hamilton and Allen Reservoirs. The most sought-after fish include the fresh-water perch and eels.

Water-based activities

Swimming, surfing, sailing, and power-boating are popular at many coastal localities in the study area. Canoeing is increasing in popularity in the lower rocky sections of rivers on the coastal

Disused vehicular tracks provide easy strolls.

fall of the Otway Range. A number of the inland lakes have high potential for water-based recreation, and use of them is growing. Lake Colac has five clubs associated with it - yachting, rowing, sea-scouts, angling, and power-boating. Colac City Council is providing a new camping park by the lake to cater for an increasing demand.

Golfing, tennis, horse-racing, etc.

These activities form an important part of the recreation requirements of the local population, and the provision of facilities may require substantial site alteration. They usually lie close to population centres, and those on areas of public land are usually administered by local government or committees of management.

Recreational Resources on Public Land

Only a small proportion of public land in the study area has been specifically reserved for recreation. In the original land surveys, the coastal reserve and many other small reserves were set aside for public purposes. These included sports grounds and recreation reserves in all towns and special reserves around sites of natural beauty, such as some of the waterfalls in the Otway Range. However, there is a lack of such reserves on the fertile volcanic plains. Only about 400 ha of public land outside townships has been set aside for recreation in this agricultural zone. Small reserves exist on some areas of interest such as Mount Rouse or Red Rock.

In the last two decades, a number of reserves with high nature conservation and recreation value have been created on public land. These include the Port Campbell National Park (708 ha) and Forests Commission scenic reserves at Maits Rest (74 ha), Calder River (38

Hopkins falls, near Warrnambool, is one of the many falls that attract tourists.

ha), Grey River (49 ha), and Kalimna Falls (89 ha). Larger reserves have recently been declared by the Forests Commission on the eastern border of the study area at Lorne (3,679 ha) and Angahook (2,914 ha).

Recreational use of the study area is of course not confined to areas specifically set aside for that purpose. Opportunities for recreation are available to varying degrees on the remaining public land, often supplemented by private land as well.

In order to understand the recreational potential and type of recreational use of land, it is convenient to define several zones.

Urban zone

No large urban areas lie within the study district. The city of Warrnambool has the largest area, followed by Colac, Camperdown, and Mortlake. Within the urban zone, specific relatively small areas are provided for formal recreation activities such as tennis, golf, bowls, football, and general recreation. Facilities are often provided for campers, caravanners, and tourists.

Agricultural zone

About 75% of the study area is agricultural land, particularly in the north and west. It is characterized by extensive clearing or alteration of the natural vegetation. It has been classified into four categories, based mainly on topographic differences: flat plains, stony rises, undulating to hilly, and steep dissected land.

Stone fences add interest to the landscape in the stony rises.

Extensive areas of flat agricultural land occur on the basalt plains. Such an open landscape does not have a high potential for outdoor recreation. The general lack of features tends to emphasize the value of those that do exist.

Stony rises, representing Recent basalt flows, occur extensively around Lake

Corangamite and in some other parts of the study area. The rugged terrain - of uncleared rises interspersed with many small lakes - provides an interesting study to the naturalist. Early settlers who clared parts of the rises for grazing used the basalt stones to build durable fences, and their intricate workmanship adds attraction to an otherwise open agricultural landscape.

Undulating to hilly agricultural land is confined mainly to the Tertiary coastal plain and the lower flanks on the northern side of the Otway Range. This landscape is more aesthetically attractive than the two previously described, providing good opportunities for pleasure driving.

Areas of steeply dissected land have been cleared for agriculture in the Otway Range, mainly on the coastal side. The scenic grandeur of this landscape is one of the distinctive features of the Otways. The steep cleared hills afford distant views, providing great attraction to the hiker, pleasure driver, or picnicker.

Zones of natural vegetation

These zones are described in detail in Chapter 10. Most of the public land in the study area, other than lakes, remains under natural vegetation. Two zones can be distinguished by their recreational potential; steep land, and very undulating to hilly land.

Steep forested land (slopes greater than 20 degrees) covers much of the Otway Range, particularly on the coastal side. The damp, heavily forested terrain is dissected by deep fern gullies and gorges, with many waterfalls forming on the steep descent to the sea. Distant views are often seen through the trees. The zone provides excellent opportunities for nature study, bushwalking, pleasure driving, and picnicking.

The zone of undulating to hilly terrain (slopes less than 20 degrees) covers much of Otway Range on the inland side. The forest vegetation encloses the landscape and distant views are seldom seen. Although aesthetically less pleasing than the previous zone, it still proides good opportunities for many recreation activities. The native woodland and heathland of the eastern and western flanks of the Otways support a rich flora and attractive wildflower displays can be observed, particularly in spring.

Coastal zone

About 240 km of coastline forms the southern boundary of the study area. It represents the most scenically diverse section of coastline in Victoria. For the purpose of this chapter, three broad subdivisions can be recognized: east of Cape Otway: Cape Otway--Warrnambool: and west of Warrnambool.

East of Cape Otway, the seaward edge of the Otway Range consists predominantly

The coastline provides many attractions, including the sites of shipwrecks such as the "Loch Ard".

of a steep rocky coastline with many spectacular views. Rock platforms extending out to sea are popular with fishermen and provide good opportunities for observing coastal reef flora and fauna at low tide. Some beaches, such as those at Lorne and Johanna, provide good surfing.

The speed of erosion between Cape Otway and Warrnambool has left steep cliffs, tunnels, arches, and rock stacks, which attract many sightseers. Examples are the Twelve Apostles, Loch Ard Gorge, and London Bridge.

Sandy beaches and dunes are confined to the section of the coast west of Warrnambool.

Softwood zone

About 3,600 ha of softwood plantations occupy public land in the study area, confined almost entirely to land near or

Pine plantations are popular for some forms of recreation.

The aftermath of recreation.

on the Otway Range. Mature plantations have attractions of their own, and are becoming increasingly popular for recreational activities such as camping and picnicking. The Aire Valley plantation contains a number of species of exotic conifers and presents a visually diverse environment popular for pleasure driving.

Inland waters

Approximately 35,400 ha of public land in the study area consists of water contained in inland lakes. The generally open landscape surrounding most of these lakes and difficulties of access across freehold land to some extent detract from their potential for water-based recreation. However, fishing and duck-shooting are popular in some localities, such as Lake Colac, which is also popular with power-boating and yachting enthusiasts. The water supply reservoirs in the Otway Range are mostly closed to direct recreational use.

Estuaries

Several estuaries exist at the mouths of rivers in the study area. These include the Aire, Hopkins, Curdies, and Shaw Rivers. Estuaries provide sheltered water for boating and swimming, and are good localities for fishing.

Land Use Compatability

In some cases competition between recreational uses and other land uses does occur in the study area. Recently the increased demand for outdoor recreation has caused the exclusion of other activities, such as timber production, from prime recreation areas. In other cases recreation can occur alongside many other activities. Organized sports requiring site development (such as golf courses) tend to exclude other uses. On the other hand less-intensive activities such as pleasure driving or bushwalking have large-scale land requirements and create few conflicts with other uses.

Often one recreational use of an area will conflict with another. For example, the activities of motorized recreation vehicles are beginning to conflict with other recreational and non-recreational uses, particularly on public land in the east of the study area. This area is under increasing pressure from the large urban populations of Melbourne and Geelong.

Pattern of Recreation Trips

Very little quantitative data relating to the pattern of recreation trips in the study area are available, but some existing and likely future patterns are obvious.

The increase in population of Geelong and Melbourne will result in greatly increased recreational usage of public land, particularly along the coast and in the Otway Range. Easier access to the study area, due not only to improvements to roads within the area but also to developments such as the West Gate Bridge, will add to this increase. At the present time visitors come mainly from Geelong, Melbourne, or towns within the study area. However a significant number of people from South Australia visit the area, particularly the Otways, during holidays.

Recreational activities in the study area at present tend to be concentrated on the coast, but this pattern is likely to change as these activities diversify and access improves.

References

Clayton, G. The demand for recreation travel. *Proceedings of the 5th Conference, Australian Road Research Board, 1965* (2), 208-26.

McMichael, D.F. Society's demands for open-air recreation, wilderness and scientific reference area. *Institute of Foresters of Australia 6th Conference, Thredbo, May 1971.*

Mercer, D. Planning for coastal recreation - an overview. *Coastal Resources Forum, Natural Resources Conservation League, Melbourne, March 1972.*

HARDWOOD PRODUCTION

Hardwood forests cover most of the public land on the Otways. Largely as a result of past land-settlement schemes, wildfires, and the difficulty previously experienced in establishing regeneration in the mountain areas, these forests are not yielding anywhere near their high potential for timber production.

Re-establishment to achieve the maximum level of productivity of which these forests are capable now depends upon the removal of large quantities of lower-quality wood, considered useless for sawing but suitable for pulpwood, and the removal of dense scrub growth from areas denuded of forest.

Steep slopes may render farming uneconomic, and the land reverts to scrub.

Effect of early land use

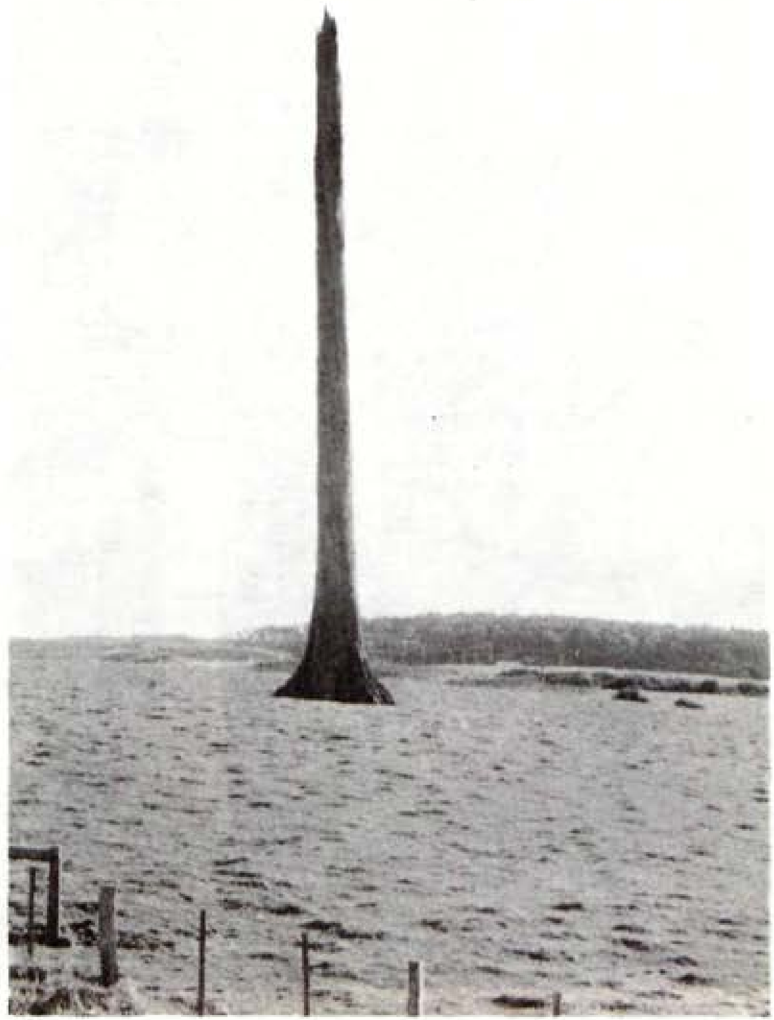
The hardwood forests are the remnants of magnificent forest stands that were present, in particular on the Otway Range, prior to the area being thrown open to settlement in the latter part of the 19th Century (see Chapter 4). This action was criticized by a number of officials, who recognized the value of these areas for timber production. Thus in 1887 reports by F. D'A. Vincent deplored the releasing of the forested land for settlement, and indicated that: "there is every reason to suppose that much of the land has been taken up for the sake of the timber". Vincent's statement is supported by the Forest Department's annual report of 1912: "After 30 years of settlement the freight on the narrow-gauge line is composed almost wholly of timber".

Despite strong recommendations in 1897 by the then Surveyor General (S.K.

Vickery) and Inspector of Forests (J. Blackburne) that "all unalienated lands in the Otways district, as indicated, together with any allotments relinquished or forfeited, should be incorporated in this forest", further settlement of land was permitted. Between 1899 and 1904 the Benwerrin and Wymboliel lands were thrown open to settlement. By 1910 the Annual Report of the Forests Department reported: "Indeed a marked feature of this district is the wilderness of inferior growth and scrub, the result of partial clearing by fire, which is taking the place of the great forest of blue gum and ash which once occupied it".

In addition to the depredation of the forest by land settlement schemes, wildfire has had a marked detrimental effect on the forest. In 1919 wildfires further decimated the high-quality forest and caused property losses from which fringe-area settlers were unable to recover. These fires did, however, result in the prolific regeneration of high-quality forests in the area, and the Forests Commission purchased abandoned farmland carrying belts of this class of regeneration.

Unfortunately, further fires in 1939 destroyed some of the young age classes and, on the area burnt, brought about accelerated deterioration of older standing trees. The result is now a dearth of merchantable sizes in regrowth and a deterioration in log quality in the older age groups and regeneration that survived the burning.



Mountain ash stag in the Otway Ranges: monument to past forests.

Open forest IV of manna gum and mountain ash in the Parker River catchment: highly productive mountain forest.

Forest Types and Products

Three broad hardwood forest types recognized in the study area are the mountain forests, the foothill forests, and the unproductive forest.

Mountain forests

These are defined as 'pure' mountain ash forest and adjoining mixed-species forests where the mature stand height exceeds 40 m. This stand height boundary coincides closely with the boundary of the high-rainfall understorey species such as musk. It also corresponds roughly with the 1,600-mm-rainfall isohyet on the northern slopes of the Otway ridge and the 1,200-mm isohyet on the southern slopes.

Distribution of the mountain forests is shown on the vegetation map (open forest IV). Within the study area they total approximately 41,280 ha, of which 36,830 ha are on reserved forest and 4,450 ha are on Crown land.

Predominant species are mountain ash, messmate stringybark, manna gum, southern blue gum, and mountain grey gum. The high volumes per hectare and fast growth rates of these species in the study area (see Table 11) place them among the most important commercial species in Australia.

They provide both sawn timber and pulp for paper and hardboard. The sawn tim-

Table 11

HARDWOOD TIMBER PRODUCTION

Category	Structural form	Main timber species	Predominant Soils	*Productivity (MAI in m^3/ha/m)
A High	Open forest IV	Mountain ash, messmate, manna gum, blue gum, mountain grey gum	Friable brownish gradational	Probable MAI range is 7--21 depending on site index; suitable for sawlogs and pulpwood
B Moderate	Open forest III	Messmate, mountain grey gum, brown stringybark, and narrow-leaf peppermint	Friable brownish and ye low gradational	Estimated MAI about 4; potential MAI about 5; suitable for sawlogs and pulpwood
C Low	Open forest II	Messmate, brown stringybark, gums, and narrow-leaf peppermint	Yellowish gradational	Estimated MAI about 1--4; potential MAI about 3--5; suitable for sawlogs, pulpwood, and minor products
D Very Low	Open forest I and woodland	Brown stringybark, shining peppermint	Leached sands and duplex soils	MAI very low, unsuitable for sawlog/pulpwood production

*Notes on productivity

1. MAI (mean annual increment) - Total volume production to 10-cm small-end diameter under bark divided by the number of years in the rotation.
2. Potential MAI is that expected to be achieved from natural forest with improved utilization, better stocking, and more intensive management

ber is used for house-framing and a wide range of general construction purposes.

Regeneration of these mountain forests requires conditions of exposed soil or an ash bed, no overhead shade, and a supply of seed. Such conditions occur naturally following wildfire in mature stands; they may be artificially created by clear-felling, controlled burning, and seeding.

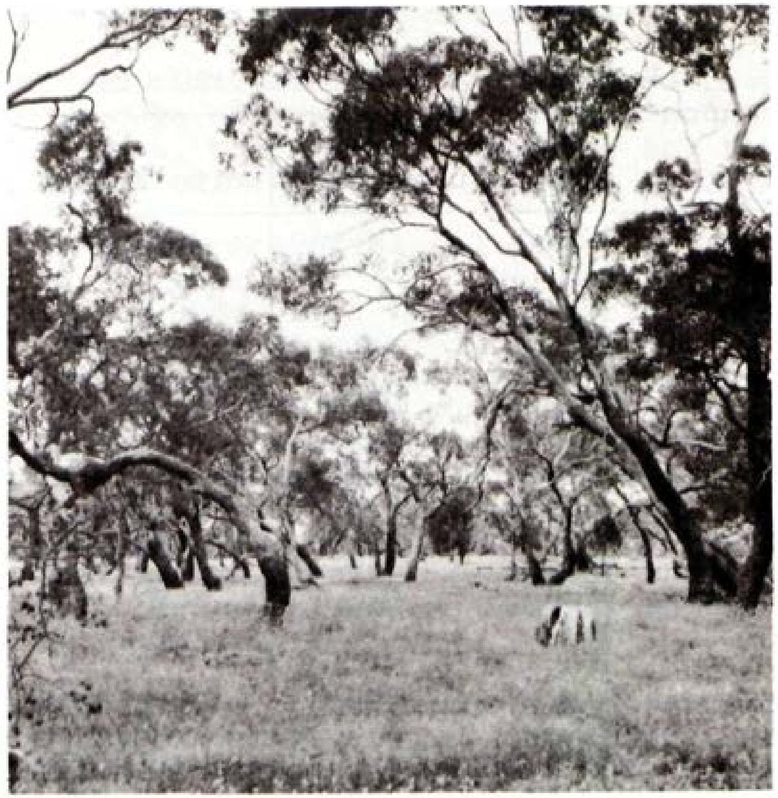
Foothill forests

These are defined as all forest below 40 m mature stand height that is capable of producing an economic yield of sawlogs. (Present economic minimum yields are approximately 22.0 m^3/ha of 10-m sawlogs with small-end diameters under bark greater than 25 cm.)

Distribution of the foothill forest is shown on the vegetation map (open forest II and III). The study area contains approximately 60,000 ha of foothill forest - 51,400 ha on reserved forest and about 8,600 ha on Crown land.

Predominant species for timber production are messmate, mountain grey gum, southern blue gum, manna gum, and brown stringybark.

Although the foothill forests have slower growth rates than the mountain forests, they are still important timber-producing areas (see table 11).



This woodland near Woorndoo is unproductive for timber.

The species are used for both sawn timber and pulp for paper and hardboard.

Unproductive forests

These are defined as all areas not capable of producing an economic yield. Mature stand height is generally below 15 m. Predominant species are brown stringybark and shining peppermint.

Distribution of unproductive forest is shown on the vegetation map (open forest I and woodland. The study area contains approximately 22,200 ha of it, 7,730 ha on reserved forest and 14,470 ha on Crown land.

Present Supply Situation

Sawlog supplies

The timber industry directly employs 360 people in the study area, with an additional 59 people employed by the Forests Commission. The industry also indirectly supports an estimated 628 people employed in service industries. Forest industries thus support about 9% of the work force recorded in the 1971 Census for the Shires of Heytesbury, Otway, Colac, and Winchelsea, i.e. those Shires covering the forested sections of the study area.

The Forests Commission is responsible for allocating sawlog and pulpwood supplies. It recognizes the importance of stable rural industries and the significant role played there by the timber industry. Accordingly, the Commission endeavours to make available a steady supply of logs.

For 1975/76 the annual supply of hardwood sawlogs allocated from public land in the study area is 50,000 m^3. It is becoming increasingly difficult to sustain this cut to the nine hardwood mills at Colac, Apollo Bay, Gellibrand, Barwon Downs, and Birregurra because of a decline in quality of trees available for harvesting.

Pulpwood supplies

Public land in the study district can provide a sustained annual quantity of 60,000 tonnes of hardwood pulpwood. The paper-making firm of Smorgon Consolidated Industries Pty. Ltd. is currently authorized to cut this quantity annually for raw material for its paper-making plant in Melbourne.

The continued availability of this pulpwood market will permit considerable improvement in the management of commercial forests, as it allows more complete utilization of wood on the areas being

The Otway hardwood forests currently provide 50,000 cubic metres of sawlogs annually.

Public land in the study district produces 60,000 tonnes of hardwood pulpwood annually.

harvested and consequently cheaper and more effective re-establishment of new forests.

Future Wood Supply And Demand In Victoria

The long lead time necessary for wood production means that forecasts of wood supply and demand must be made many years into the future.

Such forecasts are extremely difficult to make with confidence. The supply could be again affected by events such as the catastrophic fires of 1939, which destroyed large areas of productive forests. Supplies for import will depend on the international political situation and on competition between countries for available resources.

Changes in technology could affect the demand, as could changes in population growth rate.

Despite these uncertainties, forecasts, and subsequent action, based on the best available information, are necessary to ensure that adequate supplies of wood are available to meet community requirements in the future.

Demand

The general State picture at present is that supply of sawlogs must be supplemented from interstate and by imports. Demand for sawlogs is currently about 2.4 million m^3, of which Victorian hardwood and softwood forests supply about 1.6 million m^3.

The balance is obtained by imports of softwood from South Australia (0.2 million m^3), hardwood from Tasmania (0.3 million m^3), and about 0.3 million m^3 from overseas (mainly softwood from New Zealand and North America).

The current annual demand for processed wood products such as paper, particle board, and plywood is about 1.75 million m^3 (G.R.W.E.), of which about 0.8 million m^3 is supplied from forests within the State. The major import is newsprint from Tasmania.

(Gross Round-wood Equivalent (G.R.W.E.) is the total of the various wood products expressed as the volume of round wood required to produce them.)

Future demand is calculated on the basis of anticipated population and estimated per capita consumption of the various wood products. The most recent predictions indicate that the future population of Australia may be substantially lower than earlier estimates. In 2001, the population of Victoria is now expected to be between 4.05 and 4.78 million.

Consumption per capita is expected to increase from 1.46 m^3 (G.R.W.E.) in 1970 to about 1.73 m^3 (G.R.W.E.). By the year 2000, Victorian demand for wood products is thus expected to be between 7.0 million m^3 and 8.3 million m^3 (G.R.W.E.).

In addition, it is expected that a proportion of the South Australian demand for sawlogs will eventually be met from Victorian Forests.

Supply

The existing hardwood and softwood forests in Victoria do not meet all of our requirements, the current shortfall being met by imports.

The current softwood extension programme is intended to supplement the supply in future. It is estimated that the maximum annual supply obtainable from Victorian forests in 2000 without detriment to future productivity will be about 6.0 million m^3.

This estimate is made on the assumptions that the current softwood plantation programme is maintained on both public and private land (see Chapter 16) and that the area of native forest available

This messmate plantation, on purchased farmland, is part of the district's future wood supply.

Sawlogs, harvested during dry weather, are stored for later processing.

for timber production is not reduced. If maximum practicable utilization can be made of both sawlog residue and recycled paper, then the effective supply could well be increased.

The supply and demand position in Victoria is complicated by the fact that several major wood-using industries dependent on Victorian forest supply interstate markets.

The major part of the Australian market for packaging and industrial paper is produced in Victoria by Australian Paper Manufacturers Ltd. and Smorgon Consolidated Industries Pty. Ltd. About half of their combined input is round wood, and the balance is sawmill residue and recycled paper.

Other products such as hardboard, pine particle board, tissues, and light wrapping paper are also produced in Victoria and marketed interstate.

Furthermore, South Australia is expected to become a nett importer of sawlogs during the latter part of this century, and Victoria will probably then supply a significant part of the South Australian demand.

The ideal of State or even national self-sufficiency may, of course, be questioned, although increasing difficulty is expected in importing supplies of wood and wood products at reasonable cost.

Plans for The Study Area

The study area includes a large softwood plantation, future plans for which are described in Chapter 16.

Hardwood sawlogs have been the major product from the area in the past, but now hardwood sawlogs and pulpwood are produced in about equal quantities. In the future, sawlog and pulpwood procurement operations will both be of major importance, with the pulpwood-harvesting operations playing a large part in the rehabilitation of heavily cut-over area.

The Otway hardwood forests will continue to fulfil an important role in the future supply of wood for Victoria.

Other Forest Values

The value of the forests of the study area in protecting the water supplies and the native fauna and flora are emphasized in other chapters and the utilization of forests for timber generally attempts to conserve these values as far as possible.

The Otway forests also have a high capacity for outdoor recreation, because they offer a forest environment close to the seaside resorts of Lorne, Anglesea, and Apollo Bay. The current usage of the forests for recreation is described in Chapter 14.

References

FORWOOD. Forestry and Wood-based Industries Development Conference. (Australian Government Publishing Service: Canberra 1974.)

Borrie, W.J. "Population and Australia - a Demographic Analysis and Prediction." (Australian Government Publishing Service: *Canberra* 1975.)

Forests Commission of Victoria. Submission to the House of Representatives Standing Committee on Environment and *Conservation Inquiry into the Softwood* Timber Industry (unpublished).

SOFTWOOD PRODUCTION

Softwood plantations, predominantly of radiata pine (*Pinus radiata*), cover some 4,000 ha of public land in the study region. The area has been increasing in the last few years at the rate of about 120 ha per annum.

The State softwood plantations are located mainly at the head of Aire River, Webster's Hill, Boonah, Forrest, and Waarre. In addition, private companies have planted about 1,400 ha of radiata pine on freehold land.

Sawlogs from the Aire Valley plantation, the only plantation currently yielding sawlog material in the Otways, are supplied to sawmills at Colac. Current output of sawlogs and plywood logs is about 36,000 m^3 per annum. Pulpwood is supplied to chip-board and paper manufacturers at Ballarat and Maryvale. Other plantations in the area are too young to yield sawlog material.

Historical

Attempts made in the late 19th Century and early 20th to utilize land in the Otway ranges for agriculture met with little success, and portions of the land cleared by the early settlers reverted to the Crown (see Chapter 4).

The Forests Commission purchased alienated lands in the Parish of Olangolah throughout the 1920s, and the softwood plantation at Aire Valley was commenced in 1931. The plantation comprises mainly radiata pine, with small areas of Douglas fir (*Psuedotsuga menziesii*), Corsican pine (*Pinus laricio*), and sitka spruce (*Picea sitchensis*). The Websters Hill plantation, which started in 1963, and the more recent projects at Boonah (1969) and Forrest (1969) are almost entirely of radiata pine.

The emphasis on planting of radiata pine follows from its outstanding success on a number of soil types and through a range of climates in Victoria. The first recorded plantings were those made by Baron von Mueller in 1859 (in the Doncaster locality). Further widespread plantings in the 1860s and 1870s demonstrated the suitability of this species for quite a range of climate and soils.

The plantation at Aire Valley has confirmed the area as suitable for radiata pine. Plantations at Anglesea and

Radiata pine planted on former agricultural land.

Part of Websters Hill softwood plantation.

Waarre have failed, however, underlining the fallacy of believing that this species will grow practically anywhere.

Requirements for radiata pine

Sites for commercial plantations of radiata pine require:

* a minimum rainfall of 760 mm
* an acid soil of at least moderate fertility
* good drainage
* an optimum of 0.75 m and a minimum of 0.5 m topsoil over any root- or water-impeding layer
* freedom from heavy falls of snow

The Forests Commission have carried out site appreciation surveys, aimed at determining areas suitable for softwood plantations, for most of the northern slopes of the Otway Range. As it is now Forests Commission policy not to establish any further softwood plantations in the coastal fall of the Range, no site appreciation surveys of the coastal fall are available.

The areas that surveys in the study region have shown to be suitable for softwood plantations generally coincide with blocks of foothill forest where the slopes are moderate.

Capability

Although radiata pine grows quite rapidly in this region by world standards, wide variations in growth rate occur due to differing site factors. Growth rates can be expressed in terms of site quality, which is a measure of the total volume of timber produced.

Plantations are assessed and placed into site-quality classes (SQ) at about 10 years of age, to form the basis for calculating growth rates and the quantities of the various classes of log material that will become available for industry.

Table 12

SITE QUALITY FOR *PINUS RADIATA*

Site quality	Site Index (height in metres at age 20 years)	Total yield over 30 years (m^3/ha) *	Average annual yield (m^3/ha) *
I	31	955	32
II	29.5	850	28
III	27.5	745	25
IV	26	645	22
V	24	535	18
VI	21.5	380	13
VII	18.5	235	8

* Volumes shown are under bark to a 10 cm small-end diameter

Seven qualities have been defined. SQI to SQV cover healthy stands, SQ VI means marginally healthy, and SQ VII ranges from marginal to failed.

Site quality of a stand can be estimated from the height of the trees at the age of 20, called Site Index. A stand with a Site Index of 27 would fall into class SQ III. Table 12 sets out the productivities of the different classes. It is impossible to classify a site accurately until a stand of trees has actually grown on it. However, the form and composition of native vegetation, soil, and climatic and topographic factors are useful indicators of suitability.

Social and other effects

Softwood plantations and associated industries contribute to the welfare of the community by providing employment in rural areas and provincial towns. A plantation resource capable of supplying a complex of wood-using industries can support one family for about each 10 ha of plantation.

Plantations of successful species produce a high volume of wood per hectare. This permits development of efficient growing, harvesting, conversion, and marketing techniques, with resultant economic benefits to the consumer. The high volume of production also means that a significant part of the demand for timber (that would otherwise have to be met by imports or from larger areas of native forest with lower production) can be accommodated on relatively small, highly specialized plantations.

The softwood plantations within the study area, and particularly the Aire Valley plantation, provide a diverse and frequently used recreational resource. However, the establishment of softwood plantations usually results in destruction of native vegetation and gross

Softwood plantations provide employment in rural areas.

alteration of habitats available for native fauna.

Industry requirements

In general, the industry prefers plantations in large compact blocks, close to centres of population and served by good transport facilities. Large plantations enable the owner to benefit from economies of scale in establishment, fire protection, and road and maintenance costs. As log-transport costs make up a high proportion of the cost of materials, the plantations should be located close to the milling centre. Plantation development in the study area is aimed at supporting a viable local sawmilling industry.

Rubber-tyred machines reduce soil disturbance caused by logging.

Modern softwood sawmill near Colac.

The Demand for Softwoods

It is difficult to make even short-term forecasts of demand for a commodity, and longer periods increase this difficulty tremendously. However, the forest crops' current planting rates must be based on forecasts of the amount and nature of consumption in 30--40 years time. In Australia the current planning is based on forecasts of demand for the period 2000 to 2010.

An estimate of the future supply and demand for wood from Victoria's forests appears in Chapter 15. Australian native softwood resources cover 4.3 million ha, but are restricted to some rain-forest species (in the tropics and Tasmania) and the slow-growing *Callitris*

Table 13

SOFTWOOD PRODUCTIVITY

Category	Structural form and main species of natural vegetation (1)	Predominant soils	Estimated potential for *P. radiata*	
			Site Index (m) (2)	Productivity MAI m^3/ha/yr
[A] very high	Open forest IV: mountain ash	Friable brown gradational	29.5--27.5	28--28
	Open forest III messmate, mountain grey gum	Friable brown and yellow gradational	29.5--26	25--22
[B] high	Open forest II: messmate, mountain grey gum	Yellow gradational & friable brown gradational	26--24	22--18
[C] moderate to low	Open forest II: messmate, mountain grey gum, brown stringybark	Yellow gradational	24--18.5	18--8
[D] unsuitable	Open forest I and woodland: shining peppermint, messmate, brown stringybark	Leached sands and duplex soils	Less than 18.5	Less than 8

(1) For full details of species refer to Chapter 10, Table 7, vegetation units.

(2) MAI (mean annual increment) = total volume production to a 10-cm small-end diameter under bark, divided by the number of years in the rotation.

forests of the dry inland. The total commercial forest covers 42 million ha, of which 0.42 million ha is planted with exotic conifers.

Australia's forest products industries have expanded and become more sophisticated with the country's growth in population and affluence. Many of these industries prefer softwood as the raw material, due to its lightness, lack of defect, and pulping and chipping characterisiics.

Balance-of-payments difficulties in the early 1960s caused the Commonwealth Treasury to examine the main sources of

Mature radiata pine in the Aire Valley plantation.

import expenditure. This examination revealed that Australia's import bill for timber and timber products was about $200 million per annum. Additionally it was estimated that the deficiency in home-grown softwood supplies would increase in the future. Australia has large areas of land suitable for growing softwood timber, which could produce substitutes for most of the present imports.

These forecasts caused a complete review of softwood availability, including estimates of future demand. As a result, the Australian government accepted for planning purposes that by the year 2000 A.D. Australia's annual requirements for forest products would be 31.2 million m^3 (expressed as the volume of logs used).

It was estimated that 1.2 million ha of coniferous plantations could provide half this requirement, while the rest would be obtained from native forest. Having regard to these figures, balance-of-payments difficulties, and the likely problems of finding adequate supplies of wood on world markets, the government embarked on a scheme to substantially increase softwood plantings, subject to a review every 5 years.

Commonwealth Assistance

In 1967 the Australian government passed the *Commonwealth--States Softwood Forestry Agreements Act* to ratify an agreement between the Commonwealth and States, meeting as the Australian Forestry Council. The agreement was renewed in 1972. The *Act* is designed to overcome the projected shortfall in the supply of softwood in Australia and provide Commonwealth financial assistance to help the States undertake expanded softwood planting programmes. The national target for the State forest services for the first 5 years, 1967--71 was 103,900 ha.

Victoria planted 20,200 ha during this period. The State financed 12,000 ha and the Commonwealth the balance with loan funds that are interest-free for the first 10 years.

The Victorian Forests Commission expects to plant 4,690 ha per annum for the current 5-year period, which ends in 1976. Private companies will plant about 3,200 ha per annum, bringing the annual total for the State to 7,890 ha. In the Otway area the Forests Commission expects to continue to establish new plantations at between 120 and 200 ha per year until the total area of plantations is about 8,000 ha. The projected potential of these plantations will be 100,000 m^3 annually.

Critics of the softwood programme suggest that population growth will be less than anticipated, and therefore requirements have been overestimated. They claim that overseas development in softwood production will ensure adequate supplies for Australia and that some of the economic arguments used to justify the scheme are incorrect. The principal text for this criticism is listed in the references.

References

Australia, Commonwealth. "Softwood Forestry Agreement Act 1967." (Commonwealth Government Printer: Canberra 1967.)

Australia, Forests and Timber Bureau. "Alternative Projections: New Zealand Australian Free Trade Agreement Study." (Department of Trade and Industry: Canberra 1970.)

FORWOOD. "Report of Panel No. 2: Forest Resources of the Forestry and Wood-based Industries Development Conference." (Australian Government Publishing Service: Canberra 1974.)

Jacobs, M.R. Market prospects for Australia's forest products. *Proceedings of the ANZAAS 43rd Congress, Brisbane,* 1971.

Routley, P. and V. "The Fight for The Forests." (Australian National University: Canberra 1973.)

AGRICULTURE

The Corangamite study area is characterized by its diversity of agriculture. Most forms of temperate-zone agriculture are practised in the area. The variety represented stems from the wide range of climatic conditions and soil types. Average annual rainfall varies from 450 mm in the north-eastern corner of the study area to almost 2,000 mm in the Otway Ranges. Soil types range from highly fertile soils developed on volcanic ash to infertile, very strongly acid leached sands.

Clearing of the Heytesbury forest for dairy-farming began in 1956.

About 75% of the study area is used for agriculture. The greater proportion of this land (955,570 ha) carries sown pasture, and the major agricultural industries are dairying and sheep and beef cattle grazing.

Of the 6,740 rural holdings in the study area, fewer than 6,000 are of commercial size. The trend is towards a smaller number of commercial farms - except in special areas such as the Heytesbury Settlement, where blocks are still being allocated. There is an increasing demand for small farms as hobby or part-time farms in areas within easy reach of cities.

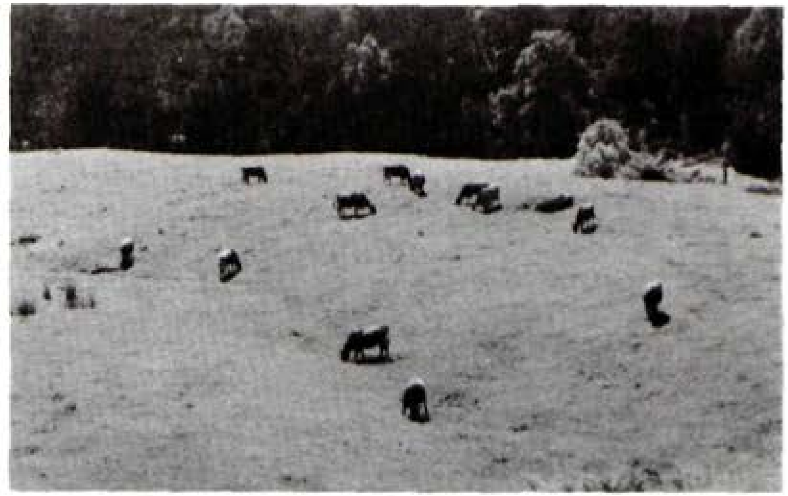
Pastures

Most of the area carries perennial grasses, the most common being perennial ryegrass, cocksfoot, and *Phalaris tuberosa*. In the lower-rainfall districts, subterranean clover is the dominant legume, while white clover is the important one in the moderate- to high-rainfall districts. Some lucerne is grown in the study area, its location being confined to relatively small areas on some farms. Poor drainage and very strongly acid soils restricts its widespread establishment.

The growing season for pasture is closely related to annual rainfall. It ranges from around 8 months in the northern localities to 11--12 months in the temperate higher-rainfall districts. In higher-rainfall districts the winter is generally more severe, due to lower temperatures, and waterlogging of soils is a common problem in many of them.

Approximately 4,600 ha of pasture are irrigated. Irrigation is limited to small areas on properties where the far-

Common pasture grasses are ryegrass, cocksfoot, and phalaris.

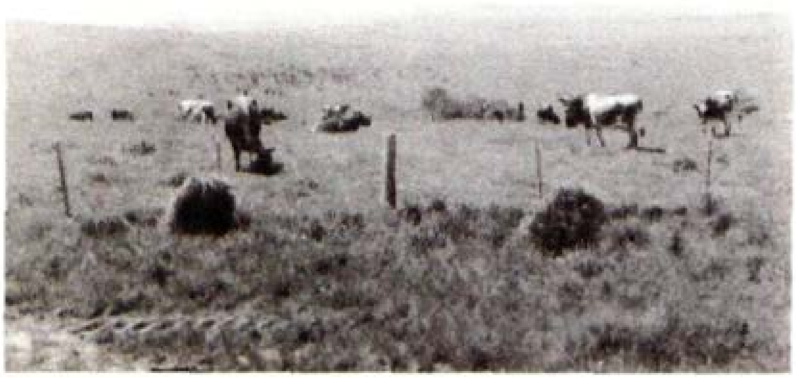


Dairy-farming is the major primary industry in the higher-rainfall areas.

mer has been able to collect and store adequate water, or pump directly from a stream or bore.

Fertilizer is required regularly on all but a few hundred hectares of soils developed on volcanic ash. On the soils north of the Princes Highway, superphosphate is the main one used. Rates vary mostly between 100 and 200 kg per ha.

South of the Princes Highway, soils are naturally less fertile and many require applications of a mixture of superphosphate and potash fertilizer annually, at rates generally between 200 and 500 kg per ha. The trace elements copper and molybdenum are used regularly on many of the soil types in these districts.



Newly developed dairy farm near Simpson.

Dairying

Around half the farms in the study area are dairy farms, of which the greater proportion lie south of the Princes Highway in the higher-rainfall districts.

The tendency over the years has been for the number of dairy farms to fall but for the number of milking cows per farm to rise. For most of the study area, milking herds average between 70 and 80 cows. The total number of dairy cattle is about 404,700.

Most milk is sold as whole milk to dairy factories on a butterfat basis. Only a small number of farms have large whole-milk contracts for city milk supply. However, many have small milk contracts (less than 90 litres per day), which dictates that they milk at least some cows throughout the year.

Calving starts in March--April in the northern dairying districts, in June--July over the greater part of the southern areas, and in August--September in localities with the severest winters. Most calving is timed to match animal requirements with pasture production. Supplementary feed generally consists of hay, silage, and concentrates.

The reliability of the climate would allow the dairying industry in this region to be both stable and productive if profitable markets were assured.

Many dairy farms run a small sideline beef enterprise. The common practice is to rear and fatten dairy--beef cross animals.

Sheep

The sheep industry is a large and important one in the study area. The wool price slump in the late sixties led to a reduction in sheep numbers and diversification into other enterprises. Currently, about 4.1 million sheep in the area produce 20.3 million kg of wool each year. The industry can be divided into sheep primarily kept for wool production and those kept for production of prime lambs.

Woolgrowing is the major industry on the basalt plain, which is the northern part of the study area with the lower rainfall. The main breeds are Merino, Polwarth, and Corriedale, plus various crossbreeds. Traditionally, flocks have lambed in autumn, but in recent years a marked swing to winter and early spring lambing has occurred. Stocking rates are closely tied to annual rainfall and on the whole, can still be increased on many properties.

The prime-lamb industry is concentrated in the medium-rainfall belt just south of the Princes Highway. Prime lambs are also produced as a sideline on many wool-growing properties, although there has recently been some change from prime lambs to dairying or beef in the higher-rainfall districts. Lambing takes place in mid-winter to early spring. The common breed of ewe, the Border Leicester--Merino cross, is mated with a variety of ram breeds, including the Dorset Horn and Southdown. The Timboon district is a major producer of late prime lambs from mainly Romney Marsh cross ewes and Southdown rams.

Beef

The number of beef cattle in the study area has increased significantly since the 1967/68 drought. In 1973/74 it was about 490,000.

About 70% of farms in the study area carry beef cattle, but relatively few have the beef enterprise as the major

Sheep, for fat lamb and wool production, total over 4 million in the study area.

Woolgrowing is the major industry on the basalt plains.

About 70% of farms carry some beef cattle.

activity. Most farms that are primarily beef-producers are in and around the Otway Ranges and through the Darlington--Mortlake--Penshurst country. Several well-known and well-established beef studs are situated around the Mortlake district.

Most beef production is based on herds of breeding cows producing calves, which in the higher-rainfall areas (greater than 760 mm) are sold as vealers and in the lower-rainfall areas are sold as mature beef at about 1½--2 years of age. Relatively few beef-producers buy in steers to fatten.

The large majority of beef cattle are run on sheep properties, and the enterprises are made complementary to a certain extent in order to make the best use of pastures. Mention has already been made of the dairy--beef enterprises associated with many dairy farms.

Crops

The cereals produced in the study area are oats, barley, and wheat. Cropping for grain is confined to the basalt plains across the northern part.

Cropping areas and yields vary considerably from year to year, depending on season and the price of the product.

Oats is the most important crop, and about 15,000 ha is generally sown to this crop for grain. About 5,000 ha is sown to wheat and a similar area to barley. Most oats are used for stock feed, a small proportion being retained on farms for use and the balance being sold either privately or through the open market. Barley-growers aim at producing malting-grade grain, but each year a proportion fails to reach this standard and is used for stock feed. Wheat is sold to the Australian Wheat Board, and barley to the Victorian Barley Board.

Silos for receiving wheat and barley are located at Berrybank and Skipton in the study area and at Willaura, Tatyoon, and Westmere in the neighbouring areas.

In recent years the area sown to oilseed crops has increased significantly. Rape and linseed are the most important of these crops. In 1973/74, about 4,000 ha was sown to rape and a similar area to linseed. Linseed has been grown in the Winchelsea area for many years, while rape for oilseed has only become significant recently. Farmers grow both crops under contract to companies dealing in oilseeds. They are more difficult to grow than cereal crops, and the area is unlikely to expand significantly in the absence of a price incentive.

Only certain soils in the cropping belt can be regularly cropped. In virtually all cases, cropping is done in rotation with a pasture phase. There is no fallowing to conserve moisture.

Fodder

As the major agricultural industries are based on grazing animals, fodder production is an important part of management.

Fodder, mainly pasture hay, is required for stock at various times through the season when pastures lack either quantity or quality.

By far the largest quantities of fodder produced for conservation are grass and clover hay (106,500 ha). Haymaking in the spring months is common to all farms throughout the study area. The area cut for hay (and the yield) varies from year to year depending on the season and supplies on hand.

The lower rainfall areas in the north of the district are reliable for producing subterranean clover hay. In the southern district the quality of the hay from the white clover pastures is often not as good, due to late cutting and/or spoilage by rain during harvest. Consequently, in an average season, the graziers in the north sell quantities of hay to dairy-farmers in the south.

In some years, significant quantities of hay are sold outside the study area to districts that are experiencing a poor harvest.

Some crops are grown especially to produce conserved fodder. Normally, they also support some grazing. The most important are oats and lucerne (about 3,000 ha of each).

Most conserved hay is fed to stock over the winter months to supplement the slow pasture growth. In dry summers fodder is also required to maintain the condition of stock. Smaller quantities of fodder are used to feed breeding stock around the time of lambing or calving, and some is used to finish fattening stock before slaughter.

The area sown to grain fodder crops in addition to lucerne is small (about 6,000 ha) and is often associated with pasture establishment or renovation. Oats is the most common winter crop, while rape, millet, and turnips are the most common summer fodder crops. Quite small areas (5--15 ha) of summer crops are often useful for prime lambs, weaners, and milking cows.

Only small quantities of silage are made in the study area, mostly in the southern areas on dairy-farms.

Vegetables

Several vegetable crops - potatoes, onions, and peas - are grown on a broad-acre basis. There is very little intensive market-gardening in the study area.

Potatoes cover approximately 1,400 ha in three main localities: Koroit--Warrnambool, Alvie--Cororooke (just north of Colac), and in the Otway Ranges. The area varies from year to year depending on the price of the produce. Most of the potatoes are grown under dry conditions, although in recent years there has been a trend to supplementary irrigation.

Two crops of potatoes grow in the study area: an early crop is sown in late winter and harvested in late spring, and a late crop is sown in mid spring and harvested in autumn. The Otway area is important for producing seed potatoes. Its isolation and climate confer advantages for the production of disease-free tubers.

Onion-growing is a declining industry because of problems with soil-borne disease and competition from newer, large-scale onion-growers in other areas. The area in 1971/72 was 460 ha, most of it in the Alvie--Cororooke area just north of Colac. Onions require fertile and well-drained soils and are confined to the red and black volcanic soils.

Peas are mainly produced under contract to frozen-food companies. For the past few years some 40.000 ha of peas have been grown in the study area, mostly on basalt plains soils between Winchelsea and Darlington. On naturally drained soils, the crop is sown from July to September, with harvesting starting in November. Later crops are sown on the wetter soils from September to January, depending on season, and so harvesting continues in the district up to March.

The deep, well-drained soils where irrigation water is available have potential

The climate and isolation of the Otway Range make it valuable for producing disease-free seed potatoes.

for intensive market-gardening. In recent years, interest has been shown in some of the rich volcanic soils and river flats.

Seed production

The production of certified perennial ryegrass seed is an important sideline around Winchelsea, and has been for many years. Other pasture seeds are not produced in significant quantities in the study area.

Honey

The potential of much of the land, particularly public land, for honey production is high. However, to date the study area has been largely untapped as a source of honey.

Bee-keepers who operate in the area have found that strawberry clover and white clover in pastures produce choice honey in good years.

The messmate and brown stringybark forests on the flanks of the Otway Range can provide good crops of medium-grade honey. They have value for building up the condition of hives in years too dry for nectar secretion in clovers, and increase the quantity and quality of pollen in normal years.

The production of pollen and nectar in the Otway Ranges makes the area highly suitable for the breeding of queen bees.

Honey is a largely untapped resource in the study area.

This, and its isolation from other honey-producing areas, results in the Otways being one of the most suitable in Victoria.

Use of Public Land for Agriculture

The Rural Finance and Settlement Commission started development of the Heytesbury Settlement in 1956. The total area cleared and sown is 42,500 ha and, in the period to 1975, 351 dairy farms were established on 28,300 ha. The Commission plans to establish a further 100 dairy farms, the first five of which were settled in 1975. Currently, the Commission is running a beef enterprise on land yet to be settled. Some of this land is considered unsuitable for dairying, but is suitable for beef production or the production of softwoods.

The Department of Agriculture has 280 ha of the original Glenormiston Estate just north of Noorat. In 1971 a 2-year Diploma course in farm management commenced and the Estate was called the Glenormiston Agricultural College. The College farm conducts a variety of enterprises, including dairying, beef, and sheep. Some experimental work is also done on the property.

The Department of Social Welfare has a 60 ha area, the Corriemungle Prison Camp in the Heytesbury Shire. This minimum security prison holds about 50 prisoners and conducts a variety of agricultural pursuits. The aims are to give prisoners worth-while work, as part of their training, and to provide food for the camp, with any excess being forwarded to other departmental institutions in the prison division. The camp has been active in developing neighbouring public land for agricultural purposes in recent years. This land has been sold as farmland once the pastures have been established.

Agricultural capacity of public land

Most of the public land is in and around the Otway Ranges. Generally, none of it has prime agricultural value. Most is steep or heavily forested, or has soils of low fertility. In some instances these features are combined. Development of this land for agriculture has doubtful economic value and, when considering alternative land uses, is unlikely to be a competitive proposition.

References

"Rural Industries (Victoria) 1973/74." (Commonwealth Bureau of Census and Statistics: Melbourne 1974.)

MINERALS

The study area is not rich in mineral deposits, although it has good potential for petroleum exploration. Road-construction materials, particularly scoria and tuff, are extensively worked for use in the area. A large agricultural limestone quarry at Curdies supplies most of Victoria. Extensive brown-coal deposits are present and were formerly worked at Wensleydale and Deans Marsh. Further reserves of brown coal can be inferred from prospecting information at Benwerrin, Kawarren, and Gellibrand.

Apart from the mineral deposits referred to above, the main mineral potential of the study area lies in possible clay and bentonite deposits in the Otway Ranges.

Metallic Minerals

No known deposits of metallic minerals occur in the study area, although deep leads were worked at Pitfield just outside it.

The lithology of the Otway Group suggests a possibility of uranium deposits in the Otway Range but, as no aerial or ground radiometric work has been carried out, this possibility is unproved.

Fuel Minerals

Oil and natural gas

The Port Campbell 1--4 wells drilled around Port Campbell in the period 1958--1967 all produced some flows of natural gas and oil from the Waarre Formation, although the reserves in the separate thin reservoirs encountered in each well were not large enough to be economic at the time. However, the wells establish the fact that this part of the Otway Basin is a petroleum province, even though further wells within the study area have so far failed to establish the presence of economic oil or gas fields.

Brown coal

Reserves of high quality brown coal are present in the Eocene sediments (Wangerrip Group) outcropping round the Otway Ranges east of Gellibrand.

The known reserves are:

Deans Marsh-Bambra	-	1,000,000 tonnes
Wensley Bray (Wensleydale)	-	1,000,000 tonnes
Benwerrin	-	75,000 tonnes

Wensleybray coal mine has a reserve of 1 million tonnes of brown coal.

Brown coal has also been located at Kawarren and Gellibrand, but the size of the reserves has not been established.

Black coal

Black-coal seams less than 0.6 thick are known in the Otway Ranges within the Otway Group both north of Apollo Bay and near Wangerrip. No economic seams have been located, although considerable prospecting and boring have been done.

Non-metallic Minerals

Limestone

The Port Campbell limestone outcrops extensively along the coast from Princetown to Warrnambool and extends inland nearly to Cobden. This limestone has been quarried since 1938 by Victorian Agricultural Lime Co. Ltd., in a large operation near Curdies railway station. The quarry, which has adequate reserves, is on private land conveniently located on a railway spur line. Because of the low rail-transport costs, the quarry can supply a large part of the market for agricultural lime in Victoria.

The limestone at Curdies requires the addition of shale or marl to achieve the

Limestone quarry on private land at Curdie.

correct composition for cement-making. A German company produced some cement at Curdies before World War I, using an admixture of the underlying Gellibrand marl. An outcrop of Tertiary limestone has also been quarried, just north of Kawarren railway station.

Other limestone quarries are at Port Fairy and Warrnambool. The Port Fairy (Moyne) deposits are in Port Campbell limestone and are suitable for cement-making.

The Warrnambool quarry is in a Pleistocene dune limestone (Bridgewater Formation) deposit that was formerly quarried for use as building stone in Warrnambool. It has also been investigated for cement production, but the silica content is too high.

The calcareous dunes of the Bridgewater Formation extend discontinuously along the coast from Buttress Point to the western boundary of the study area. At Point Ronald and Castle Cove they form a large potential source of limestone with 50--90% calcium carbonate.

Bentonite

A bentonite deposit is known on Charleys Creek 1½ km south of Gellibrand. The deposit, which is 7.3 metres thick, forms a bed within the Otway Group. Reserves of about 71,000 tonnes have been proved. The bentonite is a non-swelling calcium type and could be used as an absorptive agent in clarifying oils or water-softening. Probably other deposits exist elsewhere in the Otway Ranges.

Clay

Clay for brick-making at Colac is produced from pits at Barongarook and Deans Marsh. The Wangerrip Formation and Otway Group have large potential reserves.

Phosphate

The coastal exposure of the Dilwyn Formation around the Aire River mouth and around Princetown includes horizons with up to 3% phosphate and possibly higher.

However, drilling in the Princetown area near the exposures and inland of them has so far failed to locate any sizeable deposit of phosphate rock. No drilling has yet been carried out at the mouth of the Aire River.

Phosphate is present in isolated horizons in the Gellibrand marl in Birregurra 1 and Koort Koort Nong 3 in the Colac district at grades of up to 10%.

Also a phosphate bed of Lower Pliocene age, 0.3 metres thick averaging 2.82% phosphate, outcrops around a lake 1½ km north of Lake Gnarpurt.

Construction Materials

In the 1971/72 financial year, 729,936 tonnes of construction materials (sand, gravel, crushed rock, and scoria) were produced within the study area. Of this production, 27% came from pits or quarries outside the control of the Mines Department, either because the excavations were less than 2 m or because the quarries were operated by a local government or government body purely for their own use.

Sand

Sand deposits are not particularly plentiful in the area, although coarse quartz sands present in the Wangerrip

Gravel deposits occur on the northern flanks of the Otway Ranges, but are not used extensively.

Group (Pebble Point Formation) of Eocene age outcrop around and in relict areas on the Otway Range.

There is a fine sand deposit of Eocene age 0.8 km south of Lavers Hill. It was tested and proved to be a possible source of glass sand in 1920.

The Pleistocene dune limestone has also been worked as a source of glass-making material at Aringa near Port Fairy, the carbonate content of the deposit being suitable for the glass-making process.

The Dorodong Sand of Pliocene age present near Warrnambool also provides a source of sand.

Creeks flowing into the north side of Lakes Corangamite and Gnarpurt, as well as other streams nearby draining areas of granite outcrop, contain fine sand deposits. One on the north side of Lake Gnarpurt is being worked. Granite sand is also obtained at Lismore.

Gravel

Gravel deposits are present in the Wangerrip Formation on the northern flank of the Otway Range. However, they are not being used extensively at present. Scoria, being plentiful, is preferred.

Crushed rock

Crushed rock from quarries in the Otway Group is used extensively along the

Ocean Road and on roads through the Otway Ranges. Crown land in the Otways could provide a good source of crushed rock (from Otway Group sandstone) to replace scoria. It would also be less expensive than crushed basalt, being about half the cost ex-quarry.

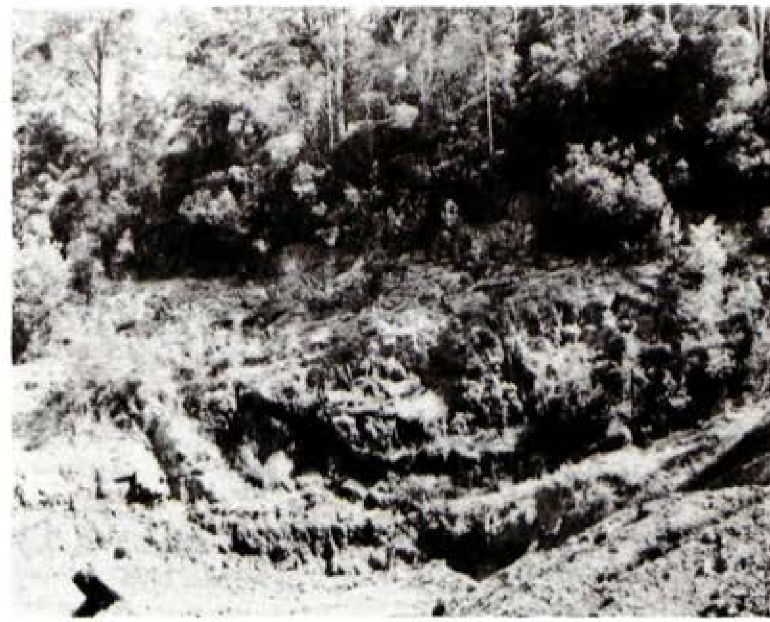
A number of quarries produce crushed basalt, including one in the Wiridigil Hills north-east of Camperdown. Adequate reserves of basalt are present on private land to replace the use of scoria entirely, should the community be prepared to accept the considerable extra cost.

Scoria and tuff

Scoria and tuff comprise about 65% of the construction materials used in the study area. This material costs about one-third the price of crushed basalt.

The scoria, representing nearly the last phase of volcanic activity, is found forming volcanic cones, with the coarsest and hardest (welded) material in the centre of the cone grading to finer-grained, more friable, and then bedded material outward from the cone into tuffs. The best material for road-making is usually on the outside of the cone near its base.

Tuff also occurs and is quarried from around the circular crater lakes (maars) or from the tuff rings that are believed to be the first phase of volcanic activity. The maars are more common around Terang and Panmure (for example, Lakes Keilambete and Elingamite), while scoria cones are more common to the north (for example, Mount Porndon, Mount Leura, Mount Elephant, and Mount Noorat).



The Otway sediments provide rock suitable for crushing.

The accompanying map shows the location of the eruptive centres that have been worked for scoria and tuff.

At present only a few scoria cones - for example, Mount Rouse, Mount Leura, Red Rock, and Tower Hill - are public land. At Mount Fyans and Mount Porndon, thin basalt flows overlie the scoria, indicating that it may be possible to locate scoria or tuff deposits underneath areas of 'stony rise' phase 2 Newer Volcanic on the land surrounding the cones.

References

Baragwanyth, W. Sand at Lavers Hill, Cape Otway District. *Records of the Geological Survey of Victoria*, 1920, 4, 471-2.

Bowen, K.G. Further report on bentonite at Gellibrand, Victoria. *Mining and Geological Journal of Victoria*, 1970, 6, (6), 33-9.

Kenny, P.L. Geology of Kawarren--Gellibrand district. *Mining and Geological Journal of Victoria*, 1938, 1 (3), 76-9.

McKenzie, D. Survey of Victorian scoria and tuff deposits. *Mines Department of Victoria, Unpublished Report*, 1974.

Thomas, D.E., and Baragwanyth, W. The geology of the brown coals of Victoria. Part 3. *Mining and Geological Journal of Victoria*, 1941, 4 (2), 41-63.

WATER UTILIZATION

The catchments of the wet Otway Ranges have a high potential for water harvesting and they supply virtually all of the surface water used for domestic and industrial purposes in the study area as well as a large proportion of that used by the adjacent city of Geelong. About 55% of the Otway water currently harvested is used in the Barwon Supply System to supply Geelong and the Bellarine Peninsula, and a further 20% is diverted into the Otway Supply System.

Existing and Future Storages

The largest storages are the West Barwon dam near Forrest (22,000 Ml) and the off-river Wurdee Boluc reservoir near Winchelsea (19,000 Ml).

Other storages are usually fairly small headworks and service basins associated with the various town water supplies. Sites for future storages have been investigated by the State Rivers and Water Supply Commission and several potential sites exist on the Gellibrand and Aire Rivers. Provision of storages in this area will, however, be the subject of an inquiry by a Parliamentary Public Works Committee. The possible use of Lake Munderong as a raw water storage has also been investigated, but indications so far are that water-quality and contamination problems may result from the peat layer on the bottom of the lake.

Present Water Usage

Total usage from the Otways at present is approximately 38,000 Ml per annum, of which some 34,000 Ml is for town supplies. This represents approximately 30% of minimum annual stream flows or 10% of mean annual stream flows. Groundwater reserves also have a high potential for the supply of water for domestic purposes and irrigation, depending on quality, and several towns draw domestic water from bores.

Town supplies (domestic water)

Table 14 sets out details of the source, quality, and treatment of the various town supplies, and Appendix 3F gives additional details of present daily usage and controlling water authority.

A more detailed description of the Barwon and Otway Supply Systems is set out below.

Barwon Supply System (Geelong Waterworks and Sewerage Trust)

Water for Geelong and the towns listed in Table 14 is supplied from the headwaters of the Barwon River. It is not treated and is of satisfactory quality. The major storage - the West Barwon Dam near Forrest - has a capacity of 22,000 Ml. The catchment area covers 4,900 ha, and supply can be augmented to some extent by pumping from the nearby Barramunga Creek. Water flows to the East Barwon River from the West Barwon through a tunnel below the dam. It is then diverted from the East Barwon River via a channel system to the Wurdee Boluc reservoir.

Water can be diverted into the channel at several major creek crossings and is also drawn from it to supply Birregurra via a branch channel. From the Wurdee Boluc reservoir, water passes through channels to the Geelong Waterworks and Sewerage Trust Pettavel Basin and to State Rivers and Water Supply Commission storages at Anglesea and Torquay.

The West Barwon Dam near Forrest stores domestic water for Geelong and the Bellarine Peninsula.

Wurdee Boluc reservoir: an off-river storage, supplied by a channel from the Barwon River.

Table 14

TOWN WATER SUPPLIES

City/town	Associated supply area	Source	Treatment	Quality
Geelong	Bellarine Peninsula Anglesea, Torquay, Birregurra, Winchelsea	Barwon River	Nil	Satisfactory
Warrnambool	Simpson, Cobden, Terang, Camperdown, Lismore, Derrinallum, Allansford	Gellibrand River Arkins Creek	Chlorination	Satisfactory - will eventually require full treatment as usage increases
Colac	Cororooke, Coragulac, Alvie	West Gellibrand River, Olangolah River	Nil	Satisfactory
Apollo Bay	-	Barham River (West Branch)	Nil	Satisfactory
Forrest	-	West Barwon Dam	Nil	Variable due to location of outlet - a new outlet is to be installed
Gellibrand	-	Lardners Creek	Chlorination	Satisfactory
Lorne	-	Erskine River	Nil	Variable - bacteriological content unsatisfactory on occasions Storage basins are to be fenced
Koroit	-	Shallow bores	Nil	Calcium (440 mg/l) and nitrate (55 mg/l) are a problem
Mortlake	-	Springs, bores	Chlorination	Satisfactory
Penshurst	-	Springs, bores	Nil	Moderately hard
Peterborough	-	Artesian bore	Aeration, alum dosing	High temperatures, high iron content, hardness, colour, and turbidity are problems with bore water. Treatment such as alum dosing, aeration, cooling, and settling can generally bring quality within acceptable limits
Port Campbell	Timboon	Artesian bore	Aeration	
Port Fairy	-	Bores	Cooling	
Wye River (proposed)	-	Wye River	Nil	Satisfactory

The safe yield of the system is about 24,000 Ml a year. There is a great seasonal fluctuation in demand, and in successive dry years storage capacity is barely adequate to meet the requirements. In the drought year of 1967/68, a search began for underground resources to supplement the supply. Resources of considerable promise have been located at Barwon Downs and a trial production bore is soon to be commissioned. A yield of 10 Ml a day is expected initially, with a long-term objective of at least 25 Ml a day.

West Arkins Creek: part of the Otway water supply system.

Otway Water Supply System (State Rivers and Water Supply Commission)

This system supplies water to Warrnambool and a number of townships west of the Otway Ranges (see Table 14). The main supply is the Arkins Creek catchment in the Otway Ranges at an elevation of 340 m above sea level. The forested catchment has an area of 749 ha, and is owned by the State Rivers and Water Supply Commission. It is closed to public access. Water gravitates from small diversion wiers by pipeline to district storages, the main ones being Donald's Hill near Camperdown (222 Ml), Mount Ewen near Terang (600 Ml), and Tank Hill near Cudgee (759 Ml).

During summer the supply is augmented by pumping from the Gellibrand River at Carlisle, and at present about one-third of the normal annual demand of 6,500 Ml is met from this source.

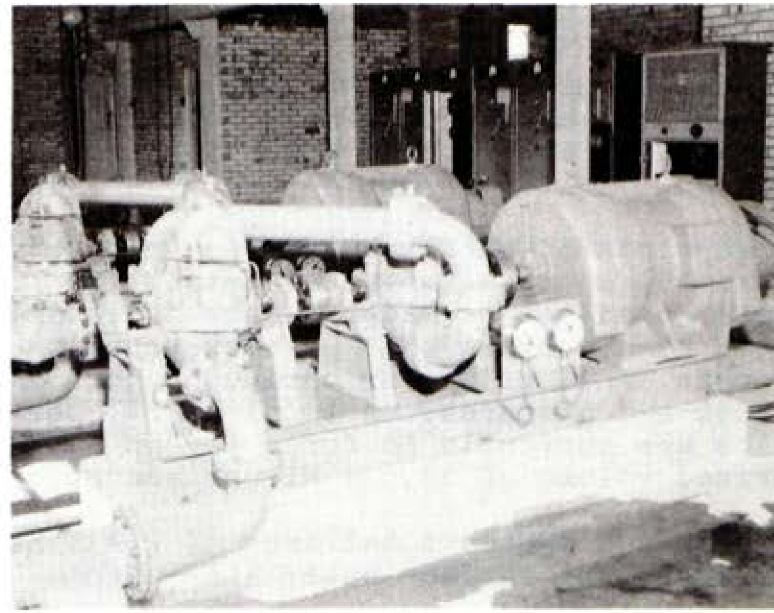
The existing system has now been enlarged to its economic limit and increased supplies, particularly to meet the expected requirements of the City of Warrnambool, are to be obtained from the South Otway Scheme, which is currently under construction.

This work is expected to be completed by the end of 1975 and involves pumping from the Lower Gellibrand River near its junction with Kennedy's Creek. The catchment area above this point is about 97,000 ha, which is more than double the catchment area above the original pumping station at Carlisle. A good deal of the catchment carries farms, giving rise to excessive colour, turbidity, and bacterial content in the River, and water harvested during winter will require full-scale treatment.

However, during the summer-autumn period water quality in the River is not impaired and until full treatment is provided pumping can be undertaken at selected periods to provide water of satisfactory quality.

Water is lifted to an excavated service basin of 100-Ml capacity near Port Campbell, from which it gravitates to Warrn-

Mount Ewen District Storage: Otway water supply system.



Gellibrand Pumping Station, at Carlisle, augments the Otway water supply system during summer.

ambool. Towards the end of 1975, a chlorinator will be installed at the outlet of this basin to disinfect the supply as it enters the system.

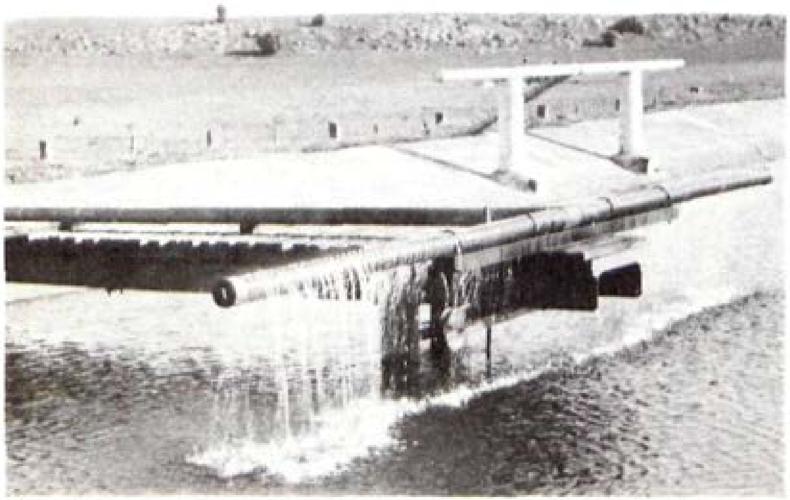
The South Otway Scheme will initially provide an additional 9 Ml of water per day, rising to 18 Ml per day by later booster pumping, which almost equals the capacity of the existing system. The enlarged Otway System should be adequate to meet water requirements until at least 1990, when the annual demand is expected to reach 12,300 Ml.

Irrigation

Annual permits are issued to enable farmers to obtain a defined volume of surface or underground water for irri gation.

Diversions of surface water are not yet metered, so no accurate assessment of water used can be made. Usage is estimated by a formula that assumes certain depths of watering for various types of crops and pastures. A total of 247 permits are currently in force for an authorized volume of 13,531 Ml per annum.

Two-thirds of the total area of 2,436 ha irrigated by surface water lies within the catchment of the Hopkins and Merri Rivers, and most of it is permanent pasture. The area irrigated with surface water has more than doubled since 1967 (see appendix 3D).



Port Fairy Storage Basin: groundwater is cooled to remove dissolved iron.

Underground water is presently used to irrigate approximately 2,314 ha, and licenses total some 12,045 Ml per annum. The main area lies along the coastal plains between Port Fairy and Port Campbell and a small portion (approximately 10%) is used around Lake Corangamite between Camperdown and Colac. Most of the irrigated area carries permanent pasture, but about one-third is made up of annual crops, lucerne, and market gardens (see Appendix 3C).

Future Requirements

Surface water

Continuing demands will be made for additional water from the Otway Ranges for town supplies, particularly for the continued development of Geelong.

However, the demand for surface water for irrigation is not expected to increase substantially, as the cost of collection, storage, and distribution of the large amounts of water required by the areas most in need of it would prove excessive.

Total usage of Otway surface water at present is only 30% of minimum annual stream flows. The Aire River has high potential for domestic water production but is not yet utilized, although a number of sites suitable for dams are known to exist.

Surface water supplies in the study area should thus be adequate to meet expected demands, provided other sources such as groundwater are developed concurrently.

Underground water

Domestic supplies to towns with a lack of suitable surface water supplies will draw on underground resources to a greater extent.

Potential supplies at Barwon Downs are presently being investigated as a means of supplementing Geelong's water supply during drought years. In addition, deep aquifers at Nullawarre could be suitable for domestic water supply, although their use would depend upon advances in the technology of desalination.

The extent to which further permits can be issued for irrigation will depend on the stage at which bore density is such that new bores begin to have an effect on the output of existing bores. This stage has not yet been reached.

References

Geelong Waterworks & Sewerage Trust. *Engineer-in-Chief's Annual Report*, 1972/73.

LAND USE RELATIONS

The preceding chapters have described the natural resources of the study area and discussed the existing and potential utilization of resources on public land. The hazards associated with these uses have also been considered. There is a growing demand for resources on public land from groups with a wide range of interests. In this situation, the interactions of various uses become an important issue that must be considered before decisions can be made regarding the allocation of public land resources. This chapter examines the nature of those interactions.

Land use compatibility

Each type of land use requires a certain set of resources for its operation and they have been discussed in the 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 into a multiple land use policy. However, this view is a simplification, and in practice each land use has unique effects on others. The main complicating factors include:

* Activities occur at different levels of intensity. (Compatibility between two activities at a low intensity of operation may be reduced if the operations of one intensify.)
* Some activities occur for a short period, thus restricting their effect and allowing other activities to continue in the 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.)

* Spill-over effects of an activity may have ramifications for other uses outside the immediate area of the former's operations.

* Compatibility between uses in an area changes over time as the once-harmful effects of one activity are lessened.

* Prevailing social attitudes towards tolerance of harmful inter-effects may change. (In some cases improved technology - for example better methods of water treatment - helps change these attitudes.)

* Management techniques can reduce possible harmful 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. It has not been possible to deal with relations between internal aspects of each major category of use, although the same principles would apply.

Agricultural production

Agricultural activities in the study area have in some cases introduced a di-

Stone fences in the stony rises near Warrion.

versity of visual interest that has provided enjoyment for many people, including those engaged in sightseeing, picnicking, and other forms of passive recreation. The intricate stone fences of the Stony Rises, for example, provide an interesting and unusual feature.

Agriculture is normally incompatible with conservation of native fauna and flora since, although some benefit, most species are severely reduced in number or eliminated by the removal of native forest and the introduction of alien plants and animals.

In some cases agriculture has little effect on water production. However, the conversion from forest to grassland often leads to increases in total water yield, turbidity, and salinity, as well as a reduction in summer stream flow.

The use of additional public land for agriculture would compete with timber production, apiculture, recreational activities requiring forested country, and many aspects of nature conservation.

Agriculture is incompatible with nature conservation, but can enhance scenic values.

Softwood timber production

Timber production in plantations is a relatively inflexible land use, as it involves the intensive management of a single crop species. Since about 80% of a pine plantation complex is cleared of natural vegetation, softwood planting competes with nature conservation, hardwood timber production, honey production and some recreational activities. It also competes with agriculture.

On the other hand, softwood plantations can add visual diversity to an area. Because of their relatively open understorey, they provide good opportunities for picnicking and other recreational activities such as orienteering.

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. Water production is not affected, provided adequate steps are taken to prevent soil erosion.

Timber production can be beneficial to some forms of outdoor recreation by providing access tracks for walking and pleasure driving.

Harvesting operations have an immediate but generally short-term effect on local vegetation, fauna, and recreation.

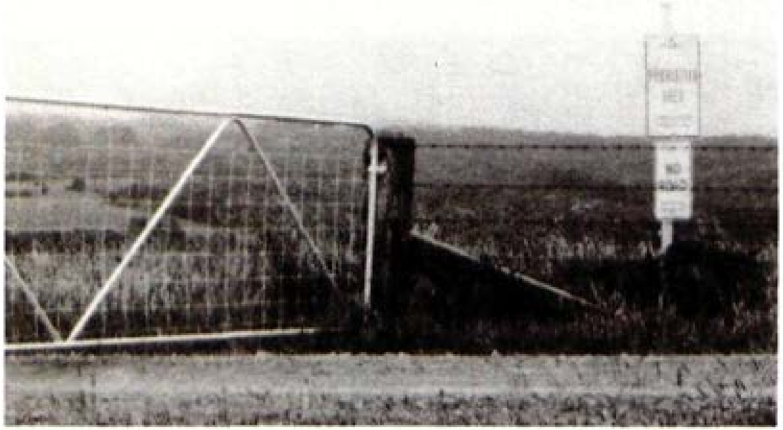
Such effects become more noticeable as the size of the area being harvested increases.. In mountain terrain the visual impact of harvesting may adversely affect some recreation values at points some distance from the actual operation.

Increasing the levels of hardwood production decreases its compatibility with other uses. It may favour certain timber species, remove trees containing nest sites for fauna, considerably reduce the size to which trees are allowed to grow, and intensify harvesting activities.

Hardwood timber production competes with agricultural and softwood timber production and with recreation activities requiring solitude.

Softwood production competes with nature conservation.

Low-intensity hardwood logging is a flexible land use.



Water production competes with recreation where catchments are closed to public access.

Water production and conservation

The production of water is an important use on public land. To some extent it is competitive with agriculture, softwood and hardwood timber production, mining, and recreation, depending on the intensity of production and the management techniques employed in these activities. The competition applies especially to the quality of water and the seasonal distribution of yield.

Logging, clearing, overgrazing, and excessive traffic contribute to soil disturbance, causing increased surface flow, which results in stream turbidity and siltation of reservoirs.

Water storages increase the opportunities for some forms of recreation, such as foreshore picnicking and water-based activities.

Inundation by dam waters has variable effects on nature conservation. It destroys the original habitats, and this may be important if a dam site contains unique or unusual species. However, it creates a new aquatic habitat that is of value for some fish and waterfowl. The variations in level as a water storage is utilized reduce its value for nature conservation. Dams also alter flow regimes downstream, and may consequently further affect wildlife habitat.

The draining of wetlands together with flood mitigation and river improvement works have benefited agriculture and urban development but have reduced the quality of the aquatic habitats.

Mining

Mining and extractive industries are scattered throughout the study area. Extractive industries are competitive with most forms of land use, through site disturbance, roading, and pollution of runoff.

Landscape values may be seriously affected, as, for example, occurs where scoria pits are developed on the sides of volcanic cones. The potentially harmful effects of extractive industries on public land are localized, however, and can usually be minimized by careful siting and proper attention to soil conservation and rehabilitation.

Public utilities and transport

In addition to water supply, these include the distribution of electricity, gas pipelines, telecommunication installations, roads, and railways. In general these activities use only small areas of public land, but in most cases they represent inflexible uses.

Transport routes have been essential for the development of all economic land uses and have widened the range of most people seeking recreation.

Separate easements for electricity transmission and pipeline installations are competitive with vegetation and some wildlife habitats, and are visually

Roads may provide for recreation, but have a dramatic impact on the landscape.

unattractive along their alignments. But they are useful as fire breaks and access tracks.

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.

Outdoor recreation

Outdoor recreation encompasses a wide range of activities. Recreation that requires natural forest environment is competitive with most other land uses, including low-intensity hardwood production and low-intensity forest grazing, and is therefore an inflexible land use.

Most recreational activities are more flexible and are compatible with a wide range of other activities, although some pursuits can become self-competitive, especially at high usage rates.

Nature conservation

Areas set aside for strict nature conservation and for scientific purposes are competitive with all other uses except water production and are therefore inflexible.

Uses of large areas of public land for recreation, water production, and hardwood production can, however, be compatible with the retention of many nature conservation values. But these values are incompatible with activities that radically change the native vegetation, such as urban development, softwood plantations, and many agricultural enterprises.

PART IV

BLOCK DESCRIPTIONS

BLOCK DESCRIPTIONS

This part describes for each block its general characteristics, the nature of the land, its capabilities for various uses, and the likely hazards and conflicts involved with such uses, and finally highlights those outstanding capabilities or other features that are of special significance.

A consistent format of headings and sub-headings has been used so that the reader can readily find specific information within one block and compare it with others. The discussion under most sections refers specifically to public land.

Block boundaries are shown on the map titled Public Land and Descriptive Blocks, in the back pocket of this report.

Capability

This term refers to the suitability of public land for various uses. Assessment is based on a number of considerations, including the inherent characteristics of the land, the proximity of public land to centres of population, the level of accessibility within it, the relative scarcity of the type of land, and the hazards associated with the various uses.

In most cases, this report deals with capabilities in general terms, because the amount of information available varies from block to block, and because some of the values are difficult to quantify. In assessing capability, comparisons have been made with other blocks and with other parts of Victoria.

1. CAPE OTWAY

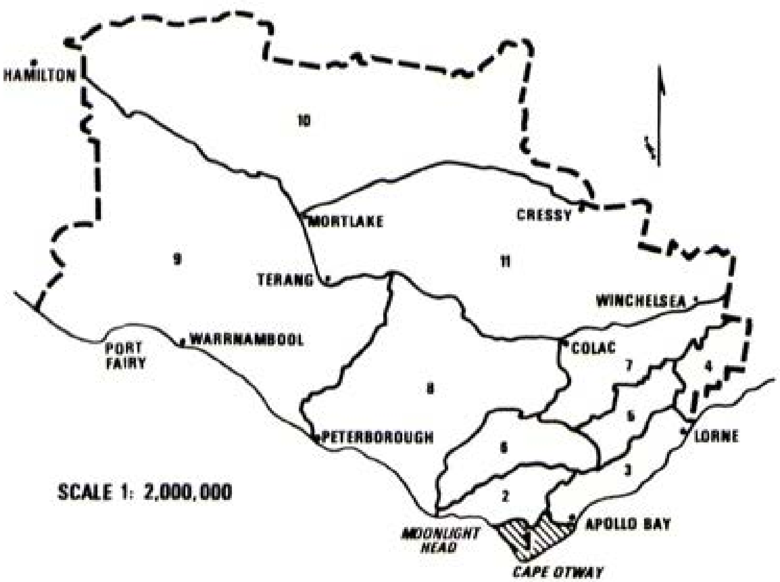
General

Present tenure

The public land is predominantly forested and covers 8,190 ha (64% of the total area).

General description

About 30% of the block is cleared for agriculture, and the remaining 70% carries native vegetation. Topography is steeply dissected in the north, and typical of the Otway Ranges, but is subdued in the south. Massive sand dunes fringe the western coastline. Almost all environments encountered in the forest and bush land surrounding and located on the Otway Range occur within the block. On the coast at Blanket Bay is a small holiday settlement located mostly on Crown land.



Present use

The land in the north-west is used predominantly for dairying, while that in the south-west supports beef cattle grazing. The eastern half carries native vegetation, areas of which are used for hardwood production and recreation.

Nature of the Land

Climate

Annual rainfall varies from 850 mm to 1,000 mm, with a pronounced winter maximum. The growing season extends from March to December. Growth is not restricted by temperature during any part of the year on the coast, but at the higher elevations low temperatures do limit plant growth during winter.

Physiography and geology

This area is geologically diverse. Outcrops of Lower Cretaceous sediments of the Otways group occur as well as outcrops of the Wangerrip group of Tertiary sediments. Quaternary sands, including the Bridgewater formation, form large deposits on the western coast. The mountainous northern section of the block contrasts with the subdued relief in the south, which contrasts again with the high dunes along the western coast.

Soils

A variety of soils, related mostly to the different types of parent materials, occur in this area. They include leached sands and calcareous sands, and yellow and brown duplex, yellowish friable gradational, and friable brown gradational soils. Shallow red and black soils are occasionally developed on dune limestone.

Vegetation

Vegetation types show a wide diversity. Marked changes in structure and floristics over short distances reflect sudden changes in parent material and soils.

Cpen forest IV of mountain ash and messmate grows in the north of the block and occasionally further south in gullies

Rugged cliffs of Lower Cretaceous sediments, Cape Otway.

Man-made structures can enhance and dramatize a landscape.

Manna gum woodland on orange sands.

where Lower Cretaceous sediments have been exposed by dissection. Open forest II and III of blue gum and associated species is widespread. Woodland of manna gum occurs, but is confined mainly to privately owned land. Woodland of brown stringybark grows in dry situations on sandy soils; where these soils occur in wet situations they often carry a woodland of bog gum.

A number of rare and interesting plants have been recorded in the block. *Correa reflexa* var. *nummulariifolia,* a variety of common correa, occurs near the Parker

Correa reflexa *var.* numullariifolia *is restricted to the sea-cliffs near the mouth of the Parker River.*

The potoroo (left) and the short-nosed bandicoot (right) are found in the woodlands with a heathy understorey

River. Bog gum is widespread on the Cape Otway peninsula. The long clubmoss has been found near the Parker River and also an apparently undescribed species of fork fern. The yellow leek orchid has been recorded on Cape Otway, as has the leafy greenhood.

Fauna

The animal species typical of the habitats that occur here are discussed in chapter 11 and listed in Appendix 6. Habitats represented in this block include wet open forest, dry open forest, grassy woodland, heathy woodland, coastal scrub, inland flowing waters, and estuaries. Because of this diversity of habitats, many different animal species occur. Among the more interesting are the tiger cat, short-nosed bandicoot, Swainson's antechinus, white-footed dunnart, and forest raven.

Capabilities

Nature conservation

This block has a high capability for nature conservation. It contains a great diversity of environments and consequently a large variety of plant and animal species are represented. The sand dunes along the western coast are an interesting geomorphic feature. The bog gum woodland is an unusual vegetation type.

Recreation

The area has high recreation potential. It is not used extensively for recreation at the moment, but use by campers and motorized recreation vehicles is increasing. Because of its potential for nature conservation, the planning of increased recreational activity in this area will have to be carefully considered.

A small holiday settlement is established on public land at Blanket Bay.

Hardwood timber

Productive stands of mountain ash, messmate, and blue gum occur in the northern section of the block and have a high potential for hardwood production. But further south, productive potential decreases as tall open forests grade into open forest I and woodland.

Softwood timber

There are no softwood plantations on public land in this block. In general, where soils are suitable for this use slopes are too steep. On flatter terrain drainage would present a problem to the establishment of radiata pine plantations.

Agriculture

Soils on public land, other than leached sands and calcaeous sands, in general have a moderate to high capability for this use. Steep slopes in the north of the block would preclude agricultural development. Native vegetation in this area has a high capability for honey production.

Minerals

Black coal seams occur in the Lower Cretaceous sediments, but these are uneconomic to mine. Dune limestone has formed on calcareous dunes along the coast. Calcareous sands are currently being mined on the western coast.

Water

This block contains the headwaters of a number of streams, including the Parker and Geary Rivers and Stony, Blanket Bay, and Deep Creeks. The Aire River enters the sea at Glenaire. Lake Horden and Lake Craven are located within this block. Water in all streams is of extremely good quality, suitable for domestic consumption.

Hazards and Conflicts

Erosion of dunes is occurring where sand has been extracted. The natural character of the environment is being disturbed in places by recreational activities such as trail-bike riding. Fire is a serious hazard in the area in summer.

Significance

This contains the widest diversity of environments occurring in any of the blocks, consequently a large number of plant communities and animal habitats are represented. The Cape Otway area is probably the most significant for nature conservation within the study area. Its significance for production of domestic water may increase in the future.

2. AIRE RIVER

General

Present tenure

The public land covers 17,190 ha (58% of the total area).

General description

About half of the block has been cleared and is used for agriculture; the remainder is under natural vegetation, except for the Aire Valley softwood plantation in the north-eastern corner. The dominant parent materials are Lower Cretacecus sediments, but areas of Tertiary sediments do occur. In the north and the south of the block the terrain is relatively suhdued, but the remainder is mainly steep.

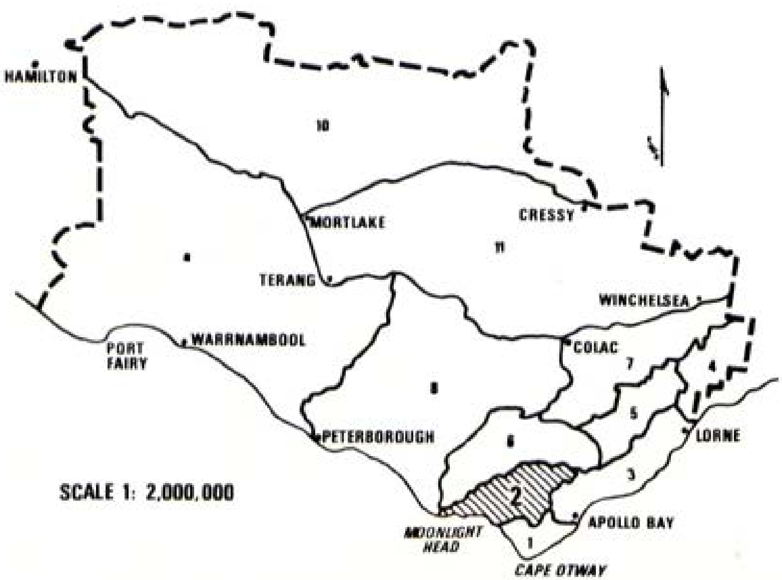
Present use

On cleared land, dairy-farming, beef cattle grazing, and potato-growing are the dominant land uses. On public land hardwood and softwood timber production are practised.

Nature of the Land

Climate

Annual rainfall varies from 900 to almost 2,000 mm depending on elevation, with a pronounced winter maximum. Along the coast the growing season extends from March to December and growth is not restricted bv temperature during any part of the year. However, this changes with elevation until on top of the range low temperatures may restrict growth from May to October.



Physiography and geology

Topography is undulating on top of the range but becomes very steep on the coastal fall. Terrain near the coast is relatively subdued. The block contains the headwaters of a number of important streams, including the Aire River.

The dominant parent materials are Lower Cretaceous sediments, although Palaeocene deposits (Tertiary sediments of the Wangerrip group) overlie these in the south.

Soils

On Lower Cretaceous sediments soils form a gradational sequence with increased elevation and rainfall. They change steadily from duplex near the coast to yellowish gradational soils to friable brown gradational soils where precipitation exceeds 1,200 mm. On the Wangerrip group of Tertiary sediments there are generally leached sands.

Vegetation

Native vegetation forms a gradational seauence with increased elevation and rainfall. Near the coast, there is open forest II of blue gum and messmate. As precipitation increases, this changes to open forest III and IV of these species. Open forest IV of mountain ash growing on leached sands has developed on Tertiary sediments near Redwater Creek. Stands of myrtle beech occur along Aire River. This is unusual in Victoria, where it normally occurs only as isolated trees in deep gullies in the wet mountain forests. One interesting plant recorded in the area is the leafy greenhood from near Glenaire.

Myrtle beech occurs in the deep gullies of the Aire River valley.

Fauna

The animals found in the habitats that occur here are discussed in Chapter 11 and listed in Appendix 6. The main habitats in this block include wet open forest, dry open forest, and pasture. Animals typical of these forest habitats include the potoroo, bush rat, brown antechinus, and Swainson's antechinus.

Capabilities

Nature conservation

The public land has a moderate to high capability for nature conservation. The area contains substantial areas of wet mountain forest with associated myrtle beech and fern gullies. The stands of mountain ash growing on leached sands are of particular conservation interest.

Recreation

The area has a moderate to high recreation potential, but at the moment access to many parts is not good. The Aire Valley plantation has good access roads, and sightseers and picnickers use it quite intensively.

Hardwood timber

The block has a high capability for this use, particularly the areas of mountain

Swainson's antechinus (left) and the bush rat (right) are found only in moist areas of dense scrub.

ash open forest IV. However, most of the forests are in need of silvicultural treatment in order to encourage regeneration.

Softwood timber

Considerable areas of public land in this block, where slopes are less than 20°, have a high capability for softwood production. In general, however, they support potentially productive mountain ash open forest IV. The high growth rates of radiata pine in the Aire Valley

Clearfelling in the Aire Valley softwood plantation.

Several softwood species, including Californian redwood, are growing in the Aire Valley plantation.

plantation demonstrate the capability of the land for this use.

Agriculture

Where slopes are less than 20° the capability of most public land in this block for this use is moderate to high. The capability of public land for honey production is moderate.

Minerals

Black coal seams occur in the Lower Cretaceous sediments, but are uneconomic to mine. Where Tertiary sediments outcrop, there are deposits of sand and gravel. The Otway sandstone when crushed is suitable for road surfacing.

Water

A number of streams have their headwaters in this block. These include the Johanna, Ford, Aire, and Calder Rivers. Water in all streams is of extremely good quality for domestic consumption.

A number of sites suitable for dams exist on the Aire River, which is considered to be a potential high-yield supply for Geelong or possibly the Otway system.

Hazards and Conflicts

Fire is a serious hazard during summer. At the moment there are no obvious conflicts in this block. It is likely that conflicts between water production, nature conservation, recreation, and timber production could develop in the future. The construction of a water storage on the Aire River may possibly inundate stands of myrtle beech growing in the river valley.

Significance

Of particular significance in this block is the area of mountain ash growing on leached sands developed on Tertiary sediments. This is probably the only example of this soil and vegetation combination in Victoria. The Aire Valley plantation is significant in that it produces a considerable quantity of softwood for local markets and has growth rates of radiata pine that are among the highest in Victoria. The mountain ash forests of the block are an important part of the hardwood timber resources of the study area. The Aire River catchment is significant as a future domestic water supply area.

3. TANYBRYN

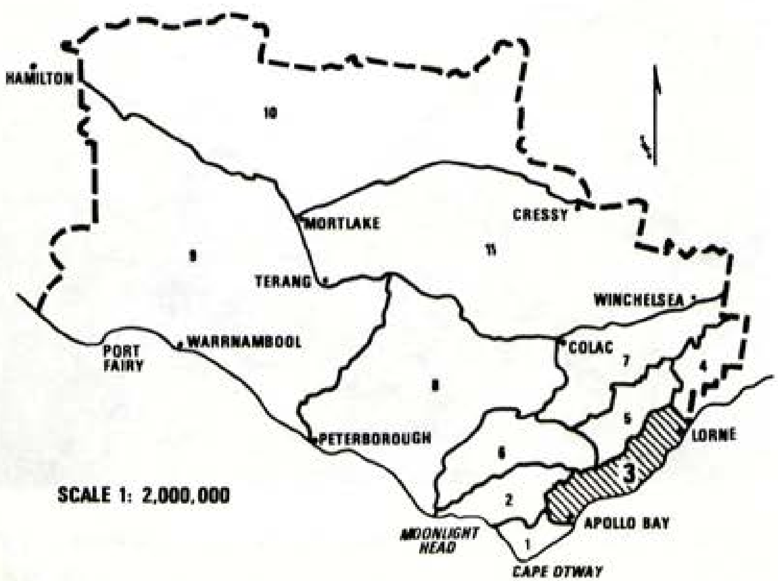
General

Present tenure

The public land covers 29,310 ha (72% of the total area).

General description

This block covers the southern slopes of the Otway Range between Apollo Bay and Loutit Bay. The dominant parent materials are Lower Cretaceous sediments and in general slopes are extremely steep, particularly near the ocean. Vegetation and soils follow a gradational sequence with change in elevation and rainfall.



About 70% of the area is under natural vegetation. The remaining 30% has been cleared and portion of this is reverting to bracken and scrub.

Present use

On cleared land dairy-farming, beef cattle grazing, and potato-growing are the dominant land uses. Over the years large volumes of hardwood have been extracted from the forests. The area is increasing in importance as a source of high-quality domestic water.

Nature of the Land

Climate

Rainfall varies from 900 mm to more than 1,500 mm per year. The growing season varies with elevation. On the coast it may continue for almost the whole year, whereas on the western end of the range low temperatures may retard it during June to October.

Landslips are a hazard on steep slopes.

Physiography and geology

The dominant parent materials are Lower Cretaceous sediments. A large proportion of this block consists of the southern slopes of the Otway Range, which tend to be very steep.

The hanging valleys of the numerous streams that enter the sea in this block indicate the dominance of marine erosion. Shore platforms fringe most of the coastline and slopes down to the sea are often extremely steep, although cliffs are seldom present.

Soils

Soils form a gradational sequence with changes in elevation and climate. Duplex soils have developed near the coast at the eastern end. With increased rainfall these grade into yellowish gradational soils. In areas where precipitation exceeds 1,200 mm, friable brown gradational soils have developed.

Vegetation

Vegetation forms a gradational sequence with increased rainfall and elevation. The general sequence from the coast to the top of the range is coastal scrub

Open Forest III, Lorne--Dean's Marsh road.

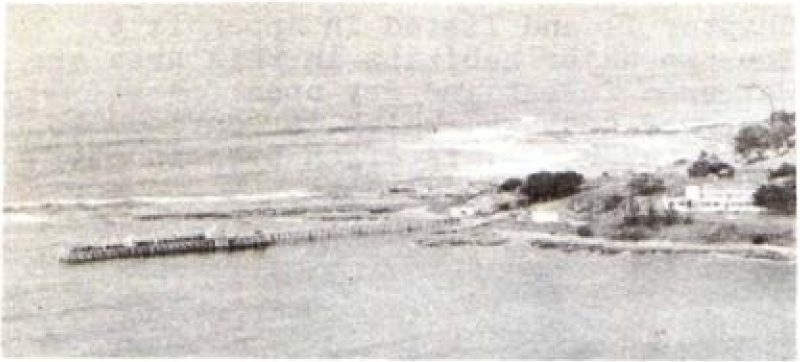
that grades rapidly into open forest I of blue gum, which then changes to open forest II and III of mixed species. Wet gullies and areas at elevations above 400 m carry open forest IV of mountain ash, mountain grey gum, and messmate.

Fauna

The animal species typical of the habitats that occur here are discussed in Chapter 11 and listed in Appendix 6. The two major habitats in this area are wet open forest and dry open forest. The grey goshawk, which is confined to the Otway Range, is often seen in this block.

The carnivorous tiger cat is found in the dense mountain ash forest.

The grey goshawk is often seen in the block (juvenile birds are white).



Lorne jetty. Loutit Bay.

Capabilities

Nature conservation

In general, public land in the block has a moderate to high capability for this use.

The area is of particular interest as it provides excellent examples of the soil and vegetation sequence that occurs on Lower Cretaceous sediments with changes in elevation.

Recreation

The scenic qualities of most of the land give this area a moderate to high capability for recreation. Recreational attractions include scenic roads, such as the Wild Dog Road and Great Ocean Road, several scenic lookouts, such as Mount Defiance and Crows Nest Lookouts, and also a number of spectacular waterfalls, including the Erskine Falls and Kalimna Falls.

The Erskine falls near Lorne is a popular scenic attraction.

Hardwood timber

Public land in this block, particularly in the south-west section, has a high capability for hardwood production. The forests, particularly mountain ash open forest IV, need extensive silvicultural treatment in order to encourage regeneration if they are to remain productive.

Softwood timber

The capability of this land for softwood timber production depends on slope. Most slopes are greater than 20° and consequently establishment and management of softwood plantations would be difficult.

Steeply sloping land is used for agriculture in the Wild Dog Creek valley.

Agriculture

Capability for agriculture in general is only moderate. Although climate and soils may be suitable, slopes are often too steep. Despite this disadvantage, dairy-farming, beef cattle grazing, and potato-growing are carried out on steep freehold land in the Wild Dog Creek area.

Capability for honey production is moderate to high.

Minerals

The public land has no significant mineral deposits. However, the Otways sandstone, when crushed, provides excellent road-surfacing material. Narrow seams of black coal occur, but these are not economic to mine.

Water

Very many streams and rivers have their headwaters within this block. These include the Barham, Smythe, Grey, Kennett, Wye, Cumberland, St. George, and Erskine Rivers. Water in all of these streams is of extremely high quality and is suitable for domestic consumption; several are used for town supplies.

Hazards and Conflicts

During summer, fire is a constant hazard in this block. Conflicts between nature conservation, recreation, timber production, and production of domestic water may develop in the future.

Landslips that block roads are not uncommon when soils become saturated during winter.

Significance

The main significance of this block lies in its potential for hardwood timber and recreation. Water production from the area is likely to grow in significance.

4. SALT CREEK

General

Present tenure

The public land covers 17,940 ha (or 61% of the total area); 2,900 ha of Crown land is held under mining lease by Alcoa Australia Ltd.

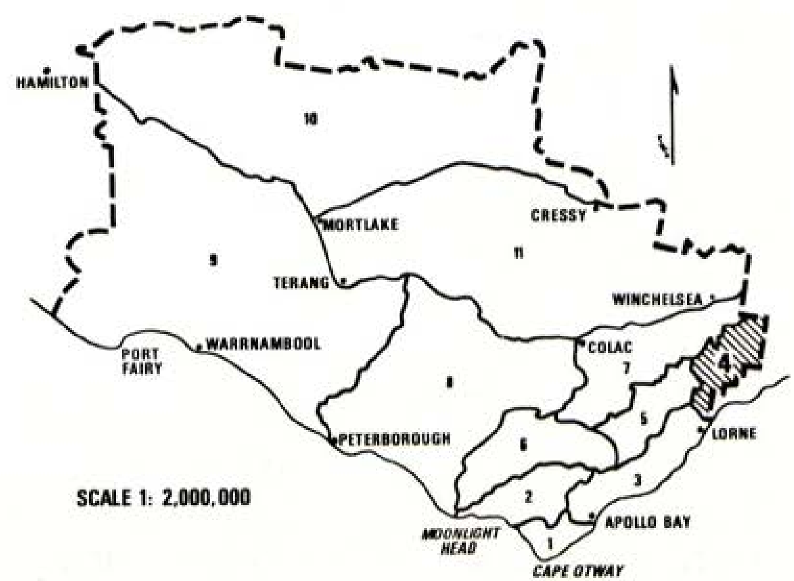
General description

This block covers the eastern end of the Otway Range not included in the Melbourne study area. It is relatively dry as it lies in the lee of the higher parts of the Otway Ranges. The rainfall decreases (with elevation) to the south, north, and east and the vegetation pattern is accordingly varied, with forests on the higher ground and dry heathy woodlands in the east. Parent materials include both Lower Cretaceous and Tertiary sediments, and the varied soils over these also affect the vegetation pattern.

Present use

The northern section of the block is cleared and is used for beef cattle grazing and sheep grazing. On public land in the north-west, 885 ha of softwood plantations have been established. Hardwood timber is extracted from the south-west, but public land further to the north-east carries forest that is generally unproductive. Alcoa Australia holds 2,900 ha of public land under mining lease.

Brown coal is mined near Anglesea (in the adjacent Melbourne study area) at present and will eventually be obtained from the portion of the lease that lies within the Corangamite study area.



Nature of the Land

Climate

Rainfall varies from 600 mm in the east to more than 1,100 mm in the west with a winter maximum. The length of the growing season varies with elevation. Growing season could be expected to last from March to January, with restricted growth from June to August.

Physiography and geology

In the south-western half the parent materials are Lower Cretaceous Otway sediments, but those in the north are Tertiary sediments consisting mainly of the Wangerrip group and Moorabool Viaduct formation. Elevation in general decreases from Benwerrin in the south-west to the flatter country in the north-east. Terrain is generally steep on the Otway sediments and becomes more subdued on Tertiary sediments. In places there are conspicuous laterite plateau remnants. The Anglesea River and a large number of streams have their headwaters in this block.

Soils

The wettest areas of the block carry friable brown gradational soils. As the rainfall decreases, on Lower Cretaceous sediments yellow gradational soils change in very dry situations to duplex. On the Moorabool Viaduct formation of Tertiary sediments the dominant soils are duplex, whereas on the Wangerrip group of sediments they are chemically impoverished leached sands.

Red ironbark open forest II; isolated occurrence north of Airey's Inlet.

Vegetation

The wettest areas of the block support open forest IV of messmate and mountain ash. The chief understorey trees are blackwood and silver wattle. Small colonies of tree ferns and associated vegetation occupy the upper parts of gullies in the south-west. The drier valley slopes are covered with a varied assortment of shrubs, principally myrtle wattle, narrow-leaf wattle, prickly moss, common wedge-pea, and common heath.

In the eastern Otways messmate and brown stringybark form open forest II and I on gradational and duplex soils developed on the Tertiary sediments. Red ironbark, sometimes in almost pure stands, forms open forest I and II in the rain-shadow area north of Aireys Inlet.

Heathy woodlands are widespread on the Tertiary sediments. Shining peppermint occurs on leached sands that have an impeding layer near the surface, while brown stringybark grows on leached sands without an impeding layer or on sodic duplex soils. Heath understorey includes thatch sawsedge, tassle rope bush, austral grass-tree, and heath tea-tree.

A number of unusual plants have been recorded in this block. They include the short-tailed leopard orchid, wrinkled buttons, and *Platylolium obtusangulum* var. *spinulosum*, a variety of the common flat-pea. The Victorian smoke bush is at the easternmost extent of its distribution in this block.

Stunted shining peppermint and heathland on impoverished sands at Bald Hills.

Fauna

The animals found in the habitats that occur here are discussed in Chapter 11 and listed in Appendix 6. The main faunal habitats in this block are wet open forest, dry open forest, heathy woodland, and pastures. This diversity results in the occurrence of many different species of native animals. The heathy woodland north of Aireys Inlet provides habitat for many bird species, including the striated thornbill and several honeyeaters.

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The mammals include the short- and long-nosed bandicoots, bush rat, red-necked wallaby, and possibly the potoroo. Eastern grey kangaroos and black wallabies are common.

Reptiles include the tree dragon and southern blue-tongue lizard.

Capabilities

Nature conservation

Capability for nature conservation is high. This applies particularly to the low woodlands and heathlands in the north-east, which are rich in both fauna and flora.. This vegetation type forms a unit with similar heathy woodland in the adjacent Melbourne study area. The area of red ironbark forest in the extreme east of the study area is an interesting isolated occurrence of this species.

The red-necked wallaby is uncommon but widespread in the heathy woodland and dry open forest.

Recreation

Capability for recreation, particularly in the north-east section, is high. The area is already used by trail bikes in some parts; sightseers and picnickers from nearby Geelong also use it extensively. The recreational demand on this land will increase as the population of Geelong increases.

Hardwood timber

While the southern section of the block has a high capability for this use, the capability in the north-east is generally low.

Softwood timber

Where slopes are not too steep, the messmate and brown stringybark open forest in the north has a moderate to high capability for this use. In fact the eastern Otways plantation covers 885 ha in this area and extension is likely if the projected total of 8,000 ha planned by the Forests Commission for the Otway plantation zone is to be obtained.

Gravel pits and rubbish dumps are necessary, but can be unsightly if rehabilitation is inadequate.

Agriculture

Capability of public land for this use is moderate to low. In general, depending on slope, it ranges from moderate on Otway sediments to extrêmely low on the Wangerrip group of Tertiary sediments.

Minerals

Extensive gravel and sand deposits are found where the Wangerrip group of Tertiary sediments outcrop. Large deposits of brown coal occur in this group of sediments and have been mined at Wensleydale, outside the study area. Within the study area it probably will be mined in the future within the lease area of Alcoa Australia.

Water

The quality of water in streams on the Otway group of sediments is high. In

Small experimental plots are used to test suitability for growth of radiata pine.

contrast, water in streams on Tertiary sediments in general is unsuitable for domestic consumption. The Wangerrip group of Tertiary sediments contains large reserves of generally good groundwater.

Hazards and Conflicts

Fire is a serious hazard during the summer. In the east of the block conflict already exists between nature conservation and recreation. This conflict applies particularly to trail bikes. Conflicts are likely to develop between coal-mining, recreation, and conservation. There is also a potential conflict between softwood production and nature conservation.

Significance

This block contains a diversity of environments. Of particular interest are the shining peppermint woodlands developed on leached sands in the east, which are extremely rich in both fauna and flora. The Wangerrip group of Tertiary sediments contains large reserves of brown coal, which will most probably be mined in the future. Areas of moderate slope with gradational soil in the north of the block are suitable for the growth of radiata pine.

5. PENNYROYAL

General

Present tenure

The public land covers 18,750 ha (62% of the total area).

General description

This block covers the northern slopes of the Otway Range between Upper Gellibrand and Deans Marsh. Slopes, although steep, are generally more subdued than those on the southern fall of the range. The dominant parent materials are the Lower Cretaceous Otway group sediments, with areas of the Wangerrip group Tertiary sediments outcropping near Forrest. In the north the Moorabool Viaduct group of Tertiary sediments occur.

Present use

The major portion of the area is under natural vegetation. The West Barwon Dam and its catchment, which is important in the supply of water to Geelong and the Bellarine Peninsula, is located in the north-west of this block. The north-east section is cleared and is used for beef cattle and sheep grazing and some cropping.

Nature of the Land

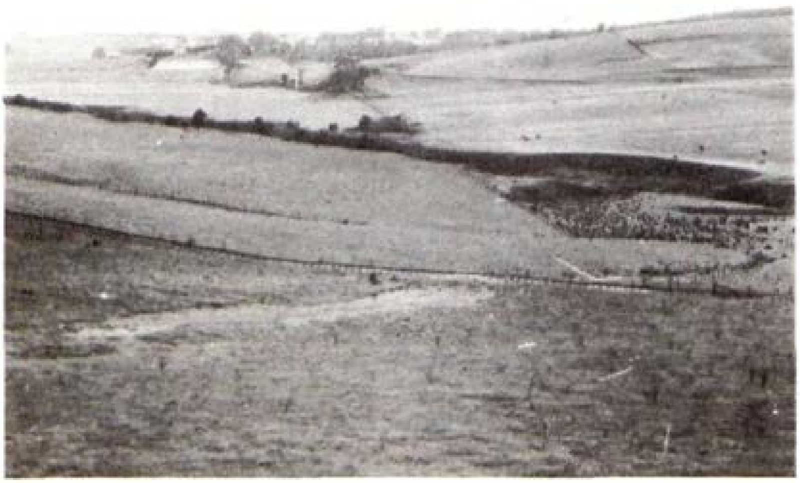
Climate

Rainfall varies from about 700 to 1,400 mm, with a pronounced winter maximum. The length of the growing season varies with changes in elevation, reflecting the changes in temperature.

Physiography and geology

The dominant parent materials are Lower Cretaceous sediments. However, there is a small area of the Wangerrip group of Tertiary sediments around Forrest and further small occurrences on the Otway Range itself. In the north the Moorabool Viaduct group of Tertiary sediments outcrop. In general, the slopes on the Otway Range are quite steep. Many streams that have their headwaters in this block have cut steep-sided valleys in the parent material.

The terrain developed on Tertiary sediments is more subdued than that on the Lower Cretaceous sediments.



Topography in the north of the block is relatively subdued.

The olive whistler is widespread in both wet and dry open forests.

Soils

On the Lower Cretaceous sediments, soils form a gradational sequence with changes in elevation and climate. They grade from duplex to yellow gradational at the drier lower elevations, and change to friable brown gradational soils in the higher wetter areas. On Tertiary sediments, soil types are generally related to changes in the characteristics of the parent material. They vary from leached sands to yellow gradational and duplex soils.

Vegetation

On the Otway Range vegetation forms a gradational sequence with increased rainfall and elevation. In general, the sequence from the bottom to the top of the Range is open forest I and II of messmate and grey gum, grading into open forest III of these species, then changing to mountain ash and messmate open forest IV in wet situations.

Fauna

The animals found in the habitats that occur here are discussed in Chapter 11 and listed in Appendix 6. The main faunal habitats are wet open forest, dry open forest, and pasture, with some small areas of heathy woodland around Forrest. Animals occurring here include the bush rat, tiger cat, Swainson's antechinus, and the long-nosed bandicoot.

Capabilities

Nature conservation

In general public land in this block has a moderate to high capability for this use. There are no plants of particular importance known to occur. However, the block has a wide range of species and of animal habitats.

Recreation

Because of the unspoilt nature of the environment and scenic qualities of most of the land, this block has a moderate to high capability for recreation. Attractions include scenic drives, and sightseeing and picnicking in the environs of the West Barwon Dam.

Hardwood timber

Capability of the block for this use increases with increased rainfall towards the south-west, where the capabilitiy is high.

Capability for hardwood production is high in the wet open forests.

Over-mature trees provide animal habitat but have little value for timber production.

However, much of the potentially productive forest area needs silvicultural treatment in order to encourage regeneration if the productive capacity is to be maintained.

Softwood timber

Most of the area has a high capability for this use. In certain situations, however, slopes are too steep (greater than 20°) for efficient softwood production.

Agriculture

Capability for agriculture is moderate. Although climate and soils are suitable, slopes may be too steep for this use to be practicable. Public land in this block has a moderate capability for honey production.

Minerals

No significant deposits of minerals are known on the public land. However, sands of the Wangerrip group of Tertiary sediments occur and are extracted from land around Forrest. Thin seams of

Moderately sloping land in the north-east of the block is used for grazing.

The West Barwon Dam stores water for Geelong.

black coal occur in the Otway sediments, but are not economic to mine.

There may be deposits of brown coal in the block.

Water

The block contains the headwaters of a large number of streams. These include the Barwon River and Monday, King, Mackie, Callaghan, Dewing, Matthews, Pennyroyal, and Marsh Creeks. The catchments of the East and West Barwon Rivers, which supply Geelong with water, are located in the north-west of this block. The outcropping Wangerrip group of Tertiary sediments provides an important intake area for underground water.

Hazards and Conflicts

During summer, fire is a constant hazard in this block. Conflicts between nature conservation, recreation, timber production, and water harvesting may develop in the future.

Significance

The main significance of this block is that it includes an important water catchment area. It is also important for hardwood production and does contain areas suitable for softwood production.

6. CARLISLE

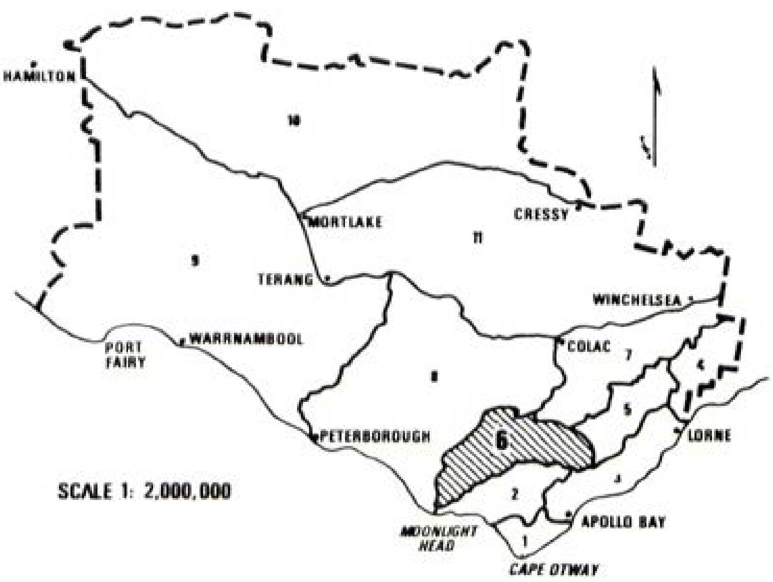
General

Present tenure

The public land covers 30,000 ha (59% of the total area).

General description

The block is bounded in the north and west by the Gellibrand River and the main Otway ridge in the south. Terrain on the flanks of the Otway Range is hilly to undulating which contrasts with the generally steep slopes of the Range itself. A large proportion of the block is public land supporting natural vegetation.



Present use

Hardwood timber, including mountain ash, is cut from the forests on the Otway Range. Two areas are set aside specifically for water production. These include an area near Olangolah operated by the Colac Waterworks Trust, and the Arkins Creek catchment to the north of Wyelangta controlled by the State Rivers and Water Supply Commission. Softwood production is practised in the east of this block in the Websters Hill Plantation. On cleared land, dairying, beef cattle production, and potato-growing are the predominant land uses.

Nature of the Land

Climate

Annual rainfall is high, varying from 900 mm in the west to nearly 2,000 mm on the Range, with a pronounced winter maximum. In elevated areas, the growing season extends from January to December, but low temperatures may restrict growth from May to October. At lower elevations the nature of the growing season changes, with less restriction by temperature and more by moisture stress.

Physiography and geology

The elevated Otway Ranges are a domal structure, composed of Lower Cretaceous sediments. Land on the top of the Range in this block is gently undulating, although slopes are steeper on the northern fall. On the northern flanks of the Range the Wangerrip group of Tertiary sediments outcrop. A small area of the Moorabool Viaduct formation occurs near Gellibrand. Throughout the area on Tertiary sediments, isolated high-level lateritic plateau remnants, such as Mount McKenzie, remain.

Soils

The soils on the Range form a continuous sequence with increased elevation and rainfall. Friable brown gradational soils occur if rainfall exceeds 1,200 mm. Where rainfall is lower, the predominant soils are yellowish gradational. Those soils developed on the Wangerrip group of Tertiary sediments are chemically impoverished leached sands. Peats occur in some swamps.

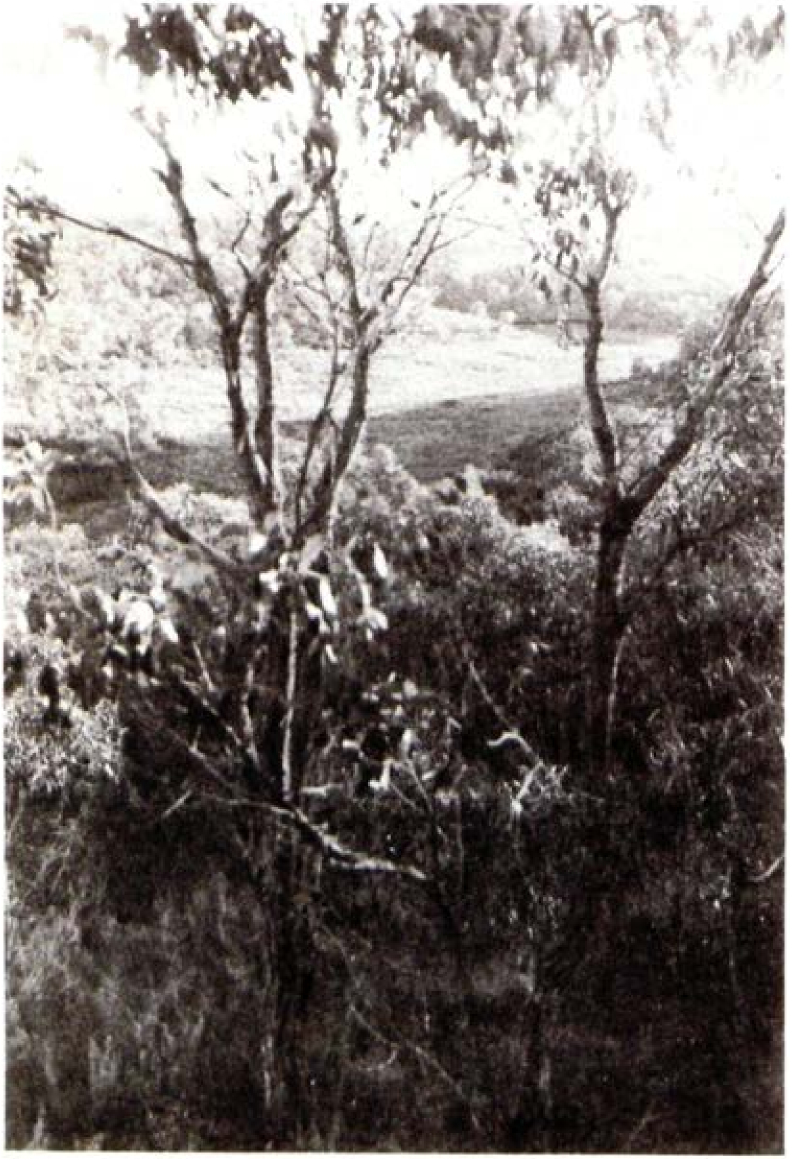
Vegetation

Vegetation forms a gradational sequence with increased rainfall and elevation. Mountain ash open forest IV grades into mixed-species open forest III and II with decreased rainfall. Closed forest of myrtle beech, blackwood, and tree ferns grow in wet gullies. The leached sands carry extensive areas of heath and shining peppermint and brown stringybark woodland.

Fauna

The animals found in the habitats that occur here are discussed in Chapter 11 and listed in Appendix 6. The main faunal habitats in this block are wet

Mountain ash; regrowth following a past bushfire.



Shining peppermint woodland and heathland on leached sands near Chapple Vale.

open forest, dry open forest, heathy woodland, and pasture. By far the most extensive area of heathy woodland in the study area occurs in this block.

Heathy woodlands typically have a dense to mid-dense stratum of low shrubs, which provide habitats for small ground-dewlling animals and both nesting and feeding areas for small birds.

They contain mammals such as the swamp rat, white-footed dunnart, and brown antechinus, and birds such as the rufous bristle bird and eastern spinebill.

Capabilities

Nature conservation

The extensive areas of shining peppermint heath woodland have a high capability for conservation. These are extremely rich floristically and represent a land type that does not occur outside the study area.

Several rare plants are found on the heathlands. They include *Helichrysum rogersianum*, which is restricted to this and two other localities in Victoria. The lizard orchid (*Burnettia curreata*), which is becoming rare in this State due to the destruction of its habitat, may be found beneath thickets of paperbark. Pointed ricegrass (*Tetrarrhena acuminata*) is also localized and rare in Victoria and is found in swampy places on the heathland.

The area of mountain ash controlled by the Colac Waterworks Trust is an excellent example of this vegetative type in its natural condition, and thus has a high capability for nature conservation.

Recreation

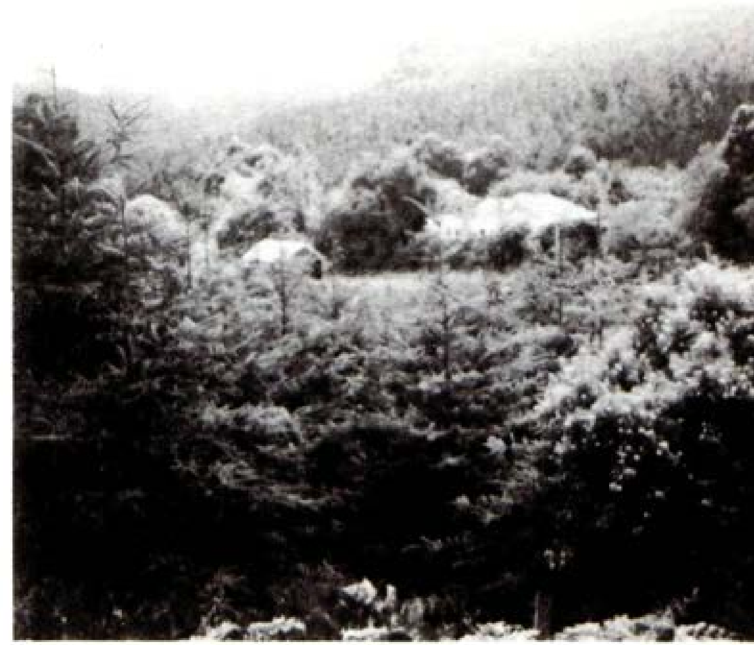
No part of the block is used intensively for recreation. The heathy woodlands have a high capability for a number of forms of recreation including activities that require solitude, nature study, and motorized recreation vehicles. The scenic beauty of the Otway Range will become an increasing tourist attraction.

Hardwood timber

The Otway Range has a high capability for hardwood timber. There is, however, a strong need for improved silvicultural techniques to restore productivity in many areas. In general, forests and woodland growing on Tertiary sediments in this block have a low capability because the chemically impoverished soils support only stunted vegetation.

Softwood timber

The Lower Cretaceous sediments of the Otway Range have a high capability for this use, as is demonstrated by the growth rates of radiata pine growing in the Websters Hill Plantation, started in 1963. However, the leached sands developed on Tertiary sediments are so chemically impoverished as to be un-



Websters Hill softwood plantation (partly on purchased farmland).

satisfactory for the growth of radiata pine.

Agriculture

Land with slopes of less than 20° on the Otway Range has a moderate to high capability for agriculture, including potato-growing and beef cattle and dairy production. In general, soils developed on Tertiary sediments are too poor chemically for economic agricultural production. Areas of alluvium such as those around Carlisle, however, have a

Undulating agricultural land near Beech Forest.

Pig-farming at Carlisle River; escaped pigs can compete with wildlife.

high potential for this use. The native vegetation has a high capability for honey production.

Minerals

Black coal seams occur in the Otway sediments but extraction is uneconomic. Otway sandstone when crushed is suitable for road surfacing. A bentonite deposit occurs at Charlies Creek, 1½ km south of Gellibrand.

The Wangerrip group of Tertiary sediments has a high potential for both sand and clay production. Brown coal seams have been found in bores at Kawarren and Gellibrand.

Water

The Otway Range here has very high capability for water production. In fact, two areas in the block have been set aside specifically for this use. These include the Colac Waterworks Trust area north of Olangolah and the Arkins Creek catchment north of Wyelangta operated by the State Rivers and Water Supply Commission. The extensive outcrops of the Wangerrip group of Tertiary sediments form important intakes for aquifers.

Hazards and Conflicts

Fire is a serious hazard in this block, particularly in the low woodlands and heath between Gellibrand and Chapple Vale. The danger of fire spreading from this area to the more productive forests of the Otway Range must be a consideration in any management plan. Land slips occur from time to time on the Otway sediments and may occur irrespective of whether or not the area supports native vegetation.

Conflicts between nature conservation, recreation, and other uses are likely to exist in the future. If pines are planted on the sands that form intake areas for aquifers, the recharge of reserves of groundwater may be disrupted.

Significance

The extensive Carlisle heathland represents by far the largest remnant of shining peppermint heath woodland in the State. The area of mountain ash forest controlled by the Colac Waterworks Trust is one of the best unspoiled examples of this forest type in Victoria. Land in this block has a high significance for the production of domestic water. The eastern section is significant for both hardwood and softwood production.

Aboriginal grinding rocks on freehold land near Gellibrand.

Aborognal grinding rocks and a rock carving located in 1962 on private land near Gellibrand are of considerable archaeological significance.

7. BIRREGURRA

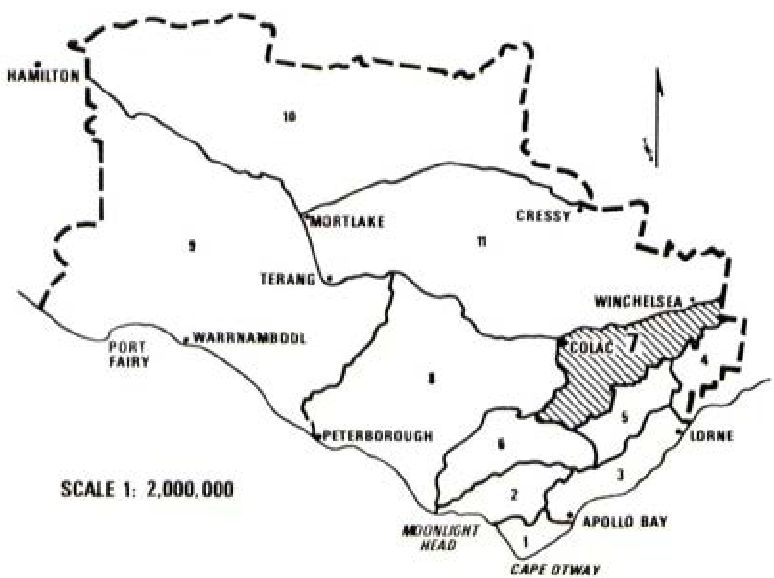
General

Present tenure

The public land covers 8,375 ha (12% of the total area).

General description

The bulk of this block has been cleared of natural vegetation. The dominant parent material is the Moorabool Viaduct group of Tertiary sediments. A small area of basalt occurs in the north-east, and extensive areas of alluvium are found along the Barwon Valley. In general, the terrain is subdued but geomorphologically complex.



Present use

On cleared land, beef cattle grazing, sheep grazing, and cropping are the dominant land uses. The public land supports some hardwood timber production and radiata pine is grown near Gerangamete.

Nature of the Land

Climate

Rainfall varies from about 650 to 850 mm with a pronounced winter maximum. The growing season generally extends from March to December, with restricted growth from June to August due to low temperatures.

Physiography and geology

The dominant parent materials are Tertiary sediments of the Moorabool Viaduct formation. Extensive areas of alluvium occur along the Barwon Valley. Towards

Dissected Tertiary sediments near Deans Marsh.

Alluvium flats of the Barwon Valley near Birregurra.

the south-west, the Wangerrip group of Tertiary sediments outcrops.

In general, the terrain is relatively subdued. There are, however, prominent laterite plateau remnants with steep slopes falling away from them. The large areas of alluvium are relatively flat and broken only by remnants of river terraces.

Soils

The changes of soil types in the area are related to climatic differences and differences in parent material. Duplex soils are widespread where the rainfall is less than 700 mm per year. Friable dark gradational soils are commonly developed on alluvium.

Reddish and yellowish gradational soils occur on the Moorabool Viaduct group of sediments where the annual rainfall exceeds 700 mm. On the Wangerrip group of sediments, leached sands are common.

Vegetation

The structure and composition of the vegetation changes with climate and with soil differences, which are related to changes in parent material. The leached sands carry small areas of shining peppermint woodland. The duplex soils generally carry open forests I and II of messmate, brown stringybark, and associated species. Where soils are gradational, open forests II and III of these species occur. One plant of particular interest that has been recorded on public land in this block is *Prasophyllum beauglehole*i, a rare leek orchid.

Fauna

The animal species typical of the habitats that occur here are discussed in Chapter 11 and listed in Appendix 6. The habitats represented in this block include dry open forest, heathy woodland, grassy woodland, and pastures. Among the unusual animals occurring here are the short-nosed bandicoot and swamp antechinus.

The brown antechinus is widespread in open forest and woodland.

Capabilities

Nature conservation

The natural bushland in this block is floristically rich and contains a diversity of habitats for native fauna. It thus has a high capability for nature conservation.

Some small areas of public land, such as Lake Ayrey, near Birregurra, provide valuable waterfowl habitat.

Recreation

The public land has a moderate capability for this use. There are no outstanding features of a recreational interest, but the natural bushland combined with the relatively subdued terrain and the proximity to Colac will result in an increased recreational use in the future.

Hardwood timber

Capability for this use is moderate. Sawlogs can be obtained from areas of open forest II, but land supporting open forest I and woodland is virtually unproductive.

Softwood timber

Public land in this block has a moderate to high capability for softwood production where the annual rainfall exceeds 750 mm. However, site quality tends to vary considerably over short distances, reflecting changes in soil properties. The radiata pine plantation near Gerangamete has displayed satisfactory growth rates.

Agriculture

Capability for agriculture on the remaining public land is generally moderate to low. Soils are often deficient

Undulating farmland in the south-west of the block.

Fine-wool production at Warncourt.

in a number of nutrients and display poor physical properties.

Minerals

There are no significant mineral deposits known on public land in this block. Sand and gravel, however, are extracted from several small pits.

Water

The quality of water in streams in the southern portion is generally good, but towards the north quality decreases. By far the most significant stream in the area is the Barwon River. Groundwater contained in the Moorabool Viaduct group of sediments, the dominant parent material in this block, is generally saline, but better-quality groundwater occurs in other geological formations below this. Lake Wurdiboluc, which is the holding reservoir for the Geelong water supply, is in the block.

Hazards and Conflicts

Severe gully erosion occurs on some freehold land in this block. Removal of the natural vegetation would probably result in similar soil deterioration on public land. Conflicts between nature conservation and softwood production may develop in the future.

Significance

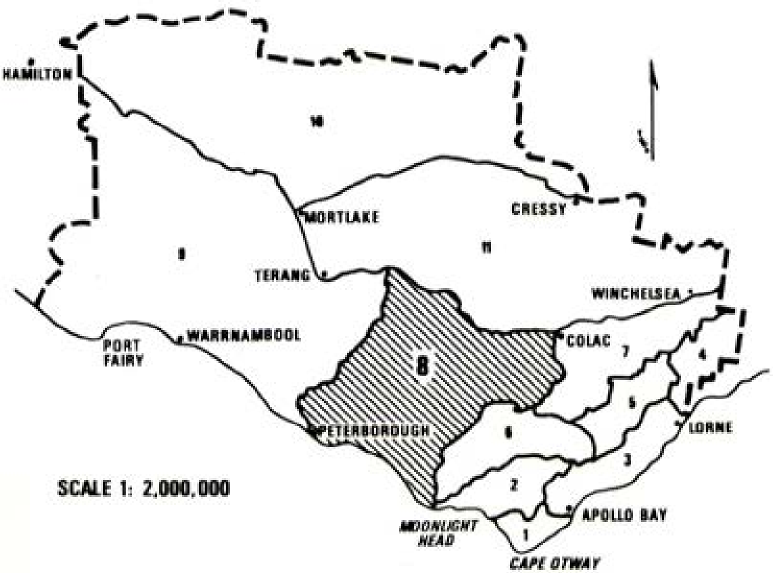
Public land in this block is significant for nature conservation. It also has a significant capability for softwood production.

8. HEYTESBURY

General

Present tenure

The public land covers 41,250 ha (21% of the total area). This includes 14,125 ha of Crown land under the control of the Rural Finance and Settlement Commission, 1,200 ha of National Park at Port Campbell, and 306 ha of Crown land under the control of the Social Welfare Department operated as a prison farm at Corriemungle.



General description

A small portion of the northern section of this area consists of flat basalt plain. Stony rises occur to the south of Lake Corangamite. Further south, the terrain developed on Tertiary sediments is undulating. Most of the land has been cleared for agriculture, including about 25,000 ha that have been cleared in the last 15 years by the Rural Finance and Settlement Commission. Only a few remnants of this extensive forest remain.

Present use

In the south of the block, dairy-farming is the predominant land use. Cattle and sheep grazing, together with some cropping, are practised in the north. Hardwood timber, gravel, and sand are extracted from some areas of public land. A pine plantation established at Warre near Port Campbell has proved uneconomic, although remnants still exist.

Nature of the Land

Climate

Rainfall varies from 700 mm in the north to more than 900 mm in the south. Growing season generally extends from March to December, with restricted growth from June to August due to low temperatures.

Physiography and geology

Apart from the small area of basalt in the north and the stony rises to the south of Lake Corangamite, the predominant parent materials consist of Tertiary sediments. The main sediments outcropping in this area are the Heytesbury and the Moorabool Viaduct formations. Lower Tertiary sands and gravels of the Wangerrip Group occur near Fergusons Hill.

Cave in lava flow, Mount Porndon.

The laterite plateau is dissected by the Curdie River to the south of Cobden.

The bulk of the land falls within the major physiographic subdivision of Coastal Plain. A characteristic of the terrain is extensive, laterite plateau remnants. On the basalt plain near Camperdown, relics of eruptions are the volcanic cones of Mount Leura and Mount Porndon, and the crater lakes Lake Bullen Merri, Lake Gnotuk, and Lake Purumbete. Lava caves on private land at Mount Porndon are of special geological interest.

The coastline is characterized by spectacular cliffs that are currently being quickly eroded, leaving rock stacks, caves, arches, and tunnels.

Soils

Duplex soils are developed on both basaltic and Tertiary sediments in the north of this block. Towards the south, soils become gradational. Lateritic soils occur on laterite plateau remnants. Leached sands occur on small Recent sandsheets or outcrops of the Wangerrip group of sediments. Shallow red and black soils are sometimes developed on Miocene limestone. Calcareous sands occur occasionally on the coast.

Vegetation

The natural vegetation on public land represents a relic of the vast Heytesbury forest. In general, it consists of open forest II of messmate and manna gum. Open forest III occurs in some gullies, and occasional patches of woodland consisting of shining peppermint, apple box, and brown stringybark grow on leached sands. The natural vegetation has been removed from about 14,000 ha of public land under the control of the Rural Finance and Settlement Commission.

Rare plants that have been recorded in this block are concentrated in the Port Campbell area; they include the swamp diuris, square raspwort, morning flag, and stout sun orchid.

Fauna

The animal species typical of the habitats that occur in this block are discussed in Chapter 11 and listed in Appendix 6. These habitats include open forest, heathy woodland, grassy woodland, coastal heath and scrub, and inland flowing and standing waters.

In this block the satin bower-bird and swamp wallaby are at the western limit of their distribution. The habitat suitable for the ground parrot occurs, but there have not been any records of this species here for a number of years. Several interesting animals, including the quoll, have been recorded in the stony rises.

The satin bower-bird is at the western limit of its distribution in this block.

Capabilities

Nature conservation

The relics of the Heytesbury forest on public land have a high capability. They represent a few remnants of a much more widespread environment rich in both plants and animals.

Lerista bougainvillii, *a rare diurnal thigmotherm, occurs in the stony rises.*

Recreation

Capability of the coastal public land for this use is high. The cliffs in this area represent the most spectacular section of coastline in Victoria. There is, however, a danger of the capacity of the land for this use being exceeded. The Warre plantation is used fairly extensively for recreational activities at present. Other areas of public land in this block do not support high recreational use at the moment.

Safe access for sightseers at Loch Ard Gorge.

Hardwood timber

Public land in this block has a moderate capability for hardwood production. However, cutting over some areas in the past has been ruthless and uncontrolled. Consequently silvicultural techniques must be applied to restore productivity. Isolated areas such as the forested public land near Timboon are important in supplying timber for local use.

Softwood timber

Because of the relatively high rainfall combined with well-drained soils, the capability of most public land in this block - including some land under the control of the Heytesbury Rural Finance and Settlement Commission - is moderate to high. However, some areas are unsuitable for this use. An example is the Waarre plantation of radiata pine near Port Campbell, which has failed to be economic.

Agriculture

Most public land has a moderate to high capability for this use, except in areas where slopes are steep or soils are chemically impoverished leached sands. The newly developed land at Heytesbury has a high fertilizer requirement if productivity is to be maintained. The Tertiary sediments of this area are liable to gully and tunnel erosion unless careful attention is paid to soil conservation.

The pine plantation at Waarre has failed to be economic.

Minerals

Public land in this block has no significant mineral deposits other than the Port Campbell limestone, which outcrops extensively along the coast. This limestone is mined on freehold land at Curdie to produce agricultural lime. Scoria is extracted from private land at Mount Leura, near Camperdown.

Water

The quality of water contained in the streams varies. In general it is unsuitable for domestic consumption, but is quite suitable for stock use and irrigation. The water in the Gellibrand

River, which forms part of the south-eastern boundary of this block, is of better quality and is used for urban consumption in the South Otway water supply scheme. Groundwater is widespread, and that contained in the Wangerrip or Heytesbury group of sediments is of good quality.

Hazards and Conflicts

On public land, fire is a severe hazard during summer. On cleared land, gully and tunnel soil erosion is becoming an increasingly obvious hazard. Conflicts between nature conservation, recreation, gravel extraction, and timber production are certain to develop in the future on public land.

Significance

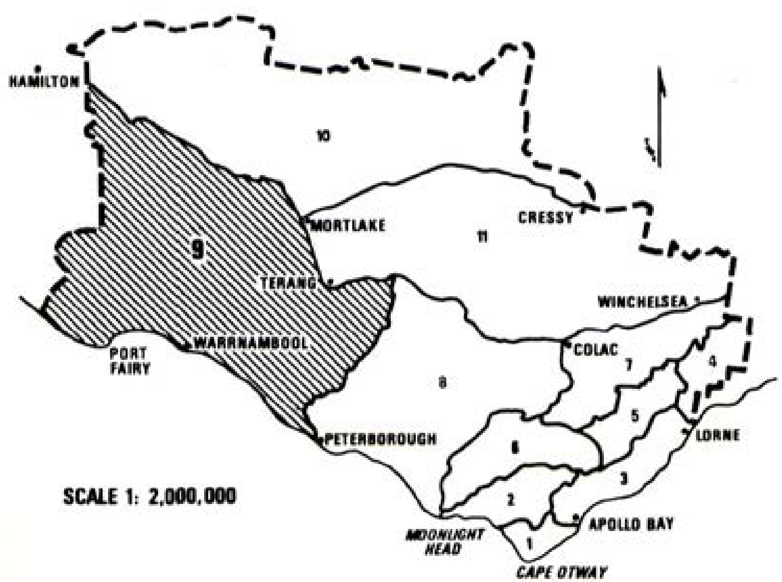
The coastline of this block has high geomorphological significance. The relatively small areas of natural vegetation on public land represent some of the last relics of the once extensive Heytesbury forest. A significant area of public land, which has already been cleared, is productive agricultural land. It is also suitable for radiata pine plantations.

9. WARRNAMBOOL

General

Present tenure

Public land covers 6,560 ha (or 2% of the total area), mainly confined to a coastal fringe between Port Fairy and Warrnambool. The bulk of this is permanently reserved Crown land. Other areas include Tower Hill (606 ha), the Framlingham forest (1,220 ha), and Lady Julia Percy Island (150 ha).



General description

The bulk of the terrain is a flat basalt plain, which is almost entirely cleared and supports improved pasture. The only forested area of public land is the Framlingham forest, although small reserves exist at Mount Rouse, Caramut, and Mortlake. Towards the south the country becomes gently undulating, with several volcanic cones such as Mount Warrnambool and Tower Hill.

The coast varies from steep cliffs at Peterborough to extensive sand dune areas west of Port Fairy. Between Warrnambool and Port Fairy, estuaries have formed behind the sand dunes at the mouths of the Moyne and Merri Rivers.

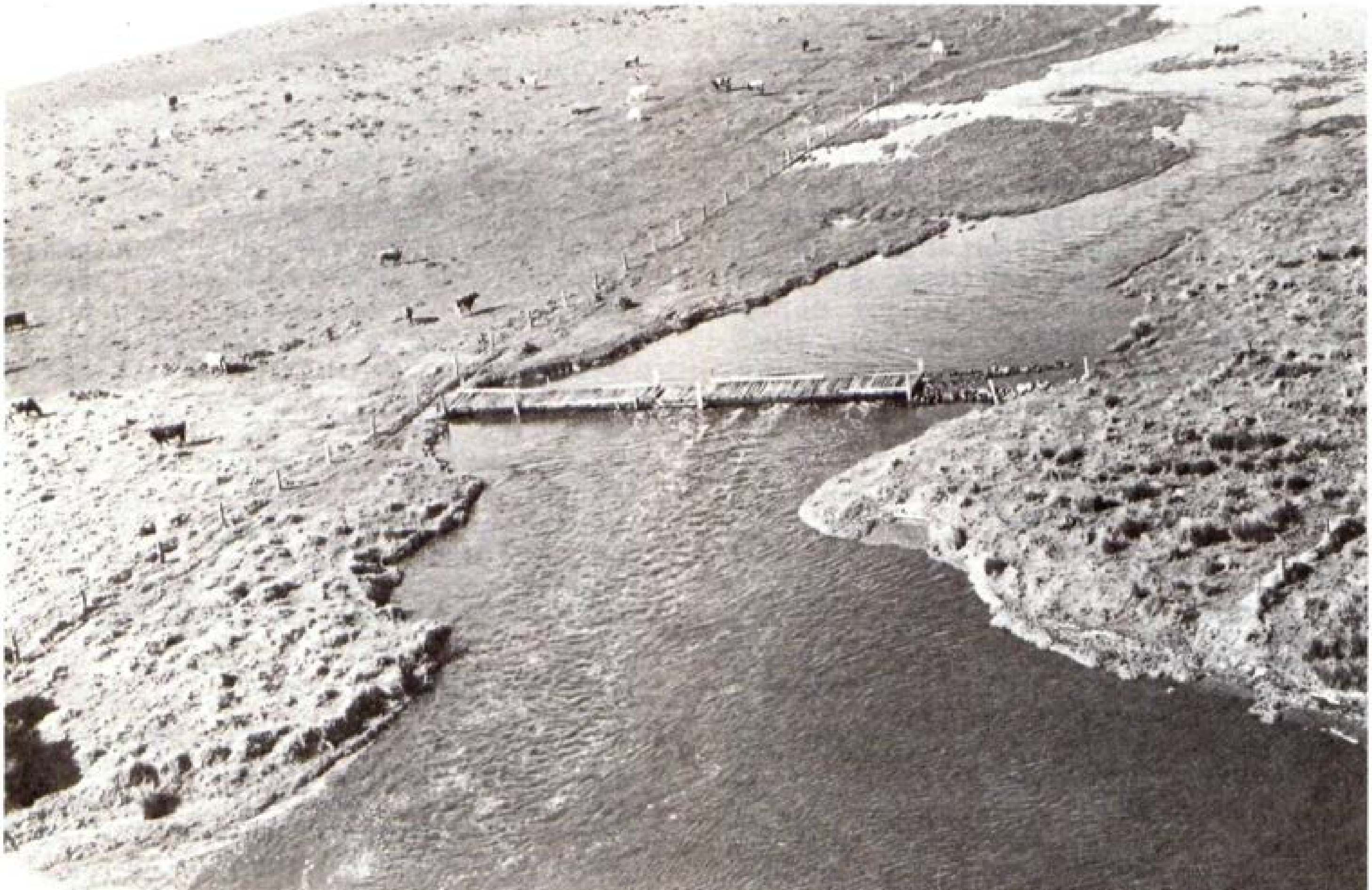
Present use

Most of the land in this block is used for agriculture. Sheep and beef cattle grazing predominate in the north, while the south supports dairy-farming and potato and onion cropping.

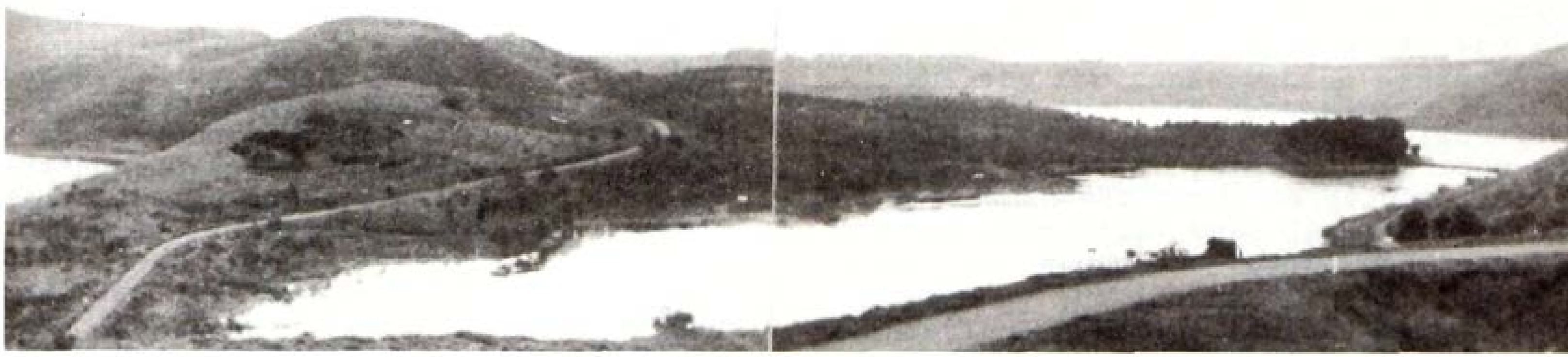
Much of the private land near the coast between Warrnambool and Tower Hill has been drained by the diversion of the

Merri River to the sea through Rutledge's Cutting.

These drainage works have also affected areas of public land that are grazed under licence. Although some of the land thus drained can only be used during summer it is highly productive, with a stocking capacity of five or six cattle per hectare.



Much of the freehold land near the coast between Warrnambool and Tower Hill is subject to flooding.



Tower Hill is a nested caldera, with scoria cones built up in the original caldera lake.

The Framlingham forest area is managed for recreation and timber production. The coast between Port Fairy and Warrnambool is used extensively for recreation, while the remainder of the coastline serves this purpose to a lesser extent. The nested caldera, Tower Hill, is a wildlife reserve and efforts are being made to restore the original vegetation, which was completely destroyed during the first few years of settlement.

Nature of the Land

Climate

Average annual rainfall increases from about 600 mm in the north to nearly 1,000 mm in the south, with a winter maximum. In the north the growing season typically lasts from March to December, with low temperatures restricting growth from June to August. By contrast, the growing season in the south lasts from March to December, with restricted growth due to low temperatures in July only.

Physiography and geology

Cainozoic rocks predominate throughout the area, the bulk consisting of newer volcanics. Extensive sand dunes of Quaternary age occupy the coast between Port Fairy and Warrnambool, but have limited occurrence between Warrnambool and the eastern border of the block. Between the coast and Cobden, there are Tertiary limestones, marls, and sands. In general, the terrain of the basalt is subdued, broken only by stream dissection, stony rises, and volcanic cones. The terrain of the Tertiary deposits is gently undulating. Pliocene laterite plateau remnants exist on older Tertiary sediments.

Lady Julia Percy Island, 10 km offshore, was apparently formed by submarine volcanic activity at about the same time as the adjacent mainland volcanoes, and was never joined to the mainland.

Soils

In the northern section of the block the predominant soils developed on basalt are dark clays. These soils generally have a thin veneer of lighter-textured material at the surface. To the south, soils on basalt become duplex. On Tertiary sediments both gradational and duplex soils have developed.

Duplex soils are confined to areas where the rainfall is less than 800 mm a year. These are yellowish brown or brown, or reddish if developed on lateritic material. Where the rainfall is greater than 800 mm on Tertiary sediments, the soils are gradational.

Undifferentiated calcareous sands are found on Recent dunes fringing parts of the coastline. Friable fertile gradational soils are developed on volcanic ash that has settled in the immediate vicinity of eruptive centres such as Tower Hill. Younger basalt flows carry shallow stony soils, and red to black soils have formed on Tertiary limestone.

Vegetation

Most native vegetation has been cleared from the land in this block. The coast between Port Fairy and Warrnambool carries typical dune communities of coast tea-tree, melaleuca, coast wattle, white correa, and other species.

A remnant of the widespread forest that once covered the southern portion occurs at Framlingham. In this area there is open forest II of messmate, manna gum, and occasional swamp gums. The understorey is typical of open forest II mixed-species communities.

One rare plant that occurs on the block is *Pterostylis tenuissima*, which has been recorded on swampy shaded ground at Cudgee Creek near Peterborough.

Fauna

The animals typical of the habitats that occur in this block are discussed in Chapter 11 and listed in Appendix 6.

The main faunal habitats include dry open forest, coastal scrubs, pastures and grassland, and inland standing waters.

Lady Julia Percy Island is an important breeding area for many birds, and the nesting species include little penguins, short-tailed shearwaters, fairy prions, diving petrels, sooty oystercatchers, swamp harriers, peregrine falcons, nankeen kestrels, welcome swallows, white-fronted chats, skylarks, and Australian pipits. The Australian fur seal also has a major breeding colony there.

The formation of the island in isolation from the mainland is reflected in the paucity of terrestrial animals.

Capabilities

Nature conservation

Because almost all lands in this block have been cleared of native vegetation, the few remaining areas of the natural environment have a high capability for this use.

These areas provide habitat for more than 80 bird species. Some, for example the lesser knots, are quite rare, while others such as little stints are becoming scarce. No mammals, apart from introduced species such as rabbits, are known to occur along the coast between Warrnambool and Port Fairy.

Native animals such as the kangaroo, wallaby, and small members of the dune fauna would be expected to recolonize the area if it were managed for wildlife.

The capability of Tower Hill Wildlife Reserve for fauna conservation will increase as the natural environment is restored. The importance of Lady Julia Percy Island as a breeding area for birds and seals is high. The Framlingham reserve has a particularly high capability for conservation since it represents the only substantial remnant of the forest once widespread in the southern portion of the block.

Although in many cases dune environments along the coast have been substantially altered by the impact of man, many interesting plant species and communities remain, which support an important animal population.

Lady Bay at Warrnambool; Middle Island in the background.

Recreation

The public land along the coast, particularly the section between Port Fairy and Warrnambool, has a very high capability. Activities include swimming, fishing, scenic observation, and exploration.

Many shipwrecks have occurred along the coast, and several relics provide additional attractions.

Unfortunately, uncontrolled recreational activities on this coast in the past have resulted in deterioration of some of the natural environment, particularly dune communities.

Tower Hill - because of its ready access and scenic grandeur - has a high capability for recreation. The Framlingham reserve will become increasingly important for recreational activities in a natural environment in the future. The small reserve on Mount Rouse offers a commanding view of the surrounding basalt plain and is the only reserve of public land on a volcanic cone in the northern part of the block. The Hopkins Falls near Cudgee is a notable feature.

Hardwood timber

The only area of public land with a capacity for hardwood production is the Framlingham reserve. Capability for this use is high, particularly in view of the difficulty of obtaining any hardwood timber from any other nearby area.

Stream-gauging station on Muston Creek.

Softwood timber

The only areas of public land with a reasonable capability for softwood production are Tower Hill and the Framlingham reserve. Capability for these uses in these areas is probably high. However, both areas are already committed to uses that are not compatible with softwood production.

Agriculture

With the exception of the coastal land, public land in this block has a high potential for agriculture.

Two fresh-water crater lakes on public land, Lake Terang and Lake Elingamite, have been partially drained in order to make the fertile volcanic loam available for pasture production.

Minerals

Basaltic rock suitable for crushing and construction purposes is widespread. Calcareous and siliceous sands occur along the coast between Warrnambool and Port Fairy. Scoria suitable for surfacing roads and tracks has been extracted from some volcanic cones within the area, but almost all of this land is in private ownership.

Aerial view of dunes showing tracks made by off-road vehicles.

Unstable sand dunes require protection from uncontrolled public access.

Water

In general, water from streams in this block is unsuitable for domestic use. In some cases, however, it is suitable for and is used for irrigation. Groundwater is widespread but variable in quality.

Hazards and Conflicts

On coastal public land, particularly the section between Warrnambool and Port Fairy, uncontrolled recreational activities are conflicting with conservation values of the land.

Examples of this are poorly sited car parks and the numerous tracks created by uncontrolled vehicle use. Both of these may allow erosion and damage to vegetation. Extension of roads in the area would increase this conflict. At readily accessible areas along the coastline, overhanging cliffs are a danger to the public. Some such cliffs have been removed using explosives. This raises conflicts with nature conservation, as caves and overhangs used as breeding areas by bats occur along this coast.

The draining of fresh-water lakes and swamps to gain land for agriculture raises conflicts with the preservation of habitat for water-fowl.

It is possible that conflicts between nature conservation, recreation, and timber production will also develop in the Framlingham forest reserve.

Significance

Because the public land forms such a small proportion of the total area in this block, it has a very high significance related to preservation of remnants of the natural environment. Lady Julia Percy Island, Tower Hill, and the estuaries and sand dunes between Warrnambool and Port Fairy have high significance for nature conservation.

10. CHATSWORTH

General

Present tenure

Public land covers 3,430 ha (or 1% of the total area). Except for an area of 475 ha north of Hexham, it consists almost entirely of lakes, which include Linlithgow, Kennedy, Barnie, Logan, Deep, Salt, Pink, and Paddy Lakes and Nerrin Nerrin Swamp.

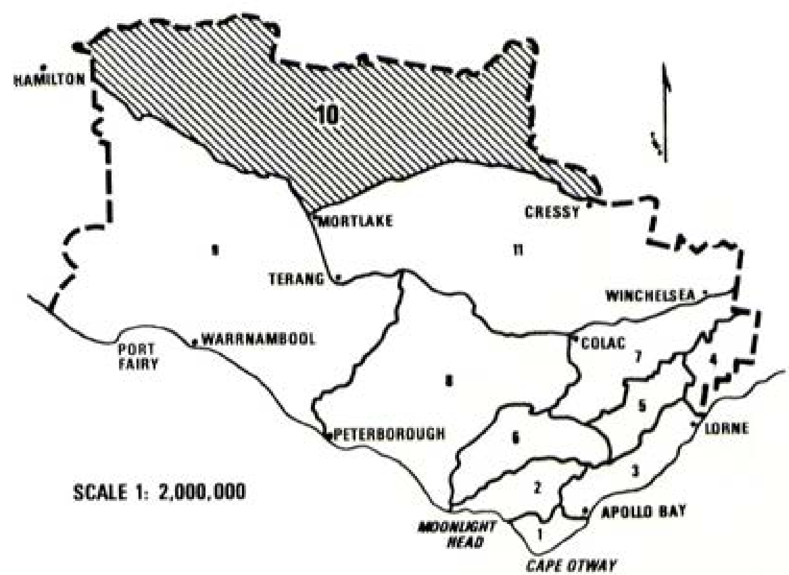
General description

The land consists almost entirely of a flat basalt plain, above which rise volcanic cones including Mount Shadwell, Mount Hamilton, and Mount Fyans. Stony rises have developed around Mount Fyans, and the block contains a number of small lakes. Almost all of the freehold land has been cleared of natural vegetation and is sown to improved pastures.

Present use

Most of the land is used for agriculture. Woolgrowing is the major industry, the main breeds being Merino, Polwarth, and Corriedale. Most farms also carry beef cattle, although it is rarely the major activity, except for several well-established beef studs. The dominant legume in the pastures is subterranean clover and this lower-rainfall portion of the study area is reliable for production of clover, hay, and oats; barley and wheat are also grown. However, the presence of basalt boulders sometimes makes cultivation difficult.

The public land north of Hexham contains a pine plantation, a plantation of golden wattle and sugar gum, and an area of unimproved native grassland.



Nature of the Land

Climate

Rainfall is low - increasing from 500 mm in the north to 600 mm in the south, with a winter maximum. The growing season typically lasts from March to December, with restricted growth from June to August due to low temperatures.

Physiography and geology

The surface geology of most of the block consists predominantly of newer basalt.

Basalt plains are the predominant land form in the block.

A number of volcanic cones occur. Tertiary sediments and Palaeozoic rocks outcrop around Chatsworth. The basalt terrain is subdued, being broken only by dissection and volcanic cones. Stony rises, representing Recent basalt flows, occur north of Darlington.

Soils

On basaltic material the predominant soils are dark clays, which generally have a thin veneer of lighter-textured material at the surface. On Tertiary and Palaeozoic sediments, duplex soils have formed.

Friable fertile gradational soils have developed on alluvium and volcanic ash that has settled in the immediate vicinity of eruptive centres.

Vegetation

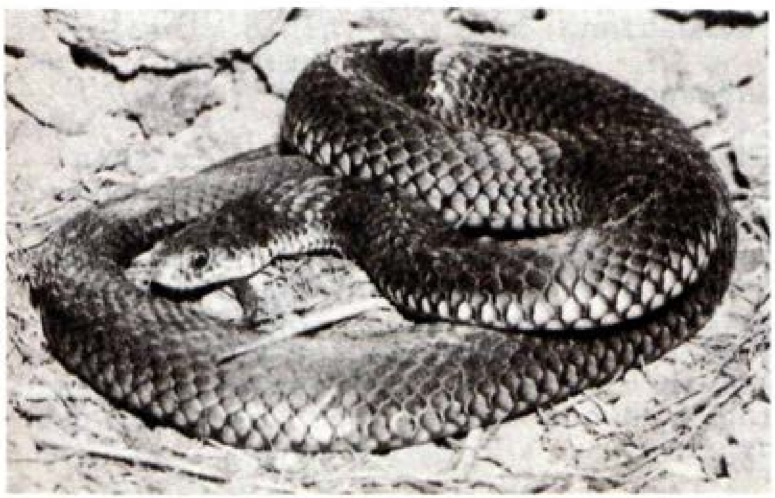
The native grassland of the volcanic plains has almost entirely disappeared. The original vegetation was apparently a grassland containing communities of wallaby grass, kangaroo grass, and spear grass on the drier soils of the low rises and of tussock grassland on the low moist areas. However, a relatively undisturbed area of about 30 ha of native grassland occurs on public land north of Hexham.

Grossly altered remnants of native vegetation occasionally occur on the shorelines of some lakes. Reed fields of cumbungi, cane grass, and rushes are found in the shallow margins of the fresh-water lakes, while mud flats and saltmarsh vegetation occur around the foreshores of the saline lakes.

Fauna

The animals typical of the habitats that occur in this block are discussed in Chapter 11 and listed in Appendix 6. The main faunal habitats include grassy woodland, softwoods, pasture, and standing waters.

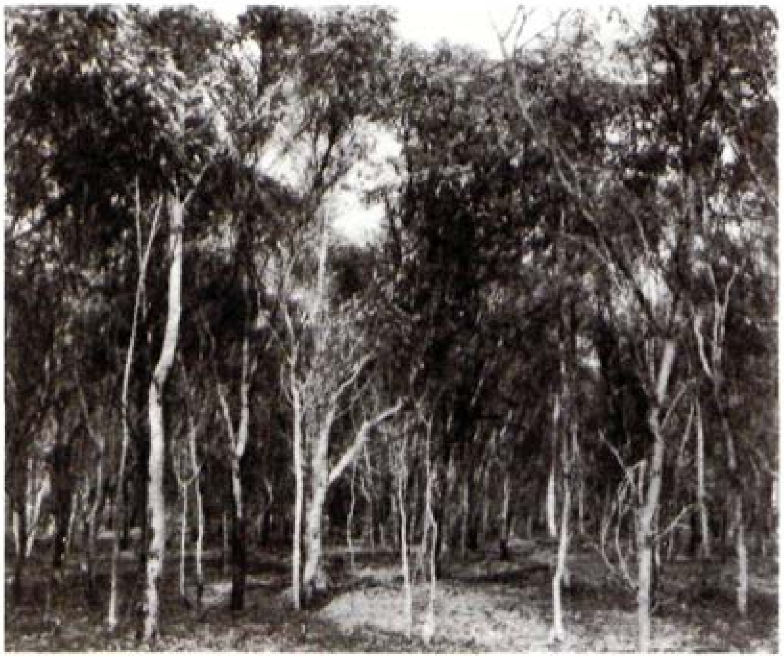
The water bodies cover a wide range of salinities, temperatures, bottom characteristics, and depths, and consequently provide a diversity of aquatic habitats. The heavily vegetated swamp areas are feeding grounds for night herons, bitterns, rails, crakes, and waterhens. Along sparsely vegetated margins, birds such as plovers, dotterels, snipe, stilts, and wagtails forage for invertebrates.



The copperhead snake is common in moist areas.

The yellow-faced honey-eater is found in both native woodland and introduced pastures.

The pastures of the block support a variety of birds, including predators such as eagles, goshawks, falcons, and kestrels. Small birds adapted to the open habitat are galahs, corellas, quails, larks, goldfinches, and white-backed magpies. At least two species,



This plantation of sugar gum and golden wattle provides animal habitat in the agricultural zone north of Hexham.

the plain wanderer and the brolga, were common on the original tussock grassland, but are now rarely reported.

Mammals of the pastures include the fat-tailed dunnart and Gunn's bandicoot, which are natives, and the hare, feral cat, fox, house mouse, and rabbit, which are introduced.

The vegetation of the public land reserve north of Hexham offers shelter for a number of animals.

Capabilities

Nature conservation

Many of the lakes in the area form important habitats for water-birds. Because of its isolation and because it includes probably the only substantial relic of natural basaltic grassland in Victoria, the area of public land to the north of Hexham has the highest possible capability for nature conservation.

Recreation

Some lakes in the area have a moderate capability for water-based recreation. Lake Linlithgow is already used for this purpose and also for duck-shooting. In general, however, no public land within this block has a high capability for recreation.

Hardwood timber

The only area of public land in this block with any capacity for hardwood production is the reserve near Hexham, part of which (about 165 ha) has been forested with a plantation of golden wattle and sugar gum. Capability for this use, however, is low but signific- and in view of the difficulty of obtaining hardwood timber from any other nearby area.

Softwood timber

No public land in this block has even a

moderate capability for this use. Pines, however, are grown on the reserve to the north of Hexham in a small plantation covering 79 ha. Production is significant in view of the difficulty of obtaining timber from any other nearby source.

Agriculture

Some of the public land swamps - such as the Nerrin Nerrin Swamp - would, if drained, be highly productive for agriculture. The reserve near Hexham is similar to surrounding productive agricultural land, and has a moderate to high capability for agriculture.

Minerals

Scoria suitable for road-making is found in volcanic cones, but almost all this land is in private ownership.

Water

Most water contained in streams and lakes in this area is brackish or saline and unsuitable for domestic consumption. In some cases, however, it is used for irrigation. Groundwater is widespread, but of variable quality.

Hazards and Conflicts

There is a conflict between the waterfowl conservation value of some of the public land swamps and their capability, if drained, for agriculture. The swamps, which carry a heavy reed growth, may become a fire hazard for adjoining landholders if they dry up during summer. Uses incompatible with the preservation of the natural environment have been practised on the small reserve near Hexham. These include softwood production, hardwood production, gravel extraction, and rubbish dumping.

Significance

The public land lakes and swamps are significant for waterfowl conservation. The significance of the small area of basaltic grassland on public land north of Hexham cannot be overstated. It is probably the largest area of this type of vegetation remaining in Victoria.

11. CORANGAMITE

General

Present tenure

Public land covers 45,875 ha (or 15% of the total area). It consists almost entirely of Crown land lakes, and land surrounding Lakes Corangamite, Gnarpurt, and Murdeduke that has been acquired under the *Lake Corangamite Act* 1966.

There are 280 ha of public land under pasture controlled by the Glenormiston Agricultural College. More than 2,000 ha of freehold land in the Cundare Pool area has been acquired by and is under the control of the State Rivers and Water Supply Commission.

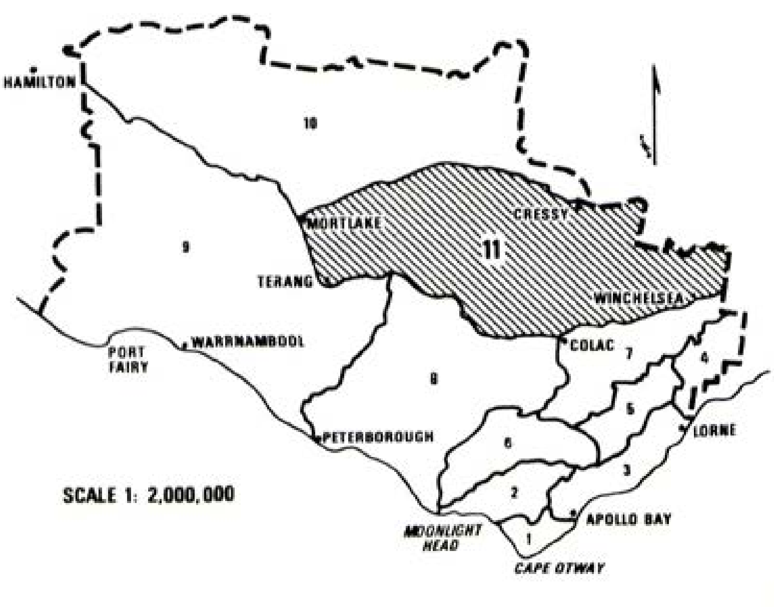
A small public land reserve is located on the volcanic cone, Red Rock, near Alvie.

General description

The bulk of the block is a flat basalt plain with many lakes - including Lake Corangamite, the largest in Victoria. The natural vegetation has been removed and most of the area is cropped or sown to improved pasture.

Present use

The bulk of the land is used for agriculture. Sheep and beef cattle grazing predominate. The fertile alluvium near Lake Corangamite supports mixed farming, including dairying and the production of peas, potatoes, and onions. Dairying is also important in the Terang--Glenormiston area. Cereal cropping is carried out throughout the whole area.



Nature of the Land

Climate

The average annual rainfall varies from about 500 mm in the vicinity of Cressy to about 700 mm in the south of the block. The growing season typically lasts from March to December, with low temperatures restricting growth from June to August.

Physiography and geology

The surface geology of most of the block consists of newer basalt. A number of volcanic cones rise above the volcanic plain, including Mount Noorat, Mount Elephant, Mount Kurweeton, Red Rock, Mount Rebecca, Mount Gellibrand, and Mount Pleasant.

Many lakes have developed in craters or depressions in the basalt. These include Keilambete, Bookar, Colongulac, Gnarpurt, Corangamite, Colac, Beeac, Weering, and Murdeduke Lakes. They vary widely in depth and salinity, depending upon their method of formation, their catchment area, and their outlet. Lake Corangamite is the largest lake in Victoria, with a surface area of 23,000 ha.

Stony rises consisting of recent basalt flows occur, particularly around the shores of Lake Corangamite. Extensive areas of alluvium have been deposited to the east of Lake Corangamite.

Soils

In the northern section of the block the predominant soils are dark clays, which generally have a thin veneer of lighter-textured material at the surface. Friable fertile gradational soils have developed on alluvium and volcanic ash. Towards the south, soils developed on basalt become duplex. Shallow stony soils occur on younger basalt flows, and saline soils have developed around the margins of some lakes.

Vegetation

No significant areas of native vegetation remain on any public land within this block. Grossly altered remnants occasionally occur on the shore-lines of some lakes.

Open forest II and woodland of manna gum grow on the stony rises near Lake Corangamite: however the understorey of these forests (which are privately owned) is dominated by bracken and has been invaded by a wide variety of exotic plants. Common shrubs are blackwood, native cherry, and prickly moses. Small patches of swamp gum with an understorey of prickly tea-tree occupy some of the depressions. Lichens, mosses, and leaf litter cover most of the rock surfaces.

Fauna

The animals typical of the habitats that occur in this block are discussed in

The long-nosed bandicoot is found in the stony rises.

The grass skink is common in grassland areas.

Chapter 11 and listed in Appendix 6. The main faunal habitats in this block are pasture and inland standing waters.

The forested areas of the stony rises contain a number of interesting mammals. The most significant recorded is the quoll. This was common in the 1930s, but has not been reported for a number of years. Unusual mammals include the long-nosed bandicoot and Swainson's antechinus. The piles of basalt rocks provide ample shelter for small mammals such as these and for reptiles, particularly the tiger snake, which is common.

The forests of the stony rises, together with the scattered remnants of the original woodland on roadsides, railway reserves, and creek frontages and the planted farm windbreaks, are collectively important to the continued success of many bird species.

The swamps and lake margins in the block provide nesting areas for many water-birds, although this habitat has been seriously reduced by clearing down to the margins of lakes and by draining of many of the swamps. Vaughan Island on Lake Corangamite is privately owned and supports breeding colonies of pelicans, straw-necked ibis, white ibis, and swans.

The differences in salinity between the lakes are reflected in differing fish populations. For example, Lake Colac - which is fresh water (salinity less than 5,000mg/l) - contains red-fin, eels, common galaxias, Victorian smelt, trout, and carp; Lake Murdeduke - which is brackish (5,000--25,000 mg/l) - contains common galaxias, small-mouthed hardy-head, and flat-headed gudgeon; while the highly saline Lake Gnotuk (more than 50,000 mg/l) contains no fish.

Capabilities

Nature conservation

The habitats with the highest capabilities for nature conservation are the dry forests and woodlands of the stony rises; these, however, are in private ownership.

The lakes of the volcanic plains represent one of the most important water-bird areas in south-western Victoria, and thus have a high capability for nature conservation.

Recreation

Some of the lakes in this block have a high capability for water-based recreation. Fishermen and duck-shooters use the Cundare pool. Lake Colac, also used by fishermen, is popular for yachting and power-boating. Lake Coragulac also supports power-boating, but other lakes are little used.

The feather-tailed glider is widespread in woodland and open forest communities.

Hardwood timber

There are no forest areas on public land. In almost all cases public land has a low capability for this use.

Softwood timber

Public land in this block has low capability for softwood production.

Agriculture

None of the lakes has a capability for agricultural production, but public land under the control of the Glenormiston Agricultural College has high capability for this use. This land is suited to grazing and a number of forms of cropping. Some of the land around Lakes Corangamite and Murdeduke was inundated by the creeping lakes in the 1950s, and was surrendered to the Crown. This land, together with some of that acquired by the State Rivers and Water Supply Commission around the Cundare Pool, is now leased for grazing, in many cases to the original owner.

Straw-necked ibis rookery, Lake Corangamite.

Minerals

Basaltic rock suitable for crushing or construction purposes occurs on public land.

Scoria is extracted from volcanic cones in this block, but almost all such land is freehold. The Crown land reserve at Red Rock contains extensive deposits.

Water

This block has a moderate capability for water production. The water contained in most lakes and streams in the area is saline or brackish and unsuitable for domestic consumption. In some cases, however, it is suitable for and used for irrigation. Groundwater is widespread and of variable quality. In the region around Lake Corangamite, it is used for irrigating pasture.

Hazards and Conflicts

Land-use conflicts on public land centre around the use of the lakes. Sewage from Colac and Camperdown is discharged after treatment into Lakes Colac and Colongulac respectively. Also, certain industries discharge trade wastes into lakes. The resultant pollution from these activities conflicts with the nature conservation and recreational values of the lakes.

A serious hazard in the past has been the "creeping lakes" problem when, following years of higher-than-average rainfall, the levels of the lakes in the block, particularly Corangamite, rose considerably. This problem is described in detail in Chapter 12, and it seems that the works undertaken to reduce the flooding have been successful.

Significance

The lakes, especially Lake Corangamite, are important geomorphological features of a basaltic landscape. They are also vitally important as water-bird habitats, and could form a significant reserve for water-based recreation in the future. Differences in salinity between lakes provide a variety of ecosystems ranging from the very simple to the very complex, which gives the lakes system an important scientific value for biological research.

PART V

APPENDICES

APPENDIX 1

METRIC CONVERSION FACTORS

QUANTITY	METRIC UNIT	IMPERIAL UNIT	METRIC TO IMPERIAL	IMPERIAL TO METRIC
Length	millimetre (mm) centimetre (cm) metre (m) kilometre (km)	inch (in) foot (ft mile	1 mm = 0.0394 inch 1 cm = 0.3937 inch 1 m = 3.281 feet 1 km = 0.6214 mile	1 inch = 25.4 mm 1 inch = 2.54 cm 1 foot = 0.305 m (30.5 cm) 1 mile = 1.61 km
Area	hectare (ha) square kilometre (sq km) (= 100 ha)	acre (ac) square mile (sq mile)	1 ha = 2.47 acre 1 sq km = 0.3861 sq mile (247 ac)	1 acre = 0.405 ha 1 sq mile = 2.592 sq km
Mass	kilogram (kg) tonne (t) (= 10,000 kg)	pound (lb) ton	1 kg = 2.20 lb 1 t = 0.984 ton	1 lb = 0.454 kg 1 ton = 1.02 t
Volume	cubic metre (m^3) megalitre (Ml) (= 1,000,000 litres)	cubic foot (ft^3) super foot (timber) acre feet (ac ft)	1 m^3 = 35.31 ft^3 = 423.7 super feet true = 332.6 super feet (Hoppus log volume) 1 Ml = 0.8098 ac ft	1 ft^3 = 0.0283 m^3 1 super foot true = 0.00283 m^3 1 super foot HLV = 0.003 m^3 1 ac ft = 1.235 Ml
Temperature	degree Celsius (^{o}C)	degree Fahrenheit (^{o}F)	1^{o}C = 5/9 (^{o}F - 32)	1^{o}F = 9/5 (^{o}C + 32)
Compound Units	tonnes per hectare (t/ha) milligrams per litre (mg/l) litres per second l/s	bushels/acre parts per million (ppm) gallons per hour (gph)	1 t/ha = 14.9 bushels/ac (wheat) = 17.9 bushels/ac (barley) = 22.2 bushels/ac (oats) 1 mg/l = 1.000 ppm 1 l/s = 791.7 gph	1 bushel/ac = 0.087 t/ha = 0.056 t/ha = 0.045 t/ha 1 ppm = 1.000 mg/l 1 gph = 0.00126 l/s

APPENDIX 2

RAINFALL PERCENTILE INFORMATION

(Millimetres)

STATION & NUMBER	ELEVATION (m)	DATA TO END 1965[1]															LATEST INFORMATION[2]		
		PERCENTILE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	NO. YEARS	MEDIAN	MEAN	NO. YEARS
LORNE 90054		30	17	20	29	40	66	72	73	82	71	59	41	32	824	81	915	924	84
		50	29	32	43	58	79	98	103	100	92	87	57	42	915				
		70	47	50	62	86	100	126	129	128	111	109	73	61	1007				
CAPE OTWAY 90015	82	30	24	21	34	50	71	74	76	76	69	54	45	37	801	102	864	879	109
		50	34	33	45	68	86	96	96	91	85	70	55	44	865				
		70	50	50	61	87	110	118	111	111	100	91	72	60	935				
PORT CAMPBELL 90067		30	21	20	30	54	72	72	80	82	72	60	35	30	833	80	891	913	87
		50	31	33	40	74	88	92	103	104	86	81	58	49	890				
		70	45	49	59	92	114	122	124	128	106	98	74	61	974				
WARRNAMBOOL SHIRE OFFICE 90081	27	30	17	15	21	34	53	53	59	56	53	38	27	27	607	89	686	690	96
		50	27	21	32	52	65	74	73	72	63	55	43	38	685				
		70	36	36	43	72	91	94	94	91	79	71	60	53	733				
BEECH FOREST 90006	518	30	37	37	58	101	135	134	154	167	147	113	90	67	1580	66	1722	1731	73
		50	62	65	86	147	171	187	192	191	170	149	119	86	1737				
		70	92	89	110	184	208	240	236	224	213	186	133	110	1862				
COLAC 90022	133	30	15	16	24	33	53	57	61	63	55	53	39	25	666	64	709	721	69
		50	24	23	36	50	70	80	77	79	75	63	51	38	714				
		70	35	45	53	73	85	99	91	98	89	82	78	56	776				
SKIPTON 89025		30	18	18	17	29	43	41	44	47	47	50	30	26	570	68	628	629	75
		50	25	33	35	47	54	54	56	57	62	61	48	40	639				
		70	38	46	61	65	74	69	69	73	76	74	68	60	695				
CAMPERDOWN 90011	165	30	18	19	26	38	60	51	61	72	63	56	37	27	702	68	755	773	74
		50	30	30	38	57	74	78	75	86	77	70	54	47	753				
		70	40	47	56	77	94	103	91	107	98	88	72	64	814				
MORTLAKE 90058		30	17	15	21	37	52	47	50	58	53	48	35	26	629	81	676	682	89
		50	30	21	31	53	65	70	65	74	64	67	44	38	674				
		70	39	40	56	67	82	83	82	88	80	82	65	57	731				
PENSHURST 90063		30	18	14	22	37	55	53	62	62	57	54	32	25	642	82	708	719	90
		50	27	25	35	54	67	71	73	77	70	65	43	39	705				
		70	41	41	50	75	85	94	88	91	89	82	82	52	774				

1. Data from: "Review of Australia's Water Resources: Monthly Rainfall and Evaporation." (Bureau of Meteorology: Melbourne 1968.)

2. Data supplied by: Bureau of Meteorology, 1975.

Appendix 3A

WATER QUALITY

CRITERIA AND OBJECTIVES FOR PUBLIC WATER SUPPLIES IN AUSTRALIA COMPARED WITH THE 1958 WORLD HEALTH ORGANIZATION STANDARDS FOR DRINKING WATER

Characteristic	W.H.O. standards 1958		Criteria for Australian public water supplies	
	Permissible	Excessive	Treated	Untreated
Physical and chemical				
Colour mg/l	5	50	5	50
Turbidity mg/l	5	25	5	25
Taste and odour	Unobject-ionable	Unobject-ionable	Unobject-ionable	Unobject-ionable
Total dissolved solids	500	1,500	500	1,500
Total iron mg/l	0.3	1.0	0.3	1.0
Zinc mg/l	5.0	15.0	5.0	5.0
Copper mg/l	1.0	1.5	0.3	1.0
A.B.S. mg/l			0.5	0.5
pH	7.0-8.5	6.5-9.2	7.0-8.5	6.5-9.2
Fluoride (F) mg/l	approx. 1.5		1.5	
Nitrate (NO_3) mg/l	approx. 45		45	

Toxic compounds	Maximum allowable concentrations W.H.O.	Australia
Chromium (hexavalent) mg/1	0.10	0.05
Arsenic (As) mg/1	0.2	0.05
Lead (Pb) mg/1	0.1	0.05
Selenium (Se) mg/1	0.05	0.01
Barium (Ba) mg/1		1.00
Cadmium (Cd) mg/1		0.01
Cyanide (CN) mg/1	0.01	0.01
Silver (Ag) mg/1		0.05
Chloroform-soluble carbon-filter extract mg/1		0.20
Bacterial count	M.P.N.* of coliforms in 100-ml portions	
Escherischia coli per 100 ml	Chlorinated: 90% 1, 100% 10; Untreated: 90% 10, 100% 20	As for W.H.O. standards
Radiological requirements		
alpha emitters	30×10^{-6}, uc/ml	As for W.H.O. standards
beta emitters	30×10^{-6}, uc/ml	
Strontium 90		
Rhodium 226		

* M.P.N. - Most Probable Number, obtained by the multiple-tube method of testing.

Footnotes

(a) Problems associated with iron content are greatly affected by the physical state of the iron compounds present, consequently permissible levels may vary depending on the nature of the supply.

(b) Sampling and testing methods to be in general agreement with American Public Health Association (A.P.H.A.) methods.

APPENDIX 3B

INDUSTRIAL AND AGRICULTURAL STANDARDS

The following table provides groundwater users with a guide to the upper limits of salinity that are acceptable for various purposes.

Uses	Upper limits of salinity (mg/1)
Irrigation	
Citrus, legumes, garden plants	1,000
Vines, grass, cabbages	1,500
Cotton, lucerne	2,500
Livestock	
Poultry	3,500
Pigs	4,500
Horses	6,500
Milking cows and ewes	7,000
Beef cattle	11,000
Dry sheep	15,000
Secondary industry	
Rayon	100
Paper	150
Petroleum	350
Carbonated beverages	850

Source: Groundwater Investigation Programme Report, Victorian Mines Department, 1971.

APPENDIX 3C

AUTHORIZED IRRIGATION FROM GROUNDWATER RESOURCES

Parish	No. of irrigation licences	Area irrigated (hectares)				Total volume authorized (Ml/annum)
		Permanent, annual, and native pasture	Lucerne	Market gardens, annual crops, and cereals	Total	
Belfast	3	19.0	-	4.9	23.9	132.0
Bootahpool	2	24.2	-	-	24.2	148.0
Colongulac	1	8.1	4.0	-	12.1	74.0
Corangamite	1	-	4.0	-	4.0	25.0
Cundare	1	8.1	-	-	8.1	53.0
Dreeite	3	20.2	26.3	-	46.5	287.0
Eckline	1	16.2	-	-	16.2	99.0
Framlingham West	1	21.0	-	-	21.0	129.0
Glenormiston	4	34.8	2.0	-	36.8	231.0
Koroit	34	241.3	8.0	169.4	418.7	1942.0
Laang	2	10.1	-	-	10.1	68.0
Marida Yallock	1	10.1	-	-	10.1	62.0
Meerai	1	8.1	-	-	8.1	50.0
Mepunga	19	304.2	12.0	44.0	360.2	2049.0
Nalangil	1	6.1	4.0	6.1	16.2	81.0
Nirranda	5	74.8	-	-	74.8	478.0
Nullawarre	5	66.7	2.0	-	68.7	425.0
Purnim	2	28.3	-	-	28.3	173.0
Tallangatta	7	74.6	-	-	74.6	463.0
Wangoom	11	46.9	-	9.2	56.1	322.0
Warrion	10	85.3	25.1	12.0	122.4	700.0
Warrong	4	28.7	2.0	42.9	73.6	291.0
Willatook	2	8.1	-	16.2	24.3	100.0
Woolsthorpe	1	-	-	4.9	4.9	·18.0
Yambuk	3	8.1	30.0	-	38.1	233.0
Yangery	36	319.1	35.0	296.5	650.6	3036.0
Yarpturk	2	40.5	-	40.5	81.0	376.0
TOTALS	163	1512.6	154.4	646.6	2313.6	12045.0

APPENDIX 3D

AUTHORIZED IRRIGATION FROM SURFACE WATER RESOURCES

Source	No. of irrigation permits	Area irrigated (hectares)				Total volume authorized (Ml/annum)	Remarks
		Permanent pasture	*Lucerne*	Market gardens, annual crops, and cereals	Total		
Barwon River Catchment							
Barwon River	30	96.4	28.9	78.8	204.1	1324.0	Some diverters outside Study Area
Gellibrand River Catchment							
Gellibrand River	20	178.7	-	2.0	180.7	1085.2	
Carlisle River	8	101.2	-	-	101.2	608.0	
Chapple Creek	1	4.2	-	-	4.2	25.0	
Kennedy's Creek	8	39.3	-	3.6	42.9	270.8	
Hopkins River Catchment							
Hopkins River	50	353.6	59.9	43.5	457.0	2829.5	Some diverters outside Study Area
Mt. Emu Creek	15	123.1	-	17.0	140.1	794.0	
Coastal Streams							
Curdies River	19	233.5	10.2	42.7	286.4	1380.9	
Moyne River	10	58.6	-	-	58.6	333.6	
Merrie River	76	728.2	45.8	136.0	910.0	4573.7	
Aire River	3	2.1	-	16.6	18.7	112.0	
Barhám River	1	2.0	-	-	2.0	12.3	
Skenes Creek	1	4.2	-	-	4.2	25.0	
Wild Dog Creek	3	7.5	-	8.3	15.8	95.0	
Sugarloaf Creek	2	6.2	-	4.2	10.4	62.0	
TOTALS	247	1938.8	144.8	352.7	2436.3	13531.0	

APPENDIX 3E

STREAM GAUGING STATIONS

STATION	Years of operation	Drainage area (km^2)	Annual discharge (Ml)			Mean salinity (mg/l)	Remarks
			Maximum	Minimum	Mean		
Aire River - Beech Forest	64/65 - 70/71	25	42,000	4,280	22,067	112	
Aire River - Wyelangta	67/68 - 68/69	88	81,435	19,082	50,252	90(est)	Includes Little Aire River discharge
Barham River (East Branch)- Apollo Bay	64/65 - 69/70	32	28,172	4,983	18,712	143	
Barwon River (West Branch) Forrest	27/28 - 48/49	52	42,853	5,385	24,830	Unavailable	Above tunnel. Includes G.W. & S.T. diversions
Barwon River - Winchelsea	22/23 - 65/66	1052	508,440	30,850	141,730	942	G.W. & S.T. diversions not included
Barwon River - Inverleigh	66/67 - 70/71	1269	237,419	6,796	93,992	1168	
Birregurra Creek - Rickett's Marsh	59/60 - 70/71	140	29,690	12	7,944	3000(est)	Includes Lake Colac and Lough Calvert diversions
Carlisle River - Carlisle	30/31 - 67/68	78	87,580	6,476	38,584	148	Gauging discontinued April, 1968
Cudgee Creek - Cudgee	65/66 - 69/70	194	48,241	6,537	24,978	626	
Cumberland River - Lorne	66/67 - 69/70	36	20,229	3,626	14,543	100(est)	
Curdies River - Curdie	56/57 - 69/70	790	277,600	5,218	127,100	662	
East Barwon River - Forrest	55/56 - 69/70	17	12,483	1,369	7,450	124	Above tunnel
Gellibrand River - Upper Gellibrand	50/51 - 69/70	52	99,230	5,711	37,029	116	
Gellibrand River - Carlisle	64/65 - 69/70	565	260,150	36,770	158,060	141	Below S.R. & W.S.C. pump-station at Carlisle

STATION	Years of operation	Drainage area (km^2)	Annual discharge (Ml)			Mean salinity (mg/l)	Remarks
			Maximum	Minimum	Mean		
Hopkins River - Framlingham	56/57 - 69/70	5157	531,450	5,341	151,410	3306	
Hopkins River - Hopkins Falls	55/56 - 69/70	8355	984,000	14,185	318,730	2280	Includes Mt. Emu Creek discharge. Approx. one half of catchment outside Study Area
Kennedys Creek - Kennedys Creek	64/65 - 69/70	282	63,970	24,855	32,934	319	
Lardners Creek - Gellibrand	64/65 - 69/70	48	34,155	5,945	21,152	119	
Little Aire River - Gellibrand	55/56 - 69/70	11	14,888	3,812	11,212	94	
Merri River - Woodford	49/50 - 70/71	899	187,774	7,870	74,318	1500(est)	
Moyne River - Toolong	56/57 - 69/70	570	95,600	2,393	39,878	1568	
Mt. Emu Creek - Skipton	21/22 - 69/70	1251	234,040	1,468	66,810	1833	
Mt. Emu Creek - Garvoc	65/66 - 69/70	3067	187,786	6,439	90,533	2000(est)	
Pirron Yaloak Creek - Pirron Yallock	64/65 - 70/71	169	40,298	185	18,626	427	
West Arkins Creek - Wyelangta	58/59 - 70/71	4	5,292	1,283	3,775	88	Above Otway Scheme diversion weir
Woady Yaloak River - Cressy	55/56 - 69/70	1158	183,710	6,846	62,290	2560	Catchment largely outside Study Area

APPENDIX 3F

EXISTING TOWN WATER SUPPLIES

Township or Area	Water Authority	Source of Supply	Daily Consumption Average (Ml)	Daily Consumption Maximum (Ml)	Remarks
Allansford	S.R. & W.S.C.	Otway System	0.50	1.00	
Apollo Bay	Apollo Bay Waterworks Trust	Barham River (West Branch) and Andersons Creek	0.90	2.30	
Birregurra	S.R. & W.S.C.	G.W. & S.T. Barwon System	0.22	0.50	
Camperdown	Camperdown Town Council	Otway System	2.01	7.25	
Cobden	S.R. & W.S.C.	Otway System	1.37	3.00	
Colac	Colac W/Works Trust	West Gellibrand & Olangolah Rivers	7.27	14.50	Consumptions include Northern Shire areas.
Forrest	Forrest W/Works Trust	West Barwon Dam	0.07	0.11	
Geelong	G.W. & S.T.	Upper Barwon Catchment	68.00	246.00	Consumptions include S.R.'s Bellarine Peninsula System.
Gellibrand	Gellibrand W/works Trust	Lardner's Creek	0.05	0.10	Estimated consumptions.
Koroit	Koroit W/works Trust	Bores	0.30	0.80	
Lismore & Derrinallum	Lismore & Derrinallum Waterworks Trust	Otway System	0.30	0.65	
Lorne	Lorne W/works Trust	Erskine & St. George Rivers	0.20	0.60	
Mortlake	Mortlake W/works Trust	Springs & Bore	0.55	1.60	
Noorat & Glenormiston	S.R. & W.S.C.	Otway System	0.62	2.30	
Otway Rural District	S.R. & W.S.C.	Otway System	1.37	2.80	
Otway Waterworks "	S.R. & W.S.C.	Otway System	1.37	2.90	
Penshurst	Shire of Mount Rouse Waterworks Trust	Springs & Bore	0.20	0.36	
Peterborough	Peterborough W/works Trust	Bore	0.03	0.05	
Port Campbell	Shire of Heytesbury Waterworks Trust	Bore	0.23	0.50	
Port Fairy	Port Fairy W/works Trust	Bores	1.60	2.50	
Skene's Creek	Skene's Creek W/works Tst.	Skene's Creek	0.02	0.16	Estimated consumptions. Works not yet operating.
Simpson	S.R. & W.S.C.	Otway System	0.32	0.90	
Terang	S.R. & W.S.C.	Otway System	0.74	1.80	
Timboon	Shire of Heytesbury Waterworks Trust	Bore	0.55	1.20	
Warrnambool	Warrnambool City Council	Otway System	7.39	15.00	
Winchelsea	Winchelsea W/works Trust	G.W. & S.T. Barwon System	0.50	1.50	
Wye River	Proposed Waterworks Trust	Wye River	0.03	0.30	Estimated consumptions.

NOTES:
1. G.W. & S.T. = Geelong Waterworks & Sewerage Trust
2. S.R. & W.S.C.= State Rivers & Water Supply Commission
3. Consumptions are generally based on 1972/73 usage. Restricts on the use of water for gardening purposes were applied in areas served by the Otway System for a period during the 1972/73 summer.

APPENDIX 3G

VARIABILITY OF STREAM FLOW

River (gauging station)	Drainage area km^2	Maximum daily flow (Ml/day)	Minimum daily flow (Ml/day)
Aire River (Beech Forest)	25	1393	1.7
Gellibrand River (Carlisle)	565	9987	17
Moyne River (Toolong)	570	6662	0
Curdies River (Curdie)	790	27848	0
Barwon River (Winchelsea)	1052	25934	0.5
Hopkins River (Hopkins Falls)	8355	30807	2.9

<u>Source</u> Victorian River Gauging to 1969
State Rivers and Water Supply Commission.

APPENDIX 4

OCCURRENCE OF PLANT SPECIES BY BLOCKS

(Some blocks were more intensively sampled than others and the absence of a recording does not mean that the species does not occur in the block.)

Scientific Name	Block Number 1	2	3	4	5	6	7	8	9	10	11
Acacia aculeatissima				+							
Acacia armata				+						+	
Acacia dealbata					+	+	+	+			
Acacia genistifolia						+					
Acacia longifolia	+							+			
Acacia mearnsii							+			+	
Acacia melanoxylon	+	+	+		+	+	+	+	+		+
Acacia mucronata	+	+	+	+	+	+	+	+			
Acacia myrtifolia	+	+		+	+	+	+	+			
Acacia pycnantha				+						+	
Acacia saligna								+			
Acacia stricta	+	+	+		+	+		+	+		
Acacia suaveolens				+		+	+				
Acacia verniciflua		+	+		+	+					
Acacia verticillata	+	+	+	+	+	+	+	+	+		+
Acaena anserinifolia	+	+	+		+	+	+	+	+		+
Acaena echinata	+			+				+			+
Acaena sp.								+			
Acetosella vulgaris		+			+	+		+	+		
Achillea millefolium					+						
Acianthus exsertus	+			+				+			
Acianthus reniformis	+							+			
Acrotriche affinis	+							+			
Acrotriche prostrata	+	+						+			
Acrotriche serrulata	+	+		+	+	+	+	+			
Adiantum aethiopicum	+	+	+	+			+	+	+		+
Agropogon littoralis									+		
Agropyron scabrum	+	+						+			
Agrostis avenacea	+	+	+		+	+	+	+	+	+	+
Agrostis billardieri	+	+						+	+		
Agrostis rudis	+	+	+		+	+		+			
Agrostis sp.						+	+				
Agrostis stolonifera	+										
Agrostis tenuis	+	+			+	+	+	+	+		
Aira caryophyllea	+	+			+	+	+	+	+	+	
Aira praecox	+					+	+	+			

Scientific Name	Block Number 1	2	3	4	5	6	7	8	9	10	11
Ajuga australis	+							+	+		+
Albizia lophantha								+	+		
Alternanthera denticulata									+		
Alyxia buxifolia	+		+					+			
Ammophila arenaria	+							+			
Amperea xiphoclada	+	+		+	+	+	+	+			
Amphibromus neesii							+	+			
Amphibromus recurvatus							+	+			
Amphibromus strictus				+							
Amphipogon strictus				+							
Amyema pendulum	+	+			+	+	+	+	+		+
Amyema preissii								+			+
Anagallis arvensis	+	+			+	+		+	+	+	
Angianthus preissianus								+		+	
Anguillaria dioica								+			
Anogramma leptophylla								+			+
Anthoxanthum odoratum	+	+			+	+	+	+	+		
Aotus ericoides				+		+	+	+			
Apalochlamys spectabilis								+			
Aphanes arvensis					+	+					
Aphelia gracilis				+				+			
Aphelia pumilio				+				+			
Apium graveolens									+		
Apium prostratum	+	+						+	+		
Aptenia cordifolia									+		
Arctotheca calendula	+								+		
Arthrochilus huntianus						+					
Arthrocnemum arbusculum									+		
Arthrocnemum halocnemoides									+		
Arthropodium milleflorum	+	+			+						
Asperula conferta	+	+			+	+	+	+			+
Asperula gunnii	+		+		+						

Scientific Name	1	2	3	4	5	6	7	8	9	10	11
					Block Number						
Asperula scoparia								+			
Asperula sp.						+					
Asperula subsimplex								+			
Asplenium bulbiferum	+	+	+		+	+		+			+
Asplenium flabellifolium			+		+			+			+
Asplenium flaccidum	+	+	+								
Aster subulatus	+							+	+		
Astroloma humifusum				+			+	+			
Athyrium australe	+	+	+								
Atriplex hastata	+							+	+		
Atriplex paludosa									+		
Atriplex semibaccata								+			+
Australani muelleri	+	+	+		+	+		+			
Azolla filiculoides								+			+
Baeckea ramosissima								+			
Banksia marginata	+	+		+	+	+	+	+			
Bauera rubioides	+	+				+		+			
Baumea acuta	+	+		+		+		+			
Baumea gunnii							+	+			
Baumea juncea						+		+			
Baumea laxa					+			+			
Baumea rubiginosa							+	+			
Baumea tetragona	+	+				+					
Bedfordia salicina	+	+	+		+	+		+			
Bellis perennis		+									
Beyeria leschenaultii	+							+			
Billardiera longiflora					+	+					
Billardiera scandens	+	+			+	+	+	+			
Blechum aggregatum	+	+	+		+	+		+			
Blechum fluviatile	+	+	+	+	+						
Blechnum minus	+	+	+		+	+	+	+			
Blechnum nudum	+	+	+		+	+	+	+	+		
Blechnum procerum	+	+	+		+	+	+	+			
Boronia muelleri	+	+									
Boronia nana					+	+		+			
Boronia parviflora	+	+				+		+			
Bossiaea cinerea	+	+				+		+			
Bossiaea cordigera					+						

Scientific Name	1	2	3	4	5	6	7	8	9	10	11
					Block Number						
Bossiaea prostrata	+	+		+			+	+			
Brachycome cardiocarpa				+				+			
Brachycome diversifolia	+	+									
Brachycome multifida				+							
Brachycome parvula	+							+			
Brachycome perpusilla								+			
Brachycome uliginosa				+							
Brachyloma ciliatum	+			+		+	+	+			
Brassica sp.					+			+			
Briza maxima								+		+	
Briza minor	+	+			+	+		+	+	+	
Bromus mollis		+			+						
Bromus sterilis									+		
Bromus unioloides	+							+			
Brunonia australis	+	+		+	+		+	+		+	
Bulbine bulbosa	+							+			
Bulbine semibarbata								+			
Burchardia umbellata	+	+		+	+	+	+	+		+	
Bursaria spinosa	+	+			+		+	+	+	+	+
Caesia parviflora								+			
Cakile edentula									+		
Cakile maritima	+		+					+	+		
Caladenia carnea	+			+				+			
Caladenia clavigera								+			
Caladenia deformis								+			
Caladenia dilatata								+			
Caladenia iridescens				+							
Caladenia latifolia	+							+			
Caladenia menziesii				+				+			
Caladenia patersonii				+				+			
Caladenia reticulata								+			
Caladenia sp.						+					
Caladenia tessellata				+							
Caleana major				+		+					
Callitriche brachycarpa		+									
Callitriche muelleri	+										
Callitriche sp.		+			+		+				
Callitriche stagnalis								+			
Calocephalus brownii	+	+						+	+		
Calocephalus lacteus								+			

Scientific Name	1	2	3	4	5	6	7	8	9	10	11
Calochilus campestris						+		+			
Calochilus paludosus						+		+			
Calochilus robertsonii		+			+						
Calochilus sp.					+						
Calorophus lateriflorus	+	+			+	+	+	+			
Calystegia marginata	+	+	+								
Calystegia sepium	+							+	+		
Capsella pilosula	+										
Cardamine debilis					+			+			
Cardamine dictyosperma	+	+									
Cardamine sp.	+				+						
Cardamine tenuifolia									+		
Carduus pycnocephalus	+								+		
Carduus tenuiflorus	+							+	+		
Carex appressa		+			+	+		+	+		+
Carex bichenoviana	+										
Carex breviculmis	+	+						+			
Carex brownii								+			
Carex fascicularis	+		+					+			+
Carex gaudichaudiana							+	+	+		
Carex gunniana								+			
Carex inversa		+									
Carex pumila	+	+	+						+		
Carpobrotus rossii	+	+						+	+		
Cassinia aculeata					+	+		+			+
Cassytha glabella	+	+		+	+	+		+			
Cassytha melantha	+	+				+	+	+			+
Cassytha pubescens	+	+			+	+	+	+			
Cas uarina littoralis				+			+				
Casuarina paludosa	+	+		+		+	+	+			
Casuarina stricta	+	+						+	+		+
Catapodium rigidum	+										
Caustis pentandra						+		+			
Caustis sp.				+		+		+			
Centaurium minus	+	+			+	+	+	+	+	+	
Centaurium pulchellum	+	+				+		+	+	+	
Centella cordifolia	+	+					+	+	+		
Centipeda cunninghamii								+	+		
Centrolepis aristata	+	+		+	+	+		+			

Scientific Name	1	2	3	4	5	6	7	8	9	10	11
Centrolepis fascicularis		+			+	+	+	+			
Centrolepis glabra				+							
Centrolepis polygyna								+	+		
Centrolepis strigosa		+		+	+	+		+	+	+	
Cerastium glomeratum		+			+	+			+		
Chamaescilla corymbosa				+			+	+		+	
Cheilanthes tenuifolia								+			
Chenopodium glaucum								+	+		+
Chenopodium murale									+		
Chenopodium pumilio						+	+	+	+		+
Chiloglottis cornuta	+	+			+						
Chiloglottis reflexa	+			+							
Chiloglottis sp.					+						
Chorizandra enodis								+			
Chrysanthemum sp.					+						
Cicendia filiformis								+			
Cirsium vulgare	+	+			+	+	+	+	+	+	
Clematis aristata	+	+	+		+	+	+	+	+		+
Clematis microphylla	+							+			+
Colobanthus apetalus	+							+	+		
Comesperma calymega				+	+	+		+			
Comesperma defoliatum	+	+				+	+	+			
Comesperma ericinum				+	+						
Comesperma retusum						+	+	+			
Comesperma volubile	+					+	+	+			
Conospermum mitchellii				+							
Convolvulus erubescens								+			
Conyza bonariensis	+							+			
Conyza canadensis	+				+	+		+	+		
Coprosma hirtella		+	+		+	+		+			
Coprosma quadrifida	+	+	+		+	+		+	+		
Coprosma repens									+		
Correa alba	+		+								
Correa lawrenciana	+	+	+		+						
Correa reflexa						+		+			
Corybas fordhamii	+					+					
Corybas sp.	+	+							+		
Corybas unguiculatus	+										

Scientific Name	1	2	3	4	5	6	7	8	9	10	11
	Block Number										
Cotula australis								+			
Cotula coronopifolia	+							+	+		
Cotula reptans	+	+	+		+	+	+	+	+		
Craspedia glauca				+				+			
Crassula helmsii	+							+	+		+
Crassula macrantha	+			+				+			
Crassula pedicellosa				+							
Crassula peduncularis								+			
Crassula sieberana	+	+						+	+		
Crataegus monogyna		+									
Crepis sp.		+			+	+					
Cryptostylis subulata						+	+	+			
Ctenopteris heterophylla	+	+	+			+					
Culcita dubia			+		+	+	+	+			
Cyathea australis	+	+	+		+	+		+			
Cyathea cunninghamii	+	+									
Cyathea marcescens	+										
Cymbonotus preissianus	+							+			
Cynodon dactylon	+							+			+
Cynoglossum australe	+							+	+		
Cynoglossum latifolium	+	+			+						
Cynoglossum suaveolens		+						+			+
Cynosurus cristatus	+	+						+	+		
Cynosurus echinatus	+	+								+	
Cyperus eragrostis	+				+			+			
Cyperus lucidus	+	+						+	+		+
Cyperus tenellus	+	+		+	+	+		+			
Dactylis glomerata	+	+			+			+	+		
Danthonia caespitosa	+							+			+
Danthonia geniculata					+			+			+
Danthonia pallida				+							
Danthonia penicillata	+		+		+						
Danthonia pilosa							+	+			+
Danthonia procera								+			
Danthonia racemosa								+			
Danthonia semiannularis	+				+		+	+			
Danthonia setacea	+	+		+		+		+			
Danthonia spp.	+	+			+		+	+	+	+	

Scientific Name	1	2	3	4	5	6	7	8	9	10	11
	Block Number										
Daucus carota								+			
Daucus glochidiatus	+							+			
Daviesia brevifolia				+							
Daviesia latifolia								+			
Daviesia ulicifolia								+			
Daviesia virgata				+			+				
Dennstaedtia davallioides			+								
Desmodium varians			+								
Deyeuxia densa	+	+				+	+	+			
Deyeuxia minor					+	+					
Deyeuxia quadriseta	+	+		+	+	+	+	+			
Deyeuxia sp.	+	+	+		+	+					
Dianella revoluta	+	+		+	+	+	+	+	+		+
Dianella sp.								+			
Dianella tasmanica		+	+		+	+	+	+			+
Dichelachne crinita	+	+		+		+	+	+			
Dichelachne sciurea	+	+	+		+	+		+			
Dichondra repens	+	+	+	+	+			+	+	+	+
Dichopogon strictus				+				+		+	
Dicksonia antarctica	+	+	+		+	+	+	+			+
Digitalis purpurea		+				+					
Dillwynia glaberrima	+	+		+	+	+		+			
Dillwynia sericea		+		+							
Dipodium punctatum	+	+			+	+	+	+			+
Distichlis distichophylla		+						+	+	+	
Diuris longifolia								+			
Diuris palustris								+			
Diuris pedunculata								+			
Dodonaea cuneata								+			+
Doodia media			+								
Drimys lanceolata	+	+									
Drosera auriculata	+	+	+	+	+	+	+	+			
Drosera binata						+					
Drosera glanduligera				+	+						
Drosera peltata								+			
Drosera planchonii				+							
Drosera pygmaea	+	+		+	+	+	+	+			
Drosera spathulata						+					
Drosera whittakeri				+							

Scientific Name	Block Number										
	1	2	3	4	5	6	7	8	9	10	11
Drymophila cyanocarpa	+	+				+	+				
Dryopoa dives					+						
Echinopogon ovatus	+	+	+		+			+	+		+
Eleocharis acuta	+	+						+	+		
Eleocharis atricha				+							
Eleocharis gracilis	+	+									
Eleocharis sphacelata			+								
Enchylaena tomentosa	+										
Epacris impressa	+	+	+	+	+	+	+	+			
Epacris lanuginosa	+	+				+	+	+			
Epacris obtusifolia						+		+			
Epilobium billardierianum	+		+		+			+	+		+
Epilobium cinereum	+	+			+	+		+	+		+
Epilobium hirtigerum	+		+	+	+						
Eragrostis brownii		+			+	+	+	+	+		
Erica sp.								+			
Eriochilus cucullatus							+	+		+	
Erodium cicutarium									+		
Eryngium vesiculosum								+			
Eucalyptus aromaphloia			+	+		+		+			
Eucalyptus baxteri	+	+		+		+		+			
Eucalyptus camaldulensis								+	+		
Eucalyptus cladocalyx										+	
Eucalyptus cypellocarpa	+	+	+		+	+		+			
Eucalyptus kitsoniana	+	+									
Eucalyptus nitida				+	+	+		+			
Eucalyptus obliqua	+	+	+	+	+	+	+	+	+		
Eucalyptus ovata	+	+	+	+	+	+	+	+	+		+
Eucalyptus radiata	+			+	+		+	+			
Eucalyptus regnans	+	+	+		+	+					
Eucalyptus sp.	+		+			+		+			
Eucalyptus st-johnii		+									
Eucalyptus viminalis	+	+	+		+	+	+	+	+		+
Euphorbia peplus								+	+		
Euphrasia collina								+			
Exocarpos cupressiformis					+		+	+	+		+
Exocarpos strictus								+			
Exocarpos syrticola	+							+			

Scientific Name	Block Number										
	1	2	3	4	5	6	7	8	9	10	11
Festuca arundinacea	+							+			
Festuca hookeriana								+	+		
Festuca littoralis	+							+	+		
Fumaria sp.									+		
Gahnia clarkei	+					+	+	+			
Gahnia radula				+				+			
Gahnia sieberana	+	+	+		+	+	+	+			
Gahnia trifida								+			
Galium aparine		+							+		
Galium australe			+								
Galium ciliare	+										
Galium gaudichaudii	+							+			+
Galium murale									+		
Galium propinquum		+					+	+			
Galium sp.	+	+									
Gastrodia sesamoides	+	+	+	+	+	+		+			
Genista monspessulana									+		
Geranium dissectum		+									
Geranium homeanum	+										
Geranium molle	+								+		
Geranium potentilloides	+	+	+		+	+		+	+		
Geranium solanderi	+	+	+		+			+			+
Geranium sp.									+		
Gleichenia circinnata		+			+	+	+	+			
Gleichenia microphylla	+	+			+		+				
Glossodia major								+			
Glyceria australis	+	+	+		+			+	+		+
Glycine clandestina	+	+	+								
Glycine latrobeana								+			
Gnaphalium candidissimum		+				+	+	+			
Gnaphalium gymnocephalum	+	+	+	+	+	+	+	+	+		
Gnaphalium indutum	+							+			
Gnaphalium involucratum								+			+
Gnaphalium japonicum								+			+
Gnaphalium luteo-album	+	+			+	+	+	+	+		+
Gnaphalium purpureum	+	+			+	+	+	+	+		
Gnaphalium sphaericum	+	+	+		+	+		+	+		
Gnaphalium spicatum						+					
Gompholobium ecostatum		+		+	+	+		+			
Gompholobium huegelii						+		+			

Scientific Name	Block Number 1	2	3	4	5	6	7	8	9	10	11
Goodenia geniculata				+							
Goodenia humilis				+			+	+			
Goodenia lanata	+		+	+	+	+	+	+			
Goodenia ovata	+	+	+		+	+	+	+	+		
Goodia lotifolia	+	+			+	+		+			+
Grammitis billardieri	+	+	+								
Gratiola pedunculata								+			+
Gratiola peruviana		+			+		+	+	+		+
Grevillea aquifolium				+							
Gymnoschoenus sphaerocephalus	+	+				+		+			
Gynatrix pulchella		+			+	+		+		+	+
Hakea sericea						+		+			
Hakea ulicina		+		+	+	+	+	+			
Haloragis brownii								+			
Haloragis escalata								+			
Haloragis micrantha					+	+	+	+			
Haloragis tetragyna	+	+	+	+	+	+	+	+	+	+	
Haloragis teucrioides	+	+	+		+	+		+			
Hedycarya angustifolia	+	+	+		+	+		+			
Helichrysum apiculatum	+							+		+	
Helichrysum blandowskianum						+					
Helichrysum dendroideum	+	+	+		+	+	+	+	+		+
Helichrysum leucopsideum	+							+			
Helichrysum obtusifolium				+		+		+			
Helichrysum paralium	+	+						+			
Helichrysum rogersianum						+					
Helichrysum rosmarinifolium	+	+				+		+			
Heilchrysum scorpioides	+	+	+	+		+	+	+			
Hemarthria uncinata	+			+		+	+	+	+		
Hemichroa petandra								+	+		
Hibbertia acicularis						+					
Hibbertai aspera								+			
Hibbertia astrotricha						+		+			
Hibbertia fasciculata				+		+		+			
Hibbertia procumbens	+	+			+	+	+	+			
Hibbertia sericea	+										
Hibbertia sp.						+		+			
Hibbertia stricta				+			+	+			
Histiopteris incisa	+	+	+		+	+		+			

Scientific Name	Block Number 1	2	3	4	5	6	7	8	9	10	11
Holcus lanatus	+	+			+	+	+	+	+		
Hordeum hystrix										+	
Hordeum leporinum	+	+						+			
Hovea heterophylla				+							
Hydrocotyle callicarpa				+				+			
Hydrocotyle capillaris	+							+			
Hydrocotyle foveolata		+						+			
Hydrocotyle hirta	+	+	+		+	+		+	+		+
Hydrocotyle laxiflora	+		+	+				+			
Hydrocotyle muscosa								+			
Hydrocotyle sibthorpioides							+	+	+		
Hydrocotyle verticillata									+		
Hymenanthera dentata								+			+
Hymenobolus procumbens								+			
Hymenophyllum cupressiforme	+	+	+			+		+			+
Hypericum androsaemum		+				+		+			
Hypericum gramineum	+	+		+	+	+	+	+	+	+	+
Hypochoeris glabra									+		
Hypochoeris radicata	+	+			+	+	+	+	+		
Hypochoeris sp.										+	
Hypolaena fastigiata				+		+		+			
Hypolepis sp.	+	+	+		+	+					
Hypoxis glabella				+				+			
Hypoxis hygrometrica	+							+			
Imperata cylindrica	+							+			+
Indigofera australis	+	+					+	+	+		
Isoetes drummondii				+				+			
Isopogon ceratophyllus				+		+	+	+			
Isotoma fluviatil is				+				+			
Juncus articulatus	+	+			+	+	+	+			
Juncus bufonius	+	+	+		+	+	+	+	+		
Juncus caespiticius	+	+						+	+		
Juncus capitatus					+	+		+		+	
Juncus holoschoenus		+			+		+	+	+		
Juncus homalocaulis					+				+		
Juncus kraussii	+							+	+		
Juncus pallidus	+	+			+	+	+	+	+		+
Juncus pauciflorus	+	+			+	+	+	+	+		

Scientific Name	1	2	3	4	5	6	7	8	9	10	11
	Block Number										
Juncus planifolius	+	+	+		+	+	+	+	+		
Juncus procerus	+	+			+	+	+	+	+		
Juncus radula								+			+
Juncus revolutus								+	+		
Juncus spp.	+	+	+	+	+	+		+	+		
Juncus usitatus								+			+
Kennedia prostrata	+			+			+	+			
Koeleria phleiodes	+										
Lagenophora gracilis	+	+		+			+	+			
Lagenophora stipitata	+	+			+			+			
Lagurus ovatus	+										
Lasiopetalum baueri								+			
Lastreopsis hispida	+	+									
Lastreopsis shepherdii	+	+	+		+			+			+
Lavatera plebeia									+		
Laurencia spicata								+			
Laxmannia sessiliflora		+		+	+	+		+			
Lemna minor								+			
Leontodon taraxacoides	+	+			+	+	+	+	+		
Lepidosperma concavum	+	+			+	+		+			
Lepidosperma filiforme	+	+		+		+	+	+			
Lepidosperma gladiatum	+							+	+		
Lepidosperma laterale	+	+	+	+	+	+	+	+	+		
Lepidosperma lineare								+			
Lepidosperma longitudinale	+	+		+			+	+			
Lepidosperma neesii				+				+			
Lepidosperma semiteres				+	+			+			
Lepilaena sp.	+										
Leptocarpus brownii								+			
Leptorhynchos linearis				+							
Leptorhynchos squamatus								+		+	
Leptorhynchos tenuifolius								+			
Leptospermum glabrescens						+	+				
Leptospermum juniperinum	+	+	+	+	+	+	+	+	+		+
Leptospermum lanigerum	+							+	+		+
Leptospermum myrsinoides				+	+	+	+	+			
Leptospermum scoparium	+	+	+					+			
Lepyrodia muelleri				+							

Scientific Name	1	2	3	4	5	6	7	8	9	10	11
	Block Number										
Leucopogon australis	+	+				+		+			
Leucopogon ericoides								+			
Leucopogon glacialis				+							
Leucopogon lanceolatus								+			
Leucopogon parviflorus	+	+	+					+			
Leucopogon virgatus	+	+		+	+	+	+	+			
Lilaeopsis polyantha								+	+		
Limosella aquatica								+			+
Limosella australis								+			
Lindsaya linearis	+	+		+	+	+	+	+			
Linum marginale	+		+					+			
Lobelia alata	+	+				+		+	+		
Lobelia gibbosa		+						+			
Lobelia rhombifolia				+							
Lobelia sp.	+	+			+	+	+	+			
Logania ovata								+			
Lolium perenne	+	+			+			+	+		
Lomandra filiformis	+			+		+	+	+			
Lomandra glauca								+		+	
Lomandra longifolia	+	+		+	+	+	+	+	+		+
Lomandra micrantha								+			
Lomandra multiflora				+							
Lomatia fraseri		+			+						
Lomatia ilicifolia				+	+						
Lotus australis	+							+			
Lotus hispidus	+	+			+	+		+			
Lotus pedunculatus	+	+			+	+	+	+			
Luzula spp.	+	+	+	+	+	+	+	+			+
Lycium ferocissimum	+								+		
Lycopodium deuterodensum					+	+		+			
Lycopodium laterale						+					
Lycopus australis	+										
Lyperanthus nigricans				+							
Lythrum hyssopifolia	+	+			+			+	+		+
Lythrum salicaria									+		
Malus sylvestris		+			+	+	+				
Malva nicaeensis	+										

Scientific Name	1	2	3	4	5	6	7	8	9	10	11
Malva parviflora									+		
Marianthus procumbens				+		+					
Marrubium vulgare		+						+	+		
Mazus pumilio	+							+	+		
Mecodium australe	+	+	+								
Mecodium flabellifolium	+	+	+								
Mecodium rarum	+	+									
Medicago lupulina	+							+			
Medicago polymorpha									+		
Melaleuca squamea						+		+			
Melaleuca squarrosa	+	+			+	+	+	+			+
Melilotus indica	+								+		
Mentha laxiflora	+	+	+		+	+		+			
Mentha diemenica								+			+
Mentha spicata		+				+					
Microlaena stipoides	+	+	+		+	+	+	+	+	+	
Microseris scapigera				+							
Microsorium diversifolium	+	+	+		+	+					
Microtis parviflora								+			
Microtis sp.	+										
Microtis unifolia	+	+			+	+		+	+	+	
Mimulus repens	+							+	+	+	+
Mitrasacme distylis				+				+			
Mitrasacme paradoxa								+			
Mitrasacme pilosa		+			+	+	+	+			
Mitrasacme sp.	+					+					
Mitrasacme sp. "stuartii"		+				+					
Modiola caroliniana							+				
Monotoca elliptica	+	+				+	+	+			
Monotoca scoparia				+	+	+		+			
Montia australasica								+			+
Montia fontana		+	+					+			
Muehlenbeckia adpressa	+							+			
Meullerina eucalyptoides	+	+						+			
Myoporum insulare	+	+						+	+		
Myoporum viscosum								+			
Myosotis australis	+										

Scientific Name	1	2	3	4	5	6	7	8	9	10	11
Myriophyllum elatinoides									+		
Myriophyllum integrifolium				+				+			
Myriophyllum meulleri									+		
Myriophyllum pedunculatum							+				
Myriophyllum propinquum							+	+	+		
Myriophyllum sp.									+		
Nasturtium officinale		+							+		
Nasturtium sp.	+				+						
Nertera reptans	+	+					+	+	+		
Notelaea ligustrina	+	+	+		+	+		+	+		
Nothofagus cunninghamii	+	+									
Olearia argophylla	+	+	+		+	+		+	+		+
Olearia axillaris	+							+			
Olearia erubescens	+							+			
Olearia glandulosa	+										
Olearia lanuginosa	+										
Olearia lirata	+	+	+		+	+	+	+			
Olearia myrsinoides				+			+				
Olearia phlogopappa	+	+	+		+	+		+			
Olearia ramulosa	+	+		+	+	+	+	+			
Olearia sp.						+	+	+			
Olearia speciosa	+	+						+			
Olearia teretifolia				+							
Opercularia ovata				+					+	+	
Opercularia varia	+	+		+	+	+	+	+			
Ophioglossum coriaceum								+			
Orthoceras strictum						+		+			
Orthrosanthus multiflorus								+			
Ottelia ovalifolia								+			+
Oxalis corniculata	+	+	+		+	+	+	+	+		+
Parahebe derwentiana			+		+			+	+		
Parapholis incurva	+									+	
Parentucellia latifolia									+	+	
Parentucellia viscosa	+	+			+	+		+	+		
Parietaria debilis	+										
Parsonsia brownii	+	+									
Paspalum dilatatum	+				+	+		+	+		
Paspalum paspalodes	+								+		

Scientific Number	Block Number 1	2	3	4	5	6	7	8	9	10	11
Patersonia fragilis	+	+			+	+	+	+			
Patersonia longiscapa	+	+						+			
Pelargonium australe		+			+			+			+
Pelargonium inodorum		+			+			+			
Pelargonium littorale	+		+					+			
Pelargonium sp.						+		+			
Pellaea falcata	+	+	+		+			+			+
Pennisetum clandestinum	+						+	+			
Pentapogon quadrifidus							+	+			
Persoonia juniperina				+	+	+	+	+			
Phalaris minor	+							+			
Phebalium squameum	+	+	+		+	+		+			
Phragmites australis	+							+	+		+
Phylloglossum drummondii				+				+			
Physalis viscosa	+	+									
Picris echioides	+							+	+		
Picris hieracioides	+	+									
Pimelea axiflora	+	+	+		+	+		+			
Pimela flava			+		+						
Pimela glauca	+							+			
Pimelea humilis	+			+	+	+	+	+			
Pimelea ligustrina		+	+		+	+		+			
Pimelea linifolia	+	+		+	+	+		+			
Pimelea octophylla			+	+				+			
Pimelea phylicoides				+							
Pinus sp.								+	+		
Pittosporum bicolor		+			+	+					
Plantago coronopus	+	+			+			+	+	+	
Plantago debilis	+		+								
Plantago lanceolata	+	+			+	+	+	+	+		
Plantago major	+	+			+	+		+	+		
Plantago varia				+				+			
Platylobium formosum		+				+					
Platylobium obtusangulum	+			+	+	+	+	+			
Platysace heterophylla				+							
Pleurosorus rutifolius								+			+
Poa annua		+			+	+					
Poa clelandii						+					

Scientific Number	Block Number 1	2	3	4	5	6	7	8	9	10	11
Poa labillardieri	+	+	+		+	+	+	+	+		+
Poa poiformis	+	+	+					+	+		
Poa sieberana	+	+	+	+	+	+	+	+	+	+	
Poa sp.	+						+	+	+		
Poa tenera	+	+	+		+		+	+			
Polycarpon tetraphyllum	+										
Polygonum aviculare	+					+			+		
Polygonum minus	+							+	+		
Polygonum prostratum									+		
Polyphlebium venosum	+	+	+								
Polypogon maritimus									+		
Polypogon monspeliensis	+							+		+	
Polypompholyx tenella								+			
Polystichum proliferum	+	+	+		+	+		+	+		+
Pomaderris aspera	+	+	+		+	+	+	+			
Pomaderris elachophylla			+		+	+					
Pomaderris oraria	+										
Pomaderris racemosa				+	+			+			
Poranthera microphylla	+	+		+	+		+	+			
Potamogeton ochreatus	+	+									
Potamogeton pectinatus								+	+		
Potamogeton sp								+			
Potamogeton tricarinatus							+	+			
Prasophyllum archeri							+				
Prasophyllum australe	+					+	+	+			
Prasophyllum beaugleholei							+				
Prasophyllum despectans						+					
Prasophyllum elatum				+							
Prasophyllum flavum	+	+									
Prasophyllum odoratum	+							+			
Prasophyllum pallidum	+										
Pratia pedunculata	+	+	+	+	+	+	+	+	+		
Pratia platycalyx	+							+	+	+	
Pratia sp. affin. purpurascens			+		+	+		+			
Prostanthera lasianthos	+	+	+		+	+		+			
Prostanthera melissifolia		+	+		+	+					
Prunella vulgaris	+	+	+		+	+	+	+	+		
Psoralea parva									+		
Pteridium esculentum	+	+	+	+	+	+	+	+	+		+

Scientific Name	Block Number 1	2	3	4	5	6	7	8	9	10	11
Pteris tremula			+					+			+
Pterostylis alpina			+	+							
Pterostylis longifolia				+	+			+	+		
Pterostylis nana								+			
Pterostylis nutans	+			+				+			
Pterostylis obtusa			+		+						
Pterostylis parviflora				+			+				
Pterostylis pedunculata	+	+									
Pterostylis plumosa				+				+			
Ptilotus macrocephalus										+	
Puccinellia stricta								+	+		
Pultenaea canaliculata	+							+			
Pultenaea daphnoides	+	+	+	+	+	+		+			
Pultenaea dentata	+	+					+	+			
Pultenaea gunnii				+	+						
Pultenaea humilis				+							
Pultenaea juniperina			+		+		+	+			
Pultenaea muelleri		+				+		+			
Pultenaea prolifera				+		+		+			
Pultenaea scabra				+							
Pultenaea stricta	+	+					+	+			
Pultenaea subumbellata						+					
Pultenaea tenuifolia	+							+			
Ranunculus inundatus								+			
Ranunculus lappaceus	+							+			+
Ranunculus papulentus								+			
Ranunculus plebeius			+		+						
Ranunculus pumilio	+	+			+						
Ranunculus repens	+	+			+	+					
Ranunculus rivularis	+		+					+			+
Ranunculus sessiliflorus					+			+			
Ranunculus sp.				+	+			+			
Restio tetraphyllus						+					
Rhagodia baccata	+	+						+			+
Rhagodia nutans								+			+
Rhamnus alaternus								+			
Romulea longifolia										+	
Rorippa islandica									+		
Rosa rubiginosa	+	+							+		
Rubus laciniatus					+						

Scientific Name	Block Number 1	2	3	4	5	6	7	8	9	10	11
Rubus parvifolius	+	+	+				+	+	+		+
Rubus procerus	+	+			+	+	+	+			
Rumex acetosella									+		
Rumex bidens								+	+		+
Rumex brownii	+	+			+	+		+	+		+
Rumex conglomeratus	+	+							+		
Rumex crispus	+				+	+	+	+	+		
Rumex obtusifolius						+					
Rumex pulcher		+									
Rumohra adiantiformis	+	+									
Ruppia maritima	+										
Rutidosis multiflora				+				+			
Sagina apetala								+			
Sagina procumbens					+	+		+			
Salicornia australasica								+			+
Salicornia blackiana								+	+		
Salicornia quinqueflora								+	+		
Sambucus gaudichaudiana		+			+	+		+	+		+
Samolus repens	+	+						+	+		
Sarcochilus australis	+	+									
Scaevola albida	+										
Scaevola pallida	+							+			
Schizaea bifida				+		+		+			
Schizaea fistulosa						+					
Schoenus apogon	+	+	+	+	+	+	+	+	+	+	
Schoenus breviculmis				+							
Schoenus maschalinus	+	+	+		+	+					
Schoenus nitens	+	+						+	+		
Schoenus tenuissimus	+	+		+	+	+	+	+			
Schoenus tesquorum				+			+	+			
Schoenus turbinatus				+							
Scirpus americanus								+	+		+
Scirpus antarcticus	+	+						+			
Scirpus cernuus	+	+						+	+		
Scirpus fluitans				+			+	+			
Scirpus fluviatilis	+								+		
Scirpus inundatus		+			+	+	+	+			+
Scirpus maritimus								+	+		+
Scirpus nodosus	+							+	+		

Scientific Name	Block Number 1	2	3	4	5	6	7	8	9	10	11
Scirpus platycarpus	+	+									
Scirpus productus								+			
Scirpus sp.	+	+	+	+	+	+					
Scirpus validus	+								+		
Scleranthus biflorus	+										
Scutellaria humilis									+		
Sebaea albidiflora								+	+	+	
Sebaea ovata	+	+			+				+	+	
Selaginella gracillima								+			
Selaginella uliginosa	+	+		+	+	+	+	+			
Selliera radicans		+						+	+		
Senecio elegans	+										
Senecio glomeratus		+	+		+	+		+	+		+
Senecio hispidulus	+	+				+	+	+			+
Senecio jacobaea	+	+			+	+	+	+	+		
Senecio lautus	+	+			+	+		+	+		+
Senecio linearifolius	+	+	+		+	+		+			
Senecio minimus	+	+	+		+	+		+	+		+
Senecio odoratus	+	+	+					+			+
Senecio quadridentatus						+		+			+
Senecio squarrosus								+			
Senecio vellleioides	+	+	+		+	+		+			
Setaria geniculata								+		+	
Sherardia arvensis		+							+		
Sigesbeckia orientalis	+	+	+		+						
Silybum marianum									+		
Sisyrinchium iridifolium		+			+	+					
Solanum aviculare	+	+	+								
Solanum laciniatum	+	+			+			+	+	+	+
Solanum nigrum		+				+		+	+	+	
Solanum sodomaeum									+		
Solanum sp.	+						+				
Solenogyne bellioides				+				+			
Sonchus asper	+	+			+	+		+	+		
Sonchus hydrophilus								+			
Sonchus megalocarpus	+	+						+			
Sonchus oleraceus	+	+			+			+	+	+	
Spergularia media								+	+	+	
Sphaerolobium vimineum	+	+		+	+	+		+			

Scientific Name	Block Number 1	2	3	4	5	6	7	8	9	10	11
Spinifex hirsutus	+							+	+		
Sporobolus africanus	+										
Sporobolus virginicus								+	+	+	
Sprengelia incarnata	+	+				+	+	+			
Spyridium parvifolium			+		+	+		+			
Spyridium vexilliferum								+			
Stackhousia monogyna	+	+		+	+			+			
Stackhousia spathulata	+							+			
Stellaria flaccida	+	+	+		+	+		+			
Stellaria filiformis								+			
Stellaria media	+					+					
Stellaria palustris									+		
Stellaria pungens	+	+	+	+				+			
Stenotaphrum secundatum	+								+		
Stipa compacta	+										
Stipa elatior	+								+	+	
Stipa hemipogon								+			
Stipa pubescens	+	+					+	+			
Stipa sp.	+			+				+		+	
Stipa tenuiglumis								+			
Stipa variabilis								+			+
Stuartina muelleri								+			
Stylidium beaugleholei	+							+			
Stylidium graminifolium	+	+		+	+	+	+	+			
Stylidium inundatum		+		+				+			
Stylidium perpusillum								+			
Stypandra caespitosa		+				+		+			
Suaeda australis								+	+		+
Swainsonia lessertiifolia	+							+			
Taraxacum officinale	+	+			+				+		
Tetragonia implexicoma	+	+						+			
Tetraria capillaris	+	+						+			
Tetraria ciliata	+										
Tetrarrhena acuminata						+					
Tetrarrhena distichophylla	+	+	+	+	+	+	+	+			
Tetrarrhena juncea	+	+	+	+	+	+	+	+			
Tetratheca ciliata	+	+		+	+	+	+	+			
Thelymitra antennifera				+				+			

Scientific Name	Block Number										
	1	2	3	4	5	6	7	8	9	10	11
Thelymitra aristata				+				+			
Thelymitra epipactoides								+			
Thelymitra flexuosa		+		+		+		+			
Thelymitra fusco-lutea				+							
Thelymitra ixioides						+		+			
Thelymitra pauciflora	+			+				+			
Thelymitra rubra				+							
Thelymitra spp.		+			+	+	+	+		+	
Thelymitra venosa						+					
Themeda australis	+			+	+		+	+	+	+	
Thomasia petalocalyx								+			
Threlkeldia diffusa	+							+			
Thysanotus patersonii				+							
Thysanotus tuberosus	+	+			+			+			
Tieghemopanax sambucifolius						+					
Tmesipteris billardieri		+									
Tmesipteris sp.	+										
Todea barbara	+	+				+					
Tricoryne elatior										+	
Tricostularia pauciflora				+		+					
Trifolium campestre						+					
Trifolium cernuum								+	+		
Trifolium dubium		+			+	+		+			
Trifolium fragiferum	+								+		
Trifolium glomeratum		+			+				+		
Trifolium repens	+	+			+	+	+	+	+		
Trifolium subterraneum								+			
Trifolium tomentosum									+		
Triglochin centrocarpa	+							+			
Triglochin minutissima								+			
Triglochin procera	+						+	+	+		
Triglochin striata	+						+	+	+	+	+
Typha sp.	+							+	+		+
Uncinia tenella	+	+	+		+						
Urtica incisa	+	+	+		+	+		+	+		+
Urtica urens									+		
Utricularia dichotoma	+					+	+				
Utricularia lateriflora		+				+					

Scientific Name	Block Number										
	1	2	3	4	5	6	7	8	9	10	11
Vallisneria spiralis									+		
Verbascum virgatum	+							+	+		
Verbena officinalis									+		
Veronica arvensis		+									
Veronica calycina	+	+						+			+
Veronica gracilis	+							+			
Veronica serpyllifolia			+			+					
Vicia angustifolia		+			+						
Vicia hirsuta		+									
Vicia sativa					+						
Vicia tetrasperma		+									
Villarsia reniformis				+			+	+			
Viminaria juncea				+				+			
Vinca major								+			
Viola hederacea	+	+	+	+	+	+	+	+	+	+	+
Viola sieberana	+	+		+			+	+			
Vulpia bromiodes	+					+		+	+		
Wahlenbergia communis								+			+
Wahlenbergia gracilenta	+			+		+		+			
Wahlenbergia gymnoclada	+	+			+			+			
Wahlenbergia quadrifida		+	+		+	+		+			
Wahlenbergia sp.										+	
Wahlenbergia stricta					+		+				
Wahlenbergia tadgellii								+			
Wilsonia backhousei								+	+		
Wilsonia humilis								+			
Wilsonia rotundifolia								+			
Wolffia sp.								+			+
Xanthorrhoea australis	+	+		+	+	+	+	+			
Xanthorrhoea minor		+		+		+		+			
Xanthosia dissecta		+			+	+	+	+			
Xanthosia pusilla	+	+				+		+			
Xyris gracilis						+		+			
Xyris operculata						+		+			
Zantedeschia aethiopica		+									
Zieria aborescens		+	+		+						
Zostera muelleri								+			

APPENDIX 5

NOXIOUS WEEDS

The following list shows the species of noxious weeds recorded in the Corangamite study area. Distribution of the various species is indicated for each block by the number of parishes in which the species is known to occur. The total number of parishes within each block is shown at the head of the species list.

Weed Species	BLOCK											
	Aire River	Carlisle	Cape Otway	Tanybryn	Pennyroyal	Salt Creek	Birregurra	Heytesbury	Corangamite	Chatsworth	Warrnambool	number of blocks in which weed species is found
(Number of parishes in block)	7	9	3	5	7	8	18	25	43	50	55	11
African feather grass												-
Amsinckia									2	7		2
Apple of Sodom				1	1	1				1	11	5
Bathurst Burr						2	6		26	19	10	5
Bindweed								1	7	5	10	4
Blackberry	7	9	3	5	7	4	10	24	6	8	26	11
Black knapweed											1	2
Boneseed	1	1	1	4	2	7	4	9		1	1	10
Boxthorn	1		3	2	3	5	11	11	42	34	50	10
Buffalo burr							3	1				2
Californian burr												-
Caltrop									2	1		2
Camel thorn								7			1	2
Cape broom				1	3	1	5	1	3	17	45	8
Chilean cestrum												8

Weed Species	BLOCK											
	Aire River	Carlisle	Cape Otway	Tanybryn	Pennyroyal	Salt Creek	Birregurra	Heytesbury	Corangamite	Chatsworth	Warrnambool	number of blocks in which weed species is found
(Number of parishes in block)	7	9	3	5	7	8	18	25	43	50	55	11
Chinese scrub											1	1
Colocynth												-
Devil's claw (purple flower)										1		1
Devil's claw (yellow flower)												-
Dodder									1			1
Drooping prickly pear										2		1
English broom				1	2	2	1	4		1	5	7
Erect prickly pear								4	1			2
Fennel							2		3	3	3	4
Five-spined saltbush												-
Flax-leaved broom		2		3	6	5	1	1		2	5	8
Furze	6	3	1	2	2	5	16	7	21	19	42	11
Great mullein	1							1	1	10	12	4
Hawthorn			1	1	2		4	14	5	1	20	8
Hemlock		3	1	2	5	2	9	13	13	5	22	10
Hoary cress			1	1		1	3	4	20	13	4	8
Horehound								2	27	30	33	4
Italian Blackberry or												-
Cutleaf Blackberry	6	7	1	4	7	3	8	18	2		2	10
Ivy-leaf sida												-

Weed Species	Aire River	Carlisle	Cape Otway	Tanybryn	Pennyroyal	Salt Creek	Birregurra	Heytesbury	Corangamite	Chatsworth	Warrnambool	number of blocks in which weed species is found
	BLOCK											
(Number of parishes in block)	7	9	3	5	7	8	18	25	43	50	55	11
Khaki weed												-
Musk weed												-
Noogoora burr												-
Nut-grass				2	3	2	1			1	1	6
One-leaf Cape Tulip			1	1	1	5	9	1	10	7	17	9
Onion weed					4		5	1	3	1	5	6
Ox-eye Daisy	6	5	3	3		1		2				6
Pampas Lily of the Valley				1	1	1		1	2	13	13	7
Paterson's curse					1	4	7	3	27	23	16	7
Perennial ragweed												-
Poverty weed												-
Prairie ground cherry										1		1
Ragwort	7	9	3	5	7	4	10	21	2	2	14	11
St. John's wort						1		3	2	2		4
St. Peter's wort												-
Sand mustard or Sand rocket								2	1		7	3
Serrated tussock												-
Skeleton weed								6		1		2
Soursob				2	3	3	6		16	12	22	7
Spiny broom							2			2		2

Weed Species	BLOCK											
	Aire River	Carlisle	Cape Otway	Tanybryn	Pennyroyal	Salt Creek	Birregurra	Heytesbury	Corangamite	Chatsworth	Warrnambool	number of blocks in which weed species is found
(Number of parishes in block)	7	9	3	5	7	8	18	25	43	50	55	11
Spiny burr-grass												-
Spiny Emex or Three-cornered Jack											1	1
Spiny rush		2					3	6	1	3		5
Stinkwort				2	2	1	1	5	3	8	3	8
Sweet briar	1	1	1	1	3	7	3	16	18	25	55	11
Tangled hypericum												-
Thistle, artichoke												-
Thistle, golden												-
Thistle, hard head												-
Thistle, illyrian												-
Thistle, nodding												-
Thistle, perennial or Californian					1	1	1	4	2		4	6
Thistle, saffron								1	10	18	4	4
Thistle, Saint Barnaby's												-
Thistle, scotch		2						8	10	15		4
Thistle, slender	7	9	3	5	7	8	18	24	43	48	54	11
Thistle, soldier											1	1
Thistle, spear	7	9	3	5	7	6	15	25	40	46	55	11
Thistle, spotted or variegated	2	1	3	4	7	7	16	20	43	38	54	11
Thistle, star												-

Weed Species	BLOCK											
	Aire River	Carlisle	Cape Otway	Tanybryn	Pennyroyal	Salt Creek	Birregurra	Heytesbury	Corangamite	Chatsworth	Warrnambool	Number of blocks in which weed species is found
(Number of parishes in block)	7	9	3	5	7	8	18	25	43	50	55	11
Thistle, stemless												-
Thorn apple				1	1	1		4	4	6	5	7
Tobacco												-
Topped lavender												-
Tree of heaven											2	1
Tufted honeyflower		1										1
Tutsan	7	7	3	4	3	1	2	4				8
Two-leaf cape tulip					1	1	1					3
Wheel cactus												-
Whitehorse nettle or Silver-leaf Nightshade												-
Wild garlic						1	2		2	1		4
Wild mignonette							1	4	20	6	2	5
Wild teasel					1		3	1	3		3	5
Wild watsonia		1	1	2	4	3	5	9	1	1	5	10
Water hyacinth												-

APPENDIX 6

FAUNA

A. BIRDS

This appendix contains a list of birds recently recorded in the area, with an indication of the habitats in which they are likely to occur. The families and species are listed by common names following the nomenclature of the C.S.I.R.O. (1969). Species recorded in the area as only accidental or as vagrants have not been included in the list.

Habitats

1. Temperate rain forest
2. Wet sclerophyll forest
3. Dry sclerophyll forest
4. Woodland
5. Heathy communities
6. Pastures
7. Marine waters
8. Coastline habitat
9. Inland flowing waters
10. Inland standing waters

COMMON NAME	HABITAT										BREEDS IN STUDY AREA				NEST LOCATION	FOODS
	1	2	3	4	5	6	7	8	9	10	YES	LIKELY	NOT LIKELY	NOT KNOWN		
Powerful owl					X							X			Tree branches	Birds, mammals
Barking owl				X										X		Birds, mammals
Boobook owl		X	X									X			Hole in tree	Insects, mammals, birds
Barn owl						X						X			Hole in tree	Insects, mammals, birds
Tawny frogmouth		X	X									X			Tree branches	Insects, mammals
Owlet nightjar			X									X			Hole in tree	Insects
White-throated nightjar			X									X			Ground	Insects
Spine-tailed swift		aerial											X			Flying insects
Fork-tailed swift		aerial											X			Flying insects
Azure king fisher				X								X			Hole in bank	Aquatic insects, crustaceans
Laughing kookaburra		X	X	X	X	X						X			Hole in tree	Reptiles, insects, fish
Sacred king fisher			-						X	X	X				Hole in tree or bank	Reptiles, insects, fish
Rainbow bee-eater			X	X								X			Hole in sandv bank	Flying insects
Singing bushlark						X								X		Seeds and insects
Skylark						X	X				X				Ground	Seeds and insects
Welcome swallow				X	X	X	X		X	X	X				Cliff faces, under eaves, etc.	Flying insects
Tree-martin				X	X	X								X		Flying insects
Fairy-martin						X			X	X				X		Flying insects
Australian pipit						X	X				X				Ground	Seeds and insects
Black-faced cuckoo-shrike		X	X	X		X					X				Tree branches	Berries and insects
Little cuckoo-shrike				X										X		Insects
White-winged triller				X		X						X			Tree branches	Insects
Australian ground-thrush		X			X						X				Fork of tree	Insects, worms, crustaceans
Blackbird					X	X					X				Shrub	Insects, fruit
Spotted quail-thrush			X									X			Ground, low shrub	Seeds, insects
Golden-headed fantail-warbler					X	X				X	X				Near ground in thick vegetation	Insects
Little grassbird										X	X				Thick, low vegetation	Insects, seeds
Reed-warbler										X		X			Stems of reeds	Insects
Brown songlark						X								X		Insects, seeds
Rufous songlark				X		X								X		Insects, seeds
Superb blue wren		X	X	X	X	X					X				Low in shrub	Insects
Southern emu-wren					X							X			Low shrub, tussock	Insects
White-throated warbler			X	X										X		Insects
Striated thornbill		X	X	X	X						X				Tree branches	Insects

COMMON NAME	HABITAT 1	2	3	4	5	6	7	8	9	10	BREEDS IN STUDY AREA: YES	LIKELY	NOT LIKELY	NOT KNOWN	NEST LOCATION	FOODS
Singing honeyeater					X						X				Shrub	Insects, nectar
Yellow-faced honeyeater			X	X	X	X					X				Shrub, tree	Insects, nectar, fruit
White-plumed honeyeater				X		X					X				Tree branches	Insects, nectar
White-eared honeyeater			X	X	X	X						X			Low shrub	Insects, nectar
Brown-headed honeyeater		X		X										X		Insects, nectar
White-naped honeyeater		X	X			X					X				Tree branches	Insects, nectar
Cresent honeyeater		X	X		X						X				Shrub, near ground	Insects, nectar
New Holland honeyeater			X		X									X		Insects, nectar
Tawny-crowned honeyeater					X							X			Low shrub	Insects, nectar
Eastern spinebill		X	X		X	X								X		Insects, nectar
Noisy miner				X		X						X			Tree branches	Insects, nectar, berries
Little wattle bird					X									X		Insects, nectar
Red wattle bird			X	X							X				Tree branches	Insects, nectar
Beautiful firetail					X						X				Shrub, low tree	Insects, seeds
Red-browed finch		X	X	X		X					X				Shrub, small tree	Seeds, insects
House sparrow						X	X			X	X				Shrub, hole in tree, crevice	Seeds, fruit, flowers
Gold finch				X	X	X	X				X				Shrub, low tree	Seeds
Green finch						X					X				Shrub, low tree	Seeds, berries
Starling					X	X	X				X				Hole in tree, crevice	Insects, seeds, fruit
Olive-backed oriole		X	X	X										X		Insects, fruit, berries
Magpie lark						X			X	X	X				Tree branches	Insects, molluscs
White-winged chough				X										X		Insects
Dusky wood-swallow			X	X		X					X				Tree branches	Insects
Pied currawong		X	X		X	X						X			Tree branches	Omnivorous
Grey currawong		X		X	X	X						X			Tree branches	Insects
Grey butcher-bird			X	X		X						X			Tree branches	Variety of animals
White-backed magpie			X	X		X					X				Tree branches	Insects, molluscs
Satin bower-bird	X	X										X			Tree branches	Insects, fruit, berries
Australian raven						X								X		Omnivorous
Little raven			X	X		X						X			Tree branches	Omnivorous
Forest raven		X									X				Tree branches	Omnivorous

COMMON NAME	HABITAT 1	2	3	4	5	6	7	8	9	10	BREEDS IN STUDY AREA: YES	LIKELY	NOT LIKELY	NOT KNOWN	NEST LOCATION	FOODS
Little thornbill					X									X		Insects
Brown thornbill		X	X	X	X	X					X				Low in shrub	Insects
Buff-rumped thornbill				X	X						X				Hole in tree, shrub, ground	Insects
Yellow-rumped thornbill				X		X						X			Tree branches	Insects
White-browed scrub-wren		X	X	X	X	X					X				Near ground in thick vegetation	Insects
Heath wren					X							X			Ground	Insects
Field wren					X	X				X	X				Ground	Insects
Rufous bristlebird					X						X				Low shrub or tussock	Insects, seeds
White-fronted chat				X		X				X	X				Low shrub, tall grass	Insects
Jacky winter						X						X			Tree branches	Insects
Scarlet robin			X		X						X				Fork in tree, stump	Insects
Flame robin			X	X		X					X				Tree branches	Insects
Pink robin	X	X												X		Insects
Rose robin		X									X				Tree branches	Insects
Hooded robin														X		Insects
Southern yellow robin		X	X	X	X	X					X				Tree branches	Insects
Grey fantail		X	X	X	X	X					X				Tree branches	Insects
Rufous fantail		X										X			Tree branches	Insects
Willie wagtail				X		X				X	X				Tree branches	Insects
Satin flycatcher		X	X									X			Tree branch	Insects
Restless flycatcher				X										X		Insects
Golden whistler		X	X	X	X						X				Shrub, small tree	Insects
Rufous whistler			X	X								X			Shrub, tree	Insects
Olive whistler	X	X	X		X							X			Tree branches	Insects
Grey shrike-thrush		X	X	X	X	X					X				Shrub, tree, ground	Insects
Shrike-tit		X	X											X		Insects
Orange-winged sittella			X											X		Insects
Black-capped sittella				X										X		Insects
White-throated tree-creeper		X	X		X							X			Hole in tree	Insects
Mistletoe bird			X											X		Insects, berries
Spotted pardalote			X	X		X					X				Hole in tree, tunnel in bank	Insects
Yellow-tipped pardalote			X	X		X								X		Insects
Eastern striated pardalote			X	X		X					X				Hole in tree, tunnel in bank	Insects
Striated pardalote			X	X		X								X		Insects
Grey-breasted silvereye			X	X	X	X					X				Shrub, small tree	Insects, fruit, berries

COMMON NAME	HABITAT 1	2	3	4	5	6	7	8	9	10	BREEDS IN STUDY AREA: YES	LIKELY	NOT LIKELY	NOT KNOWN	NEST LOCATION	FOODS
White ibis										X	X				Emergent aquatic vegetation	Variety of animals
Straw-necked ibis										X	X				Emergent aquatic vegetation	Variety of animals
Royal spoonbill										X	X				Tree branches, tall vegetation	Aquatic animals
Yellow-billed spoonbill										X	X				Tree branches, tall vegetation	Aquatic animals
Black swan								X		X	X				Ground	Aquatic animals and plants
Freckled duck										X				X		Aquatic animals and plants
Cape barren goose						X				X			X			Herbage
Mountain duck								X		X	X				Hole in tree, bank	Herbage, aquatic animals
Black duck										X	X				Ground	Herbage, aquatic animals
Grey teal										X	X				Ground, hole in tree	Aquatic animals and plants
Chestnut teal										X	X				*Ground, hole in tree*	*Aquatic animals and plants*
Blue-winged shoveler										X		X			Ground	Aquatic animals and plants
Pink-eared duck										X				X		Aquatic animals and plants
White-eyed duck										X	X				Ground, hole in tree	Molluscs
Wood duck								X		X		X			Hole in tree	Herbage
Blue-billed duck										X	X				Ground	Aquatic animals and plants
Musk duck										X	X				Ground	Aquatic animals and plants
Black-shouldered kite					X					X		X			Tree branches	Mammals, lizards, insects
Letter-winged kite					X									X		Small mammals
Whistling eagle					X	X						X			*Tree branches*	*Mammals, birds, reptiles, carrion*
Grey goshawk	X				X							X			Tree branches	Birds, mammals, insects
Australian goshawk	X			X	X							X			Tree branches	Birds
Collared sparrowhawk	X			X								X			Tree branches	Birds
Australian little eagle					X							X			Tree branches	Mammals, reptiles, carrion
Wedge-tailed eagle				X	X							X			Tree branches	Mammals, birds, reptiles, carrion
White-breasted sea-eagle						X								X		Mammals, reptiles, fish, carrion
Spotted harrier					X									X		Mammals, birds, reptiles
Swamp harrier				X		X		X		X	X				Ground	Mammals, birds, reptiles
Black falcon					X							X			Tree branches	Birds
Peregrine falcon	X		X	X		X					X				Rock ledges, hollow trees	Birds
Little falcon				X	X							X			Tree branches	Birds, insects
Nankeen kestrel				X	X	X					X				Rock crevices, tree branches	Mammals, birds, reptiles, insects
Brown hawk			X	X	X							X			Tree branches	Mammals, birds, reptiles, insects
Stubble quail					X	X					X				Ground	Seeds, insects
Brown quail					X						X				Ground	Seeds, insects
Painted quail		X										X			Ground	Seeds, insects
Little quail					X									X		Seeds, insects
Plain wanderer					X							X			Ground	Seeds, ground insects

COMMON NAME	HABITAT										BREEDS IN STUDY AREA				NEST LOCATION	FOODS
	1	2	3	4	5	6	7	8	9	10	YES	LIKELY	NOT LIKELY	NOT KNOWN		
Brolga						X				X				X		Omnivorous
Lewin water rail									X	X				X		Insects, molluscs, worms
Banded landrail										X		X			Grass tussocks	Molluscs, aquatic insects and plants
Marsh crake										X	X				Emergent aquatic vegetation	Molluscs, aquatic insects and plants
Australian spotted crake										X		X			Grass tussocks	Aquatic insects and plants
Black-tailed native hen										X				X		Grasses, aquatic animals and plants
Dusky moorhen										X	X				Tussocks, aquatic vegetation	Aquatic insects and plants
Swamphen									X	X	X				Tussocks, aquatic vegetation	Molluscs, grass, aquatic plants
Coot										X	X				Emergent aquatic vegetation	Aquatic animals and plants
Pied oystercatcher							X				X				Ground	Molluscs, crustaceans
Sooty oystercatcher							X				X				Ground	Molluscs, crustaceans
Spar-winged plover						X	X		X	X	X				Ground	Insects, herbage, crustaceans
Banded plover						X				X	X				Ground	Insects, seeds
Pied-kneed dotterel										X				X		Aquatic insects, seeds
Hooded dotterel							X				X				Ground	Aquatic insects
Red-capped dotterel							X			X	X				Ground	Aquatic insects and crustaceans
Double-banded dotterel							X			X			X			Aquatic animals
Black-fronted dotterel							X			X	X				Ground	Aquatic insects, crustaceans
Eastern golden plover							X						X			Aquatic animals
Grey plover							X						X			Aquatic animals
Turnstone							X						X			Aquatic animals
Japanese snipe							X			X			X			Aquatic insects, worms
Whimbrel							X						X			Aquatic animals
Eastern curlew							X			X			X			Aquatic animals
Greenshank										X			X			Aquatic animals
Common sandpiper							X						X			Aquatic animals
Grey-tailed tattler							X						X			Aquatic animals
Knot							X						X			Aquatic animals
Sharp-tailed sandpiper							X			X			X			Aquatic animals
Pectoral sandpiper							X			X			X			Aquatic animals
Pied-necked stint							X			X			X			Aquatic animals
Curlew sandpiper							X			X			X			Aquatic animals
Sanderling							X						X			Aquatic animals
Bar-tailed godwit							X						X			Aquatic animals
White-headed stilt										X	X				Ground	Aquatic animals and plants
Banded stilt										X				X		Aquatic crustaceans
Avocet										X				X		Aquatic animals and plants

COMMON NAME	HABITAT 1	2	3	4	5	6	7	8	9	10	BREEDS IN STUDY AREA YES	LIKELY	NOT LIKELY	NOT KNOWN	NEST LOCATION	FOODS
Southern skua								X					X			Variety of animals
Arctic skua								X					X			Variety of animals
Pacific gull								X					X			Variety of animals and carrion
Silver gull							X	X	X	X	X				Ground	Aquatic animals, garbage
Whiskered tern							X	X		X	X				Floats on water	Fish, aquatic insects
Caspian tern										X	X				Ground	Fish
Gull-billed tern										X				X		Fish, insects, reptiles
White-fronted tern							X	X					X			Fish
Fairy tern								X						X		Fish
Crested tern							X	X			X				Ground	Fish
Domestic pigeon						X						X			Hole in tree, building cliff	Seeds, cereals
Spotted turtle dove						X								X		Seeds, insects
Common bronzewing					X							X			Shrub, low tree	Seeds, berries
Bush bronzewing					X						X				Shrub, low tree, ground	Seeds, berries
Rainbow lorikeet				X	X									X		Nectar, flowers, fruit
Musk lorikeet			X	X										X		Nectar, fruit, berries
Purple-crowned lorikeet			X	X										X		Nectar, fruit, berries
Little lorikeet				X										X		Nectar, fruit, berries
Swift parrot			X	X										X		Nectar, flowers
Yellow-tailed & black cockatoo		X	X									X			Hole in tree	Seeds, insects
Gang gang cockatoo		X	X		X							X			Hole in tree	Seeds
Sulphur-crested cockatoo		X	X	X		X						X			Hole in tree	Seeds, roots
Long-billed corella						X					X				Hole in tree, bank	Seeds, roots
Galah						X						X			Hole in tree	Seeds
King parrot					X							X			Hole in tree	Seeds, fruits, berries
Crimson rosella		X	X		X	X						X			Hole in tree	Seeds, fruit, berries
Eastern rosella				X							X				Hole in tree	Seeds, berries
Red-rumped parrot				X								X			Hole in tree	Seeds
Elegant parrot				X		X								X		Seeds
Blue-winged parrot				X	X	X						X			Hole in tree, stump	Seeds
Orange-bellied parrot							X							X		Seeds
Budgerygah				X		X					X				Hole in tree	Seeds
Ground parrot					X							X			Ground	Seeds
Pallid cuckoo				X		X						X			Parastic	Insects
Fan-tailed cuckoo			X	X		X								X		Insects
Horsfield bronze cuckoo			X	X		X								X		Insects
Garden bronze cuckoo				X										X		Insects

COMMON NAME	HABITAT 1	2	3	4	5	6	7	8	9	10	BREEDS IN STUDY AREA: YES	LIKELY	NOT LIKELY	NOT KNOWN	NEST LOCATION	FOODS
Crested penguin							X	X					X			Cephalopods, crustaceans
Little penguin							X	X			X				Ground and burrows	Fish, cephalopods
Wandering albatross								X					X			Cephalopods
Black-browed albatross								X					X			Fish, crustaceans
White-capped albatross								X					X			Fish, crustaceans
Giant petrel								X					X			Fish, cephalopods
Cape petrel								X					X			Fish, crustaceans
Medium-billed prion								X					X			Crustaceans
Dove prion								X					X			Cephalopods, crustaceans
Thin-billed prion								X					X			Cephalopods, crustaceans
Fairy prion							X	X			X				Burrows and under rocks	Crustaceans
Grey petrel								X					X			Fish, cephalopods
Short-tailed shearwater							X	X			X				Burrows	Fish, crustaceans
Fluttering shearwater								X					X			Fish, crustaceans
White-faced storm petrel								X					X			Crustaceans
Diving petrel							X	X			X				Burrows	Crustaceans
Australian pelican										X	X				Ground	Fish, crustaceans
Australian gannet								X					X			Fish
Darter										X				X		Fish
Black cormorant										X	X				Rock ledges, tree branches	Fish, crustaceans
Little black cormorant								X		X	X				Tree branches	Fish, crustaceans
Pied cormorant								X						X		Aquatic animals
Little pied cormorant										X	X				Tree branches	Fish, crustaceans
Black-faced cormorant							X	X			X				Rock ledges	Fish
Little grebe										X		X			Floats on water	Aquatic animals and plants
Hoary-headed grebe										X	X				Floats on water	Aquatic animals and plants
Great-crested grebe										X	X				Floats on water	Aquatic animals and plants
White-necked heron										X		X			Tree branches	Variety of animals
White-faced heron									X	X	X				Tree branches	Variety of animals
Cattle egret										X			X			Insects, aquatic animals
White egret									X	X				X		Aquatic animals
Little egret										X				X		Aquatic animals
Plumed egret										X				X		Aquatic animals
Nankeen night heron										X	X				Tree branches	Aquatic animals
Brown bittern									X	X	X				Emergent aquatic vegetation	Aquatic animals

B. MAMMAL ABUNDANCE, DISTRIBUTION, FOOD, HOME RANGE, NEST SITES, AND SPECIMENS COLLECTED

Tachyglossus aculeatus (echidna)

Abundance & distribution: Although not commonly observed, this species is apparently fairly widespread and common. Most documented observations are from the larger southern blocks of Crown land.

Habitat preference: Echidnas occur in all major terrestrial habitat types with the possible exception of intensive and extensive farming areas. Ants and termites form the bulk of their diet, and wherever these are found echidnas can be expected. Echidnas often travel long distances in search of food, but if food is plentiful they tend to be rather sedentary.

Most recent specimen: 1967 (NMV. C7601); observed in 1974 FWD surveys.

Ornithorhynchus anatinus (platypus)

Abundance & distribution: Platypuses are probably common and widespread in southern districts, although there are few documented records.

Habitat preference: The platypus requires water all year round, preferably streams and "fresh-water" lakes with muddy substrates. River and lake margins must have friable soils for the construction of burrows. The close proximity of burrows to the ground surface, usually less than 0.3 metres and occasionally as little as 0.1 metres of less, renders them particularly susceptible to being caved in, particularly when heavy animals such as cattle are allowed to graze close to the water's edge.

Most recent specimen: Recorded in 1974 FWD surveys.

Dasyurus maculatus (tiger cat)

Abundance & distribution: This species is uncommon and rarely observed. It is apparently restricted to the southern and central public land areas of the Otway Range and Cape Otway, although some specimens are recorded from the study area adjacent to Mount Eccles in the extreme west. East Gippsland and the Otway Range constitute the two areas considered vital for the conservation of this species in Victoria.

Habitat preference: No obvious habitat preferences have been determined. It is a carnivorous species and is unlikely to be restricted by lack of food, particularly in an area as rich in small animal life as the Otway Range. Throughout most of its range in the study area, conditions are wet and the vegetation is dense. Their stronghold is thought to be the mountain ash forests of the central Otway Range. Most recent specimen: 1973 (FWD. 9029).

Dasyurus viverrinus (quoll)
In the early part of this century quolls were common throughout most of Victoria. In the 1930s David Fleay caught several animals in the stony rises near Lake Corangamite and at that time considered them far more common than their larger relative, the tiger cat. Since the 1930s, quolls have suffered a drastic reduction in numbers throughout Victoria and the last specimen was taken near Melbourne in the 1950s. Although they are now very rare and perhaps extinct, there is a chance that they still occur in the Corangamite area.

Antechinus stuartii (brown antechinus)
Abundance & distribution: This species is common and widespread throughout the southern half of the study area, but no records exist from farmlands in the north.
Habitat preference: Woodland and forest communities are the favoured habitats of this species. It is small and insectivorous, and forages in the leaf litter and around the bases of trees. It is rarely found in coastal heaths; this habitat lacks large understorey plants and trees. The only tree community in which brown antechinus was not recorded was the manna gum forest of the stony rises near Lake Corangamite. In that area its rarity may be related to the unusual abundance of its large relative, Swainson's antechinus.
Most recent specimen: 1974 (NMV. C11645).

Anthechinus swainsonii (Swainson's antechinus)
Abundance & distribution: This species is generally uncommon, but it is widespread in southern and central areas.
Habitat preference: It is insectivorous, and characteristically forages in moist litter and humus. It is usually found in the wetter plant communities such as mountain ash and messmate forests and heathland swamps. Dense ground cover is a consistent feature of its range. Various populations of this species in the Corangamite area exhibit a high degree of morphological variability. Large dark animals inhabit wet open forests of the central Otway Range but the species is smaller and a lighter shade of brown in the woodlands of the stony rises.
Most recent specimen: 1974 (NMV. C11620).

Antechinus minimus (swamp antechinus)
Abundance & distribution: In 1963, the recorded distribution of this mammal on the Australian mainland was only one locality in Victoria and a few in South Australia.

Its recorded distribution has since been extended and now includes five separate Victorian localities on the western side of Cape Otway. It is probably common, but its distribution is restricted to a coastal strip that probably extends along the entire Corangamite study area.
Habitat preference: Swamp antechinus are only found along the coastal scarp. They inhabit tussock grasslands on sand dunes, and shrubs and grasses that grow on the cliffs and coastal escarpments. Its preference for this type of habitat is specific. It has not been recorded in any other type on the Australian mainland.
Most recent specimen: 1974 (FWD. 9836).

Sminthopsis crassicuadata (fat-tailed dunnart)
Abundance & distribution: This species is uncommon but widespread throughout the northern and central plains.
Habitat preference: Grassland and grassy woodland are the two major vegetation forms occupied. In the study area these forms are only represented on farmland. The fat-tailed dunnart is suited to farmland conditions and apparently survives as long as some rocks or logs are left lying about for use as shelter.
Most recent specimen: 1969 (NMV. C9082).

Sminthopsis leucopus (white-footed dunnart)
Abundance & distribution: This species is uncommon and has an unusual distribution that is essentially coastal but intrudes inland to the north of, but not including, the Otway Range.
Habitat preference: It has been recorded from a variety of areas, but all have a vegetation type that includes a heath-like ground cover, often on sandy soils. These vegetation types range from the low coastal heath such as at Moonlight Head to the inland open forests like those found in the Jancourt State Forest. White-footed dunnarts have not been found in the dense wet open forest II of the central Otway Range.
Most recent specimen: 1974 (NMV. C11646).

Isoodon obesulus (short-nosed bandicoot)
Abundance & distribution: This species is common and fairly widespread in the southern half of the study area. It has a distribution similar to but slightly more extensive than that of the white-footed dunnart.
Habitat preference: Most vegetation types occupied by short-nosed bandicoots have a heath-like shrub cover. The habitat is similar to that described for the white-footed dunnart and includes coastal heath and both coastal and inland heath woodlands. This species is generally not found in dry open forest II or wet open

forest II typified by the vegetation of the central Otway Range.
Most recent specimen: 1974 (FWD. 9525).

Perameles nasuta (long-nosed bandicoot)
Abundance & distribution: This species is uncommon but fairly widespread in southern districts. Its distribution includes the Otway Range, Jancourt Forest, and Ecklin South. The Victorian distribution of this species is divided into two areas: the larger includes the eastern highlands and East Gippsland, but the other is almost totally within the Corangamite study area.
Habitat preference: The long-nosed bandicoot is generally associated with wet open forest II of the type found in the central Otway Range. It also occurs in moist, heathy forests of south-western districts, where it is sympatric with the short-nosed bandicoot. It is difficult to pinpoint specific habitat requirements for the species.
Most recent specimen: 1974 (NMV. C11657).

Perameles gunnii (Gunn's bandicoot)
Abundance & distribution: This species is rare and at present is restricted to the western extremeties of the study area. Its Victorian distribution is now restricted to a relatively small area centred on Hamilton, although historical records show that it once occurred throughout the western plains.
Habitat preference: Gunn's bandicoot occurs in open grassland and grassy woodland. These conditions are now only represented in farmland and roadside reserves. If the species is to survive in Victoria, co-operation by townspeople in Hamilton and relevant landholders in western Victoria must be obtained.
Most recent specimen: 1961 (NMV. C3032).

Macropus giganteus (eastern grey kangaroo)
Abundance & distribution: This species is common and widespread, particularly in southern and central districts. Hunting pressures are probably responsible for removing eastern grey kangaroos from the small isolated areas of bush remaining in northern areas.
Habitat preference: They are generally associated with open forms of vegetation such as grassland, grassy woodland, and heathy woodland and dry open forest II. They are usually not found in the wet open forest II of the central Otway Range.
Most recent specimen: 1973 (FWD. 8664). Observed in 1974 FWD surveys.

Macropus rufogriseus (red-necked wallaby)
Abundance & distribution: This species is uncommon but reasonably widespread in

southern districts. Observations are recorded for Grey River, Barwon Downs, Moonlight Head, and Forrest.
Habitat preference: Red-necked wallabies are found in heathy woodland and some dry open forest II, both along the coastal fringe and inland to the north of the Otway Range. They do not occur in the wet open forests of the central Otway Range. This species is not well known in Victoria and precise habitat preferences have as yet not been determined.
Most recent specimen: No specimens have been collected. They were observed in 1974 FWD surveys.

Wallabia bicolor (black wallaby: swamp wallaby)
Abundance & distribution: This species is common and widespread throughout much of the study area. It does not occur in the north-west.
Habitat preference: Nearly all vegetation that contains shrubs supports black wallabies. They occur throughout the major areas of native vegetation in the study area. Open farmland and grassy woodland are the only vegetation types in which they were not found. In dense heath and heathy woodland, they coexist with red-necked wallabies.
Most recent specimen: 1973 (FWD. 7921). Observed in 1974 FWD surveys.

Potorous tridactylus (potoroo)
Abundance & distribution: This species is uncommon but widespread in the southern half of the study area.
Habitat preference: Potoroos' habitat has a dense heath or heath-like shrub understorey cover. Coastal heathy woodland, and inland, moist, heathy forests all contain populations. The ecology of potoroos is currently the subject of a research project being carried out at Naringal by Mr. J. Seebeck of the FWD.
Most recent specimen: 1973 (FWD 9082). Recorded in 1974 FWD surveys.

Vombatus ursinus (wombat)
There has been no conclusive evidence to show that wombats still occur in the study area. Historical records show that they once had a wide range through the northern and central plains, but do not indicate that they occurred in the apparently ideal conditions of the central Otway Range. The last specimen collected was in 1912 at Port Fairy.

Phascolarctos cinereus (koala)
Abundance & distribution: This species is uncommon and restricted. As far as is known, the koalas now resident in the Corangamite area originate from the release

of 1,029 animals over a period between 1945 and 1973. They were released at two localities: in the stony rises near Pomborneit, and the Grey River in the Otway Range. These two localities are still the focal points of the koala distribution in the study area.
Habitat preference: This species in southern Victoria is normally restricted to particular low woodlands because of its dietary needs. In the Corangamite area low woodlands of manna gum were once extensive to the north of the Otway Range and at Cape Otway. Other suitable feed trees form a major proportion of the woodlands and forests. This may lead to the koala's range eventually extending throughout the area.
Most recent specimen: 1962 (FWD. K150).

Trichosurus vulpecula (brush-tailed possum)
Abundance & distribution: This species is common and probably the most widespread mammal (excluding bats) found in the study area. It occurs in all areas.
Habitat preference This possum is usually found in woodland and forest, although it has become adapted to living in farm areas and along roadside reserves. It does not occur in the wet open forests of the central Otway Range or the dry open forest and woodlands.
Most recent specimen: 1973 (FWD 9009).

Pseudocheirus peregrinus (common ring-tailed possum)
Abundance & distribution: This species is common and widespread in the southern half of the study area.
Habitat preference: This possum is usually found in vegetation that has a dense overlapping canopy cover like the coastal messmate forests and/or a dense, tall shrub understorey such as that which occurs in the wet open forest II. These conditions are common in most of the woodlands and forests in the study area. The exceptions are grassy woodland and those forests in the stony rises near Lake Corangamite.
Most recent specimen: 1972 (FWD 8417). Recorded in 1974 FWD surveys.

Petaurus breviceps (sugar glider)
Abundance & distribution: Sugar gliders are uncommon but widespread in the southern half of the study area.
Habitat preference: This species is probably found throughout all woodlands and forests. It appears to attain maximum population density in the drier woodland areas like those on the foothills of the Otway Range.
Most recent specimen: 1973 (NMV. C11468). Recorded in 1974 FWD surveys.

Petaurus australis (yellow-bellied glider)
Abundance & distribution: This species is fairly rare and restricted. All documented records for the study area are from the tip of Cape Otway.
Habitat preference: This glider has an unusual distribution and its habitat requirements are difficult to define. Where it occurs elsewhere in Victoria, it is largely found in coastal areas and prefers wet open forest II of manna gum, southern blue gum, and messmate, but tends to avoid the tall mountain ash forests. It is wide-ranging, and large areas are probably necessary to ensure its survival.
Most recent specimen: 1964 (NMV. C5777). Recorded in 1974 FWD surveys.

Acrobates pygmaeus (feather-tailed glider)
Abundance & distribution: This species is probably fairly common and widespread in southern and central districts.
Habitat preference: It inhabits all native woodland and forest communities.
Most recent specimen: 1968 (NMV. C7931).

Cercartetus nanus (eastern pygmy possum)
Its status in the study area is uncertain. No specimens exist in either the National Museum or the Fisheries and Wildlife Division collections and there are no documented sightings. There is a report that a specimen was caught and filmed on a property at Naringal East. The difficulty in determining the extent of distribution prevents meaningful discussion of its habitat preferences in the study area.

Lepus europaeus (hare)
Abundance & distribution: Hares are common and widespread in northern districts.
Habitat preference: It is only found in grassland on the northern basalt plains and requires patches of dense grass for breeding.
Most recent specimen: None recorded.

Oryctolagus cuniculus (rabbit)
Abundance & distribution: This species is common and widespread.
Habitat preference: All habitats, with the exception of the aquatic and the undisturbed wet open forests, are occupied. Disused farmland and savannah woodland provide the most ideal conditions for rabbits.
Most recent specimen: Observed in 1974 FWD surveys.

Rattus fuscipes (bush rat)
Abundance & distribution: This species is common and widespread through southern and central districts. It is the most common ground mammal in the study area.

Habitat preference: Bush rats are found throughout the woodland and forests of the study area. The only areas in which they were not found were low heaths, burned heaths, and coastal grassland. Their habitat re-requisite appears to be a moist, well-developed shrub layer beneath dominant trees or tall shrubs.
Most recent specimen: 1974 (NMV. C11633).

Rattus rattus (black rat)
Abundance & distribution: This is a European species that has been introduced to Australia. In the study area it is uncommon and restricted.
Habitat preference: The black rat shows a distinct preference for the detritus left by human habitation and is never found far from towns, farms, or rubbish tips.
Most recent specimen: 1967 (NMV. C7339.)

Rattus lutreolus (swamp rat)
Abundance & distribution: This species is common and reasonably widespread in the southern half of the study area.
Habitat preference: Swamp rats inhabit all the different forms of heath and the grasslands along the coast of the study area. The heath forms vary, from low open heath like that found at Moonlight Head to the tall dense heaths found beneath messmate forest in the Jancourt Forest area.
Most recent specimen: 1974 (FWD. 9521).

Rattus norvegicus (sewer rat)
Abundance & distribution: This species is probably uncommon and restricted. It is not represented by specimens actually taken in the study area, but it almost certainly does occur in some parts.
Habitat preference: This rat is usually restricted to towns and water-courses.

Pseudomys fumeus (smokey mouse)
This species is represented by two specimens, which were collected at Turton's Pass and Beech Forest in 1933 and 1937 respectively. The 1933 record was the first known, and constitutes the type specimen of the species. Turton's Pass is thus the type locality. No other specimens have been collected from the Corangamite study area, although the species has been recorded in several other localities throughout the State. The smokey mouse is one of Victoria's two endemic mammals.

Mus musculus (house mouse)
Abundance & distribution: House mice are locally common and fairly widespread, particularly in the northern section. This species was introduced from Europe.

Habitat preference: Farmland and townships are the favoured areas, although house-mice do occur in some natural bushland. Grassy forest and woodland such as at the stony rises are suitable. Overgrown farmland, disturbed roadside fringes, or human detritus in any vegetation area are sufficient to enable a population to exist.
Most recent specimen: 1974 (FWD 9517).

Mastacomys fuscus (broad-toothed rat)
Abundance & distribution: This species is rare and its distribution is restricted to the central Otway Range and Cape Otway.
Habitat preference: It is difficult to define its precise habitat requirements. It occurs in a wide range of vegetation types, including mountain ash forest, the moist, fern gullies in the dry open forest II, low heaths along the coast, and the tussock grasses and low shrubs on the coastal scarp. The Otways population is isolated from its main area of distribution, which is in the eastern highlands, and a separate sub-species has been established to describe it.
Most recent specimen: 1974 (NMV. C11656).

Hydromys chrysogaster (eastern water rat)
Abundance & distribution: This species is locally common and widespread.
Habitat preference: It is a semi-aquatic species and lives in sheltered coastal areas, estuaries, rivers, and mountain streams. There are no documented records from the inland saline lakes in the study area.
Most recent specimen: 1973 (FWD. 9103).

Vulpes vulpes (fox)
Abundance & distribution: Foxes are common and widespread.
Habitat preference: All major terrestrial habitats are occupied. Foxes are most common on farmland.
Most recent specimen: Observed in 1974 FWD surveys.

Felis catus (cat)
Abundance & distribution: Feral cats are common and widespread in most areas.
Habitat preference: All major terrestrial habitats are occupied.
Most recent specimen: Observed in 1974 FWD surveys.

Arctocephalus pusillus (Australian fur seal)
This species is common and widespread in offshore waters along the entire Corangamite coastline. A total population of about 5,000 individuals breeds on Lady Julia Percy Island, which is off Port Fairy.

Chiroptera (bats)

The ten bat species listed probably occur in the Corangamite area, but several others may be recorded in the future. One of the ten, the grey-headed fruit bat, is a large fruit-eating species that occasionally visits the southern parts of Victoria in autumn. It is not a resident, and the area as a whole probably has little significance for its long-term survival.

The other nine bats are small insectivorous species that are probably resident throughout most of the year, although some, like the bent-winged bat, undergo limited latitudinal migrations. The small bats can be divided into two broad categories according to their roosting habits. One species, the bent-winged bat, is exclusively a cave-dwelling animal, which roosts in large colonies. There is one notable bat cave in the study area at Port Fairy. The other eight primarily roost in hollows of trees, although some, like the little bat, also roost in caves.

Little is known of the biology of the small bat species and it is difficult even to give generalizations on habitat preferences. The common species, such as little bats, Gould's wattle bats, and lesser long-eared bats, appear to be widely spread through all woodland and forest communities. White-striped bats have been recorded in a variety of woodland and forest types. Of the other species, we can only say that they probably occur in the area but under what conditions is not known.

C. REPTILE ABUNDANCE, DISTRIBUTION, ACTIVITY, HOME RANGE, AND SPECIMENS COLLECTED

Amphibolurus barbatus (bearded dragon)
Zoogeographic affinity: Eyrean and warm temperate Bassian.
Abundance & distribution: The only documented record is of a specimen 7.2 km west of Port Fairy, which is on the western limit of the study area. Probably uncommon and restricted.
Activity: Diurnal, heliothermic, and an egg-layer.
Habitat: Near Port Fairy; habitat for this species is grass on sand dunes.
Last specimen recorded: Observed 1966 (P. A. Rawlinson).

Amphibolurus muricatus (tree dragon)
Zoogeographic affinity: Warm temperate Bassian.
Abundance & distribution: Uncommon but probably widespread.
Activity: Diurnal, heliothermic and an egg layer.
Habitat: Always associated with trees and usually with an open habitat such as grassy woodland or open heathy woodland.
Last specimen recorded: 1923 (NMV D 1522).

Phyllodactylus marmoratus (marbled gecko)
Zoogeographic affinity: Eyrean and warm temperate Bassian.
Abundance & distribution: Rare but probably widespread in the north-eastern plains.
Activity: Nocturnal, thigmothermic, and an egg-layer.
Habitat: Usually found under the bark of large trees or in logs and rubble in grassy woodland or grassland on the volcanic plains.
Last specimen recorded: 1907 (NMV D1619).

Delma impar (spinifex lizard)
Zoogeographic affinity: Eyrean and warm temperate Bassian.
Abundance & distribution: Rare but widespread through the northern volcanic plains.
Activity: Nocturnal, thigmothermic, and an egg-layer.
Habitat: It occurs in the grasslands of the volcanic plains but it requires adequate shelter such as logs and rocks.
Last specimen recorded: 1963 (NMV D15441).

Anotis maccoyi (McCoy's skink)
Zoogeographic affinity: Cool temperate Bassian.
Abundance & distribution: Common but restricted to the central Otway Range.
Activity: Diurnal, thigmothermic, and developed young hatch soon after eggs are layed (ovoviviparous).
Habitat: Restricted to wet open forest II and some of the moist forms of dry open forest. It forages deep in moist litter.
Last specimen recorded: 1970 (NMV D17572).

Leiolopisma entrecasteauxi (grass skink)
Zoogeographic affinity: Cool temperate Bassian.
Abundance & distribution: Common and widespread.
Activity: Diurnal, heliothermic, and bears live young.
Habitat: Essentially a grassland species in the study area, it has been recorded in grassland on the volcanic plains and the coastal tussock grasslands and shrublands.
Last specimen recorded: 1970 (NMV D33290).

Leiolopisma guichenoti (garden skink)
Zoogeographic affinity: Warm temperate and cool temperate Bassian.
Abundance & distribution: Common and widespread.
Activity: Diurnal, heliothermic, and an egg-layer.
Habitat: It occupies most forest and woodland communities, although in dense vegetation (such as wet forests) where sunlight penetration is too low, it is restricted to clearings. They inhabit areas where logs and litter are plentiful.
Last specimen recorded: 1973 (NMV D33393).

Leiolopisma mustelina (weasel skink)
Zoogeographic affinity: Warm temperate and cool temperate Bassian.
Abundance & distribution: Uncommon and restricted to the central Otway Range.
Activity: Diurnal, thigmothermic, and an egg-layer.
Habitat: Restricted to the bark and rubble of wet open forests.
Last specimen recorded: 1970 (NMV D17570).

Leiolopisma trilineata (three lined skink)
Zoogeographic affinity: Warm temperate and cool temperate Bassian.
Abundance & distribution: Uncommon but widespread.
Activity: Diurnal, heliothermic, and an egg-layer.
Habitat: Grassland such as on the volcanic plains and around coastal fringes.
Last specimen recorded: 1973 (NMV C33391).

Leiolopisma sp. nov. (formerly referred to as *L. weeksae*)
Zoogeographic affinity: Cool temperate and cold temperate Bassian.
Abundance & distribution: Common but restricted to the central Otway Range.
Activity: Diurnal, heliothermic and bears live young.
Habitat: This species inhabits open areas of wet open forest II and is a marginal inhabitant of dry open forest II.
Last specimen recorded: 1971 (NMV D18022)

Lerista bougainvillii (Bougainville's skink)
Zoogeographic affinity: Eyrean and warm temperate Bassian.
Abundance & distribution: Rare but possibly widespread in northern districts.
Activity: Diurnal, thigmothermic, and bears live young.
Habitat: This species inhabits areas with loose well-drained soil, It occurs in grasslands on the volcanic plains and in woodlands on the stony rises.
Last specimen recorded: 1970 (NMV D14777).

Pseudomoia spenceri (Spencer's skink)
Zoogeographic affinity: Cool temperate and cold temperate Bassian.
Abundance & distribution: Uncommon and restricted to the central Otway Range.
Activity: Diurnal, heliothermic, and bears live young.
Habitat: This species inhabits wet open forest II and some types of dry open forest II. It utilizes tall dead trees and fallen logs.
Last specimen recorded: 1971 (NMV D18021).

Sphenomorphus tympanum (water skink)
Zoogeographic affinity: Cool temperate and cold temperate Bassian.
Abundance & distribution: Common and widespread in the southern half of the study area.
Activity: Diurnal, heliothermic, and bears live young.
Habitat: This species is generally associated with water although need not always be near to water. It usually occurs in clearings near streams in both wet and dry open forest II.
Last specimen recorded: 1969 (NMV D36309).

Egernia luctuosa (mourning skink)
Zoogeographic affinity: Warm temperate Bassian.
Abundance & distribution: Uncommon but widespread.
Activity: Diurnal, heliothermic, and bears live young.
Habitat: This species is generally associated with open habitats such as heath,

coastal scrub, and the grasslands on the volcanic plains. It often shelters under rocks.

Tiliqua nigrolutea (southern blue tongue)
Zoogeographic affinity: Cool temperate Bassian.
Abundance & distribution: Very common and widespread in southern districts.
Activity: Diurnal, heliothermic, and bears live young.
Habitat: Virtually all forests, woodland, heaths, and coast scrubs. The species is not found in very dense wet open forest II or wet closed forest.
Last specimen recorded: 1972 (NMV D17809).

Tiliqua scincoides (common blue tongue)
Zoogeographic affinity: Eyrean and warm temperate Bassian.
Abundance & distribution: Common and widespread in northern districts.
Activity: Diurnal, heliothermic, and bears live young.
Habitat: Complements the habitats of *T. nigrolutea*. Grassland and grassy woodland of the volcanic plains are the chief habitats.
Last specimen recorded: None in collections.

Austrelaps superba (copperhead)
Zoogeographic affinity: Cool temperate Bassian.
Abundance & distribution: Uncommon but widespread in southern districts.
Activity: Diurnal, heliothermic, and bears live young.
Habitat: Most moist vegetation types. This snake occurs in wet open forest II, some forms of dry open forest II, heathlands, and swamps. It is common near swamps and in clearings associated with dense, wet open forest II.
Last specimen recorded: 1969 (NMV D33068).

Notechis scutatus (tiger snake)
Zoogeographic affinity: Warm temperate and cool temperate Bassian.
Abundance & distribution: Common and widespread in most districts.
Activity: Diurnal, heliothermic, and bears live young.
Habitat: All habitat types. The species is particularly common near swamps, in rocky areas like the stony rises, and in forest clearings.
Last specimen recorded: 1968 (NMV D13456).

Pseudonaja textilis (brown snake)
Zoogeographic affinity: Eyrean and warm temperate Bassian.
Abundance & distribution: No brown snakes have been recorded from the area but

they occur in some northern districts, particularly on the volcanic plains.
Activity: Diurnal, heliothermic, and an egg-layer.
Habitat: Either grassland or savannah woodland.
Last specimen recorded: None recorded.

Suta flagellum (little whip snake)
Zoogeographic affinity: Warm temperate Bassian.
Distribution & abundance: Uncommon and restricted to northern districts.
Activity: Nocturnal, thigmothermic, and bears live young.
Habitat: Grasslands on the volcanic plains. The species require shelter under logs or rocks.
Last specimen recorded: 1964 (NMV D15984).

Aprasia striolata (pretty snake lizard)
Zoogeographic affinity: Eyrean and Warm temperate Bassian.
Distribution and abundance: Rare and restricted. There is only one record from the area, at Penshurst in the extreme north-west.
Activity: Thigmothermic and an egg layer.
Habitat: This species burrows through litter and friable soils in dry hot environments.
Last specimen recorded: 1974 (NMV 41619).

Egernia whitii. (White's skink)
Zoogeographic affinity: Warm temperate Bassian.
Distribution and abundance: Uncommon but widespread.
Activity: Diurnal, heliothermic and bears live young.
Habitat: This species is generally associated with open habitats such as heath, coastal scrub and the grasslands on the volcanic plains. It often shelters under rocks.

D. FISHES, MOLLUSCS AND CRUSTACEANS

This appendix contains a list of inland fishes and marine commercial species including fishes, molluscs, and crustaceans.

Habitats. The numbers appearing in the columns under each of the major aquatic habitat types signify the relative importance of that type to the species, as follows:-

1 = Restricted to this habitat.

2 = Common in this habitat, but may utilize others.

3 = Utilizes this habitat, but other habitats are more suitable.

4 = Only occasionally utilizes this habitat.

A dash indicates that the species does not normally utilize this habitat. A blank space indicates that the degree of utilization of the habitat is uncertain.

Information on each species percentage contribution by weight to the total commercial marine catch for each port in 1972-73.was supplied by the Marine Fisheries Section, Victorian Fisheries and Wildlife Division.

		HABITAT							STATUS				TROPHIC POSITION							CONTRIBUTION TO COMMERCIAL CATCH 1972-73 % TOTAL					
			STREAMS			LAKES				Actual or potential fishery															
COMMON NAME	SCIENTIFIC NAME	Marine	Mountain streams	Lowland streams	Estuary	(< 5%) Fresh	Saline (5-25%)	Saline (25-50%)	Introduced	Commercial	Amateur	Undesirable	Herbivore	1st order carnivore	2nd & higher order carnivore	Omnivore	Detritivore	Parasitic	Potential prey species	Anglesea	Lorne	Apollo Bay	Pt. Campbell	Warrnambool	Port Fairy
Pouched lamprey	*Geotria australis*	2	2	2	2		-	-										X							
Short finned eel	*Anguilla australia*	2	2	2	2	2	2	-		X															
Victorian smelt	*Retropinna victoriae*	-		2	4	4	-	-					X						X						
Dwarf galaxias	*Brachygalaxias pusillus*	-	-	2	-	-	-	-											X						
Common galaxias	*Galaxias maculatus*	2	-	3	2	2	3	3						X					X						
Spotted mountain galaxias	*Galaxias truttaceus*	-	-	3	2	-	-	-						X					X						
Cox's mountain galaxias	*Galaxias coxii*	-	2	4	-	4	-	-						X					X						
Ornate mountain galaxias	*Galaxias olidus*	-	2	4	-	-	-	-						X					X						
Grayling	*Prototroctes maraena*	3	2	2	4		-	-			X			X											
Yelloweye mullet	*Aldrichetta forsteri*	3	-	3	2	-	-	-		X	X					X	X								
Estuary perch	*Percalates colonorum*	-	-	4	2	-	-	-			X			X	X										
Yarra pigmy perch	*Edelia obscura*	-		2	-	4	-	-											X						
Southern pigmy perch	*Nannoperca australia*	-	-	2	-	4	-	-											X						
Black bream	*Acanthopagrus butcheri*	3	-	-	2	-	-	-		X	X			X						-	<0.1	-	-	-	-
Red fin	*Perca fluviatilis*	-	2	3	-	2	-	-	X	X	X			X											

COMMON NAME	SCIENTIFIC NAME	HABITAT: Marine	HABITAT: STREAMS: Mountain streams	HABITAT: STREAMS: Lowland streams	HABITAT: STREAMS: Estuary	HABITAT: LAKES: (< 5%) Fresh	HABITAT: LAKES: Saline (5-25%)	HABITAT: LAKES: Saline (25-50%)	STATUS: Introduced	STATUS: Actual or potential fishery: Commercial	STATUS: Actual or potential fishery: Amateur	STATUS: Undesirable	TROPHIC POSITION: Herbivore	TROPHIC POSITION: 1st order carnivore	TROPHIC POSITION: 2nd & higher order carnivore	TROPHIC POSITION: Omnivore	TROPHIC POSITION: Detritivore	TROPHIC POSITION: Parasitic	TROPHIC POSITION: Potential prey species	CONTRIBUTION TO COMMERCIAL CATCH 1972-73 % TOTAL: Anglesea	Lorne	Apollo Bay	Pt. Campbell	Warrnambool	Port Fairy
Sea garfish	*Hemirhamphus melanochir*	2	–	–	4	–	–	–		X	X		X							2.1	–	–	–	–	–
River garfish	*Hemirhamphus ardelio*	1	–	–	–	–	–	–		X			X												
Southern rock cod	*Physiculus barbatus*	1	–	–		–	–	–		X						X				–	–	<0.1	–	–	–
Sea mullet	*Mugil cephalus*	3	–	3	2	–	–	–		X	X					X	X			–	–	<0.1	–	–	–
Red mullet	*Upeneichthys poroseus*	3	–	3	2	–	–	–	X	X						X				–	<0.1	–	–	–	–
Deep sea trevella	*Hyperoglyphe porosa*	1	–	–	–	–	–	–	X							X				–	<0.1	0.2	–	–	–
Sweep	*Scorpis aequipinnis*	1	–	–	–	–	–	–	X	X										–	–	<0.1	0.1	–	0.4
Long finned pike	*Fam Sphyraenidae*	1	–	–	–	–	–	–	X					X						–	0.6	<0.1	–	–	–
Sand flathead	*Trudis bassensis*	2	–	–	4	–	–	–	X	X				X						–	<0.1	0.1	–	–	–
Rock flathead	*Leviprora laevigata*	2	–	–	4	–	–	–	X	X			X							–	<0.1	–	–	–	–
Yellowtail kingfish	*Seriola grandis*	2	–	–	4	–	–	–	X	X				X	X					–	<0.1	–	–	–	–
Jackass fish	*Nemadactylus macropterus*	1	–	–	–	–	–	–	X											–	<0.1	–	–	0.1	–
Parrot fish	*Pseudolabrus spp.*	1	–	–		–	–	–	X	X						X	X			–	<0.1	–	–	0.1	–
Skates & Rays		1	–	–		–	–	–	X					X						–	<0.1	–	–	–	–
Leather jacket	*Fam. Aluteridae*	1	–	–	–	–	–	–	X							X				–	0.2	–	–	0.1	–
Rockling	*Genypterus blacodes*	1	–	–	–	–	–	–	X											–	<0.1	–	–	–	–
King George whiting	*Sillaginoides punctatus*	2	–	–	4	–	–	–	X	X				X						–	–	–	–	–	
Octopus	*Octopus sp.*	1	–	–		–	–	–	X											–	0.1	–	1.6	–	–
Squid	*Loligo sp.*	1	–	–		–	–	–	X											–	<0.1	–	–	–	–
Southern rocklobster	*Jasus novaehollandiae*	1	–	–		–	–	–	X							X				36	3.8	36	29	43	30
Crabs		2	–	–	4	–	–	–	X							X				–	–	–	0.2	–	<0.1
Abalone	*Notohaliotis ruber & Shismotis laevigata*	2	–	–		–	–	–	X				X							–	4.9	27	64	5.7	30

COMMON NAME	SCIENTIFIC NAME	HABITAT: Marine	STREAMS: Mountain streams	STREAMS: Lowland streams	Estuary	LAKES: (<5‰) Fresh	LAKES: Saline (5-25‰)	LAKES: Saline (25-50‰)	STATUS: Introduced	Actual or potential fishery: Commercial	Actual or potential fishery: Amateur	Undesirable	TROPHIC POSITION: Herbivore	1st order carnivore	2nd & higher order carnivore	Omnivore	Detritivore	Parasitic	Potential prey species	CONTRIBUTION TO COMMERCIAL CATCH 1972-73 % TOTAL: Anglesea	Lorne	Apollo Bay	Pt. Campbell	Warrnambool	Port Fairy
Tupong	*Pseudaphritis urvilli*	4	-	4	2		-	-			X														
Flat headed gudgeon	*Philypnodon grandiceps*	4		3	2		4	-											X						
Blue spot goby	*Ellogobius olorum*	4	-		2		-	-											X						
Blackfish	*Gadopsis marmoratus*	-	2	2	-	-	-	-			X			X											
Rainbow trout	*Salmo gairdneri*	-	2	2	3	2	2	2	X	X	X			X											
Brown trout	*Salmo trutta*	-	2	2	3	2	-	-	X		X			X											
Carp	*Carassius sp*	-	-	2	-	4	-	-	X	X		X				X									
Roach	*Leucisous rutilus*	-		2	-	4	-	-	X			X													
Tench	*Tinca tinca*	-		2	-	4	-	-	X	X					X		X								
Mosquito fish	*Gambusia affinis*	-	-	4	-	2	-	-	X			X		X					X						
Trevally	*Usacaranx georgianus*	2	-	-	4	-	-	-		X	X			X	X					-	0.2	0.2	-	-	-
Australian salmon	*Arripis trutta*	2	-	-	4	-	-	-		X	X					X				-	-	<0.1	-	-	4.4
Mulloway	*Sciaena antarctica*	3	-	-	2	-	-	-																	
Short-headed worm-eel	*Muraenichthys breviceps*	2	-	-	2	-	-	-																	
Sandy sprat	*Hyperlophus vittatus*	2	-	-	2	-	-	-											X						
Sand fish	*Gonorhynchus greyi*	2	-	-	2	-	-	-			X														
Small-mouthed Hardyhead	*Taeniomembras microstomus*	2	-	-	2	-	-	2											X						
Australian smelt	*Retropinna semoni*	-	-	2	3	2	4	-					X						X						
Lake Eyre Hardyhead	*Craterocephalus eyresii*	-	-	-	-	3	2	2											X						
Snoek (Barracouta)	*Leionura atun*	1	-	-		-	-	-		X				X	X					14	86	27	5.5	16	3.9
Snapper	*Chrysophrys auratus*	3	-	-	2	-	-	-		X	X			X	X					9.6	1.9	13	<0.1	<0.1	-
Dusky morwong	*Psilocranium nigricans*	1	-	-		-	-	-		X	X			X	X					0.2	<0.1	-	-	<0.1	-
Bastard trumpeter	*Latridopsis forsteri*	1	-	-		-	-	-		X	X			X	X					0.6	<0.1	<0.1	-	-	<0.1
Gummy shark	*Mustelus antarcticus*	2	-	-	4	-	-	-		X	X			X						36	1.3	6.1	<0.1	24	28
Saw shark	*Pristiophorus nudipinnis*	3	-	-	2	-	-	-		X				X						-	-	0.8	-	2.6	2.1
School shark	*Galeorhinus australis*																								

E. AMPHIBIAN ABUNDANCE, DISTRIBUTION, ACTIVITY, HOME RANGE, AND SPECIMENS COLLECTED

Geocrinia victoriana

Zoogeographic affinity: Southern Bassian.

Distribution: Restricted to the Otway Range in the study area.

Abundance: Locally common.

Habitat: The tadpoles prefer shallow, shaded pools. Adults have been recorded in wet open forests.

Breeding: Eggs are deposited in concealed, moist terrestrial positions that are later flooded. From the egg stage to metamorphosis takes 6--8 months.

Note: This species is restricted to highland areas in the west of the State. According to Littlejohn & Martin (1964), the isolated Otways component has diverged from other populations in some aspects of morphology and breeding behaviour.

Geocrinia laevis

Zoogeographic affinity: Southern Bassian.

Distribution: Restricted to the coastal plains in the west of the study area. In Victoria the species is restricted to small areas along the south-west coast and to the south of the Grampians.

Abundance: Common in Warrnambool block and restricted to the west of Heytesbury block.

Habitat: Heath, dry open forest II, and woodland.

Breeding: Eggs are deposited in batches in small tunnels under moist litter or grass in areas that will flood in early winter, or near margins of permanent ponds.

Limnodynastes dumerili variegatus and *L. d. insularis*

Zoogeographic affinity: Both southern Bassian.

Distribution: *L. d. variegatus* mainly occupies an area in the south-east of South Australia and in the south-west of Victoria but its range extends along the coast to the Otway Range. *L. d. insularis* occurs mainly in Tasmania and in south-eastern Victoria, but its range extends from Geelong to Lorne in western Victoria.

Abundance: *L. d. variegatus:* By blocks: Warnambool, common: Chatsworth, Corangamite, Heytesbury, and Carlisle, uncommon; Aire River and Cape Otway, common.
L. d. insularis: Uncommon.

Habitat: Temporary and permanent dams, ponds, swamps, and running waters.

Feeding: Food includes insects.

Breeding: Eggs are laid in a large foamy mass, which floats attached to emergent stems in sheltered positions.

Limnodynastes peroni
Zoogeographic affinity: Wide-ranging.
Distribution: Entire study area.
Abundance: Common.
Habitat: More-permanent dams, pools, and swamps are utilized as breeding sites.
Breeding: Eggs are laid in very large foamy masses, which float attached to emergent stems in sheltered positions.

Limnodynastes tasmaniensis (southern call race)
Zoogeographic affinity: Southern Bassian.
Distribution: Restricted to lowlands in study area.
Abundance: Common.
Habitat: Temporary and permanent waters including dams, ponds, and swamps.
Breeding: Eggs are deposited in a small frothy mass attached to emergent stems in still water. Tadpoles are free-swimming.

Litoria aurea raniformis
Zoogeographic affinity: Wide-ranging.
Distribution: Lowlands of study area.
Abundance: Uncommon.
Habitat: The adults prefer well-vegetated permanent dams, creeks, and rivers. The tadpoles prefer shaded open waters.
Breeding: Larval life spans may extend from 12 to 19 months. Larvae are free-swimming.

Litoria ewingi
Zoogeographic affinity: Southern Bassian.
Distribution: Entire study area.
Abundance: Common.
Habitat: Temporary and permanent ponds.
Feeding: Includes terrestrial insects such as beetles and larval aquatic insects.
Breeding: Clumps of eggs are wound around submerged stems.

Litoria verreauxi verreauxi
Zoogeographic affinity: Eastern Bassian.
Distribution: Restricted to the Salt Creek block and to the east end of the Coran-

gamite block in the study area. Its main stronghold in Victoria is in the south-east of the State.
Habitat: Temporary and permanent pools.
Breeding: Clumps of eggs are wound around submerged stems.

Neobatrachus pictus
Zoogeographic affinity: Eyrean.
Distribution: Warrnambool, Chatsworth, and Heytesbury blocks.
Abundance: Uncommon.
Habitat: Most temporary waters.
Breeding: Eggs are deposited in strands among submerged vegetation. Larvae are free-swimming. From the egg stage to metamorphoses takes about 4½--7 months.

Pseudophryne semimarmorata
Zoogeographic affinity: Southern Bassian.
Distribution: Extensive along the southern coastline of Victoria but avoids wetter areas like the Otway Range.
Abundance: Common.
Habitat: The tadpoles prefer shallow shaded pools.
Breeding: Eggs are laid in small tunnels under litter, in grass, or under logs in terrestrial positions that will later be flooded.

Ranidella signifera
Zoogeographic affinity: Wide-ranging.
Distribution: Entire study-area.
Abundance: Common.
Habitat: In general, temporary or permanent flowing or still waters are utilized. Larvae prefer the bottom regions of shallow waters.
Feeding: Insects including, ditperan flies, are taken.
Breeding: Eggs are in clumps, or individually and are either attached to submerged vegetation or rest on the substratum. From the egg stage to metamorposis takes 6--10 weeks.

Ranidella parinsignifera
Zoogeographic affinity: Eyrean.
Distribution: Restricted to eastern portion of the Chatsworth block.
Habitat: More-permanent flowing or still waters.
Breeding: Eggs are attached either individually or in clumps to submerged vegetation or are deposited on the substratum.

APPENDIX 7

EXPLANATION OF SOIL TERMS

Soil horizon

A layer of soil material that lies approximately parallel to the surface and differs from other layers. A profile is a vertical section through all the soil horizons and extends into the parent material.

Texture

A measure of the proportions of the constituent particles in the soil (sand, silt, clay). It is assessed in the field on moist samples of the soil and may be checked against laboratory analysis for the actual proportions present.

The texture grades may be arranged in six texture groups as follows:

1. The Sands - sand; loamy sand; clayey sand;
2. The Sandy loams - sandy loam; fine sandy loam; light sandy clay loam;
3. The Loams - loam; loam, fine sandy; silt loam; sandy clay loam;
4. The Clay loams - clay loam; fine sandy clay loam; silty clay loam;
5. The Light clays - sandy clay; silt clay; light clay; light medium clay;
6. The Medium-Heavy clays - medium clay; heavy clay.

Soil structure

Refers to the combination or arrangement of primary soil particles into secondary particles, or peds, and may be graded according to the distinctness, cohesion, stability, size, and shape of these peds (or to their absence).

Infiltration rate

The soils ability to absorb heavy rain; it depends on properties at and below the surface (surface crushing, porosity, impeding horizons) and on existing moisture status of the soil.

Available water

Refers to the amount of water that the soil can store after drainage in a form available to plants. Such stored water may prolong plant growth after losses due to evapotranspiration exceed gains from precipitation.

Air porosity

The proportion of the soil volume filled by air several hours after rain.

Carbon:nitrogen ratio

Indicates the amount of available nitrogen. Ratios of less than 12 seem to be desirable for the satisfactory growth of most crops, and pastures, but in virgin soil the ratio often exceeds 20.

The cation exchange capacity (C.E.C.)

A measure of the soils ability to hold nutrients in a form available to plants. It bears a close relation to the organic matter and clay fraction of the soil. Ions such as phosphate or calcium can be exchanged for other ions in the soil and may thus be available for plant growth.

Soil pH

Its degree of acidity (or alkalinity) - the higher the pH, the more alkaline in the soil.

Gilgaied

Refers to calcareous clay soils with a local relief of mounds and depressions.

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