Land Conservation Council Victoria

South Western Study Area

Price $2.00

REPORT

on the

SOUTH WESTERN STUDY AREA

(district 1)

Land Conservation Council, Victoria
Melbourne: August 1972

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CONTENTS

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 Shires of Glenelg and Portland 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 these submissions.

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

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

S.G.McL. DIMMICK,
Chairman

Land Conservation Council,
464 St. Kilda Road,
MELBOURNE. 3004.

LAND CONSERVATION ACT 1970

EXTRACT

Public Land

Section 2.

(1) "Public land" means -

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

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

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

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

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

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

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

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

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

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

Functions of the Council

Section 5.

(1) The Council shall -

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

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

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

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

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

(b) the conservaton 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 recommenation shall include the Council's opinion as to the best method of alienating the land to ensure the most satisfactory use and management of the land in the public interest.

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

Investigations, Notices and Reports

Section 9.

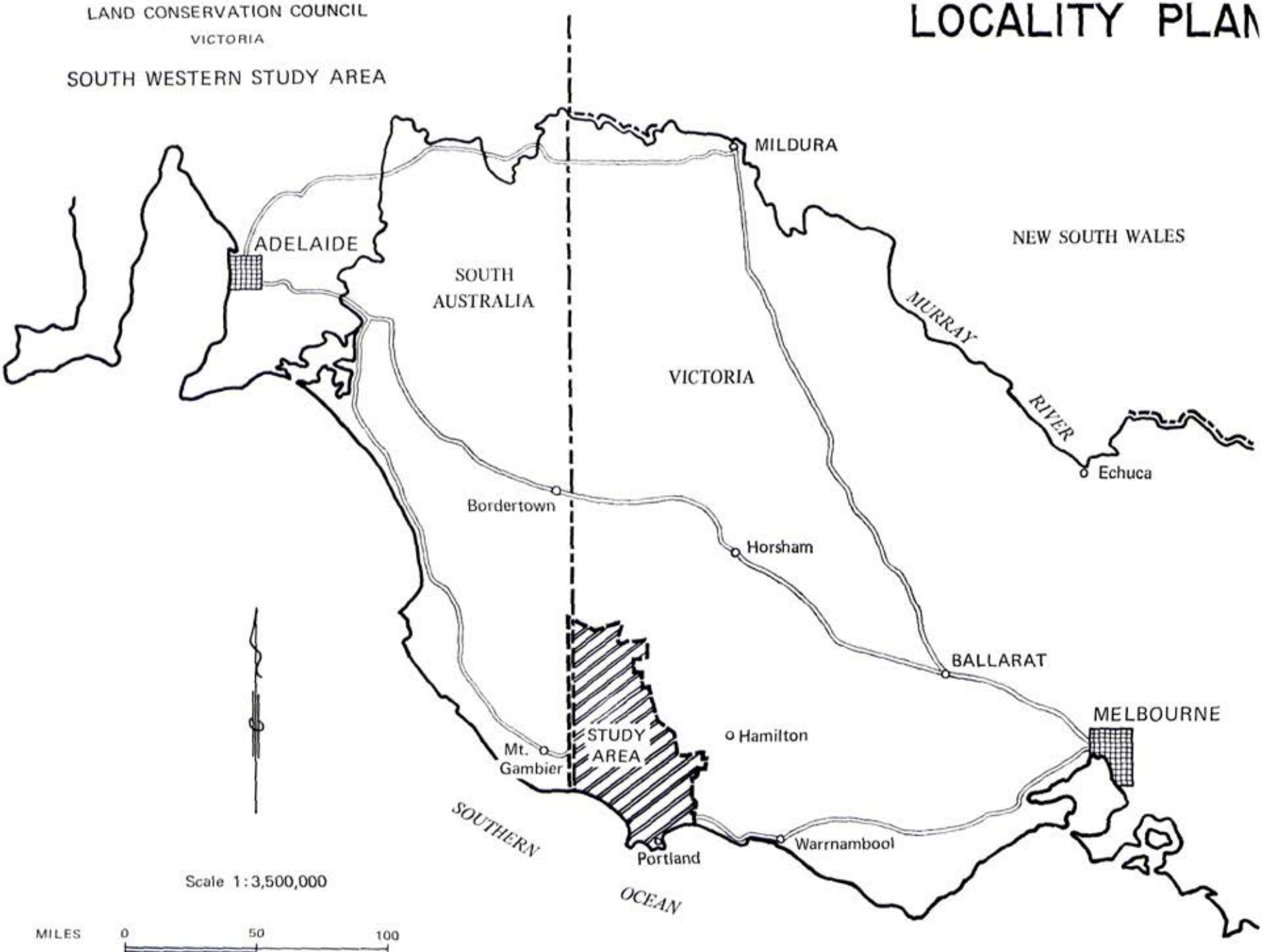
(1) The Council shall not make any recommendation under this Act in relation to any district or area without a prior investigation of the district or area.

LAND CONSERVATION COUNCIL

VICTORIA

SOUTH WESTERN STUDY AREA

LOCALITY PLAN



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(2) Before commencing any investigation under paragraph (a) of sub-section (1) of section 5 the Council shall publish a notice in the Government Gazette, in a newspaper circulating throughout the State and in a newspaper circulating particularly in or in the vicinity of the area or district to be investigated stating that an investigation of the district or area described in the notice is to be carried out for the purpose 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 insepcted and stating that any submissions to the Council in relation to such report will be considered by the Council if they are made within 60 days of such notice; and

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

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

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

Section 10.

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

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

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

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

and shall consider any 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 intention so to do to the Minister administering a government department or responsible for a public authority recommend to the Governor in Council that notice of the recommendation or that part of the recommendation that affects the government department or public authority concerned and where notice of that recommendation or part is so given by the Governor in Council it shall be the duty of the government department or public authority to use all diligence and dispatch to give effect to such recommendation so far as it affects any land vested in or controlled by it.

Copy of every Recommendation and of Proposals to be Tabled in Parliament

Section 11.

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

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

ACKNOWLEDGEMENTS

Many Government departments, organizations, and individuals assisted the Council's staff to compile this report by supplying information and photographs, checking drafts, and contributing discussion and advice.

The assistance given by the staff of the Soil Conservation Authority is gratefully acknowledged. A publication of the Authority, "A Study of the Land in South Western Victoria" by F.R. Gibbons and R.G. Downes, was a major source of information for this report.

The unpublished reports of the Glenelg Region study group of the former Land Utilization Advisory Council also provided much useful information.

The Forests Commission generously provided information and assistance, and in particular supplied most of the source material for the vegetation map. The Mines Department prepared four chapters and supplied the source material for the maps of geology and physiography.

The Department of Crown Lands & Survey prepared maps showing public land boundaries for the Council's use, and assisted the Council with the drawing of the maps in this report.

The Department of Agriculture provided much of the information for the chapter on agriculture. The State Rivers and Water Supply Commission and the National Parks Service co-operated fully with the Council's staff in the preparation of relevant parts of the report.

The following departments also assisted with the compilation of the report - the National Museum, the National Herbarium, the Ports and Harbours Division of the Public Works Department, the Fisheries and Wildlife Department, the State Electricity Commission, the Central Planning Authority, and the Department of State Development.

The assistance given by the following persons and organizations is gratefully acknowledged: Lady Bassett, Mr. D.F. Crosby, Mr. D. Mercer (Monash University), Mr. N.A. Wakefield, the Central Victorian Apiarists Association, the Mammal Survey Group, the Department of Prehistory, Australian National University, Softwood Holdings Ltd., Southern Australian Perpetual Forests Ltd.,

and field naturalists of the area.

Chapters

Mr. Frank Gibbons, Principal Research Officer, of the Soil Conservation Authority, contributed the History chapter.

Mr. P.R. Kenley, Assistant Director of Geological Survey (Technical), Mines Department, contributed the Geology, Physiography, Water Resources, and Minerals chapters, and the Hazards Affecting Groundwater section in the Hazards chapter.

Photographs

The Council is indebted to the following people who made their photographs available for the report: Mr Fred Davies, of Portland (Kentbruck Heath and Glenelg River), Mr Roy Wheeler (some of the birds of the study area), Mr Frank Gibbons (vegetation, soils, agriculture), Mr P.R. Kenley (geology and land forms), Mr Clive Crouch (mammals, reptiles), and Dr E.C.F. Bird, and Messrs I. Womersley and D. Fraser (Discovery Bay dunes, Nelson). Aerial photographs are reproduced with the permission of the Department of National Development.

PART I INTRODUCTION

AIMS AND METHODS

This report sets out to present all available information relevant to making decisions on the future use of public land in the study area.

It describes the nature of the features of the environment, and the character and distribution of the plant communities and animals of the area. It also examines the forms of land use that will make demands on public land, and attempts to assess their impact on the land. It does not contain land use recommendations for public land, but rather provides a factual basis on which land use recommendations can be formulated.

Existing information collected from published reports, government departments, public authorities, and private organizations and individuals has been supplemented by five short-term projects commissioned in fields where information was lacking. However, our knowledge of the environment, and of the interactions between land management practices and the environment, is still far from complete.

Many people who are interested in the future use of public lands may lack a technical background in some of the relevant fields. Thus, while complex issues are not avoided, non-technical language has been used as far as possible. Sections on basic principles, included in several chapters, may help to place the descriptive material in perspective and relate the various chapters to each other.

The four parts

Part I sets out the aims of the study and defines and briefly describes the study area. It discusses the philosophy of conservation of resources and gives a history of the region, including descriptions of the aboriginal inhabitants. A locality plan and a map showing the roads and towns are attached.

Part II describes the nature of the main features of the environment for the whole study area. Maps included show geology, physiography, and topography and rainfall. Another map delineates plant communities - and mammal and bird habitats are described in terms of these communities. Finally, this part considers the features of the land together and describes and maps eight distinct environments, called land zones.

Part III deals with the main forms of land use that are likely to make demands on public land. After describing the hazards that occur in the region, such as erosion, salting, and pests, it discusses any deterioriation in the condition of public lands that may occur as a result of changes of land use. Then, for each form of land use, this Part considers the present level of activity, the likely future demand, and the capability of public lands to meet these. It also assesses the capability of alienated (or privately owned) land to meet these demands. Finally, it deals with the relations between the various types of land use.

In Part IV the public land is divided into 18 blocks - based on similarities of soils, climate, and vegetation - of which a map is attached. It then describes the nature of the public land in each block, and assesses its potential for the various forms of land use. These descriptions and assessments are set in a consistent format of headings and subheadings so that the reader can readily find specific information for any block and compare it with others.

A map of public land, in the pocket at the back of the report, may be useful in preparing submissions.

Appendix I lists the common plant species of the study area, and indicates the formation or habitat in which each species is usually found.

Appendix II lists the birds and mammals of the study area and shows broad habitat type and abundance for each species.

CONSERVATION PRINCIPLES

Conservation is concerned with Man's relation to his environment. It is often said to be the wise, rational, 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 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 recognizes that a community needs land for recreational, scientific, and aesthetic purposes as well as for the production of food, timber, and minerals, or for urban and industrial use.

The Use of Resources

Two broad classes of natural resource may be distinguished:

Non-renewable or stock 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 or flow resources

The quantity of a renewable resource such as timber or wheat may increase or decrease with time. Animal and plant communities and landscape fall within this class. The balance of resource use is likely to change with time, and the definition of resources will change as technology changes.

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 advantages 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 needs of the community.

The concept of balance requires 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.

Conclusion

Outstanding natural features should be preserved.

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.

Where several land uses are compatible, land should be available for all such uses. It may be necessary to define major aims and to assess levels above which secondary uses are unacceptable.

The capacity of land to meet future changes in use in response to the needs of society or changes in technology should not be impaired. As much land as possible should be maintained as uncommitted land and managed to permit the widest possible choice of future uses.

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

Review and reassessment of land becomes necessary as society and technology change.

THE STUDY AREA

The area covered by this report consists of the land in the Shires of Portland and Glenelg. Land in the town of Portland (8,500 acres) is not within the study area. However, the future of at least the southern half of the study area is closely related to the development of Portland. The study area lies in the south-western corner of Victoria and is bounded by the Southern Ocean to the south and the border with South Australia to the west (see the Locality Plan facing page 5). The total area within the two Shires is 1.79 million acres, of which 548,000 acres is public land in substantial blocks, 1.15 million acres is agricultural land, and the remainder comprises roads, streams, townships, and private land planted with softwoods.

The study area has a subdued topography, consisting of plains and low tablelands with few hills, although tableland dissection has produced steep slopes south and east of Casterton. The public land consists of tall forests (interspersed with heaths and swamps) on fertile clay loams and moderately fertile sandy soils in the south, and low scrubby forests with some heaths on infertile sandy soils in the north.

The chief stream in the area, the Glenelg River, rises in The Grampians to the north-east and flows through to the sea at Nelson. Numerous small tributaries flow into the Glenelg - the Wannon, Crawford, and Stokes Rivers being the chief of these. The Fitzroy and Surry Rivers drain the south-eastern part of the area. West of the Glenelg River, regional drainage is very poor and swamps abound.

Population

The main townships within the study area are Casterton and Heywood, but the town of Portland and the cities of Hamilton and Mount Gambier are important regional centres serving the area. Table 1, on page 7, gives population statistics. The population of the study area declined by more than 1,100 between 1966 and 1971. The attachment of part of the Shire of Portland to the town of that name accounted for more than 300 of these, leaving a corrected decline of about 800, or 6.7%.

Although both Shires lost residents, the Shire of Glenelg showed the greater decline, losing 11.8%. In 1971 Caster-

ton township had a population of 2,175, which resembles that of the years before 1950. The population of Heywood in 1971 was 1,299 - an increase of 282 since 1966. The population of the town of Portland has shown steady growth, and it is the only municipality within the region (including adjacent areas of South Australia) that achieved a substantial increase between 1966 and 1971. Even after allowing for the gain through the annexation of part of the Shire, the town's population increased by about 17% in this period.

Towns

The towns of the region depend upon the primary industries of agriculture and forestry. The smaller centres are largely based upon retail trade and services, while the larger ones manufacture agricultural inputs and process agricultural and timber products. At Portland, facilities have been established or improved for processing meat and milk, handling wool, manufacturing fertilizer, importing petroleum, and exporting grains. All these activities are directly related to the primary industries.

Transport is particularly well developed. The Princes, Henty, and Glenelg Highways traverse the area and secondary roads and tracks provide intensive access throughout. An adequate rail system handles fertilizer, petroleum, and other imports as well as grain, livestock, and wool movements to Portland for processing and export. At present it provides daily passenger services between Portland and Melbourne. Air services are also available. The town has excellent port facilities for shipping and receiving general cargo, fertilizer materials, and bulk grain.

Development at Portland

In 1967 the Government selected Portland as one of five country centres whose development was to be assisted as part of the policy of decentralization. The Government pays the salary of a Promotion Officer, and subsidizes the activities of a Development Committee set up to attract industry and commerce to the town.

Industries prepared to operate outside Melbourne have a wide range of incentives available, aimed at removing any disadvantages they may experience compared with industries in the metropolitan area.

Portland's major asset is its deep-water port, only one hour's steaming from regular coastal shipping lanes. The town has been a minor port since it was first settled in 1834. However, since 1950 about $20 million has been spent on developing a modern harbour with tanker berths, bulk grain handling facilities, and bulk cargo berths. Development of the port is continuing. In the year to June 30, 1971, exports

Table 1

POPULATION STATISTICS 1947-71

	1947	1954	1961	1966	1971
Study area					
Shire of Portland*	6,194	7,056	6,982	6,859	6,424
Shire of Glenelg	5,288	5,949	5,887	5,838	5,148
Subtotal	11,482	13,005	12,869	12,697	11,572
Town of Portland*	3,462	4,809	6,014	6,674	8,212
	14,944	17,814	18,883	19,371	19,784
Surrounding districts					
City of Hamilton and Shires of Belfast, Dundas, Kowree, Minhamite and Wannon	22,252	28,841	27,971	28,077	25,950
Municipalities of Mount Gambier and Naracoorte, and Districts of Mount Gambier, Naracoorte, Penola, and Port McDonnell	19,380	26,116	33,276	34,640	34,478
Regional total	56,576	69,771	80,130	82,088	80,212

* Parts of the Shire of Portland were added to Portland town in 1958 and 1968

Sources: Commonwealth Bureau of Census and Statistics and Victorian Year Books
Note: 1971 figures are preliminary

Portland harbour and grain storage

through the port totalled 499,831 tons, of which 439,294 tons comprised bulk grain. Imports declined by 4.4% from the previous year, but still grossed 342,310 tons.

Further growth of Portland will depend to some extent on development and activity in the hinterland, a large part of which falls into the study area. Such development will channel outputs through Portland, and may benefit from the ability to import heavy machinery or raw materials through the port.

HISTORY

On the morning of December 3, 1800 A.D., Lieutenant James Grant of H.M. Brig "Lady Nelson" sighted Discovery Bay, becoming the first European to view the southern coastline of Australia between the D'Entrecasteaux Islands and Westernport.

There were Aborigines there, for 2 days later Grant recorded many fires along Bridgewater Bay. Moreover, they lived in a well-wooded environment. Grant's diary says of Discovery Bay: "the shore is a sandy beach...and flat land covered with brushes and large woods inland", while for Bridgewater Bay "the land appeared beautiful, rising gradually, full of woods". Today, bare and shifting sand dunes extend inland for distances up to 3 miles along these bays.

In April 1802, Baudin sailing westwards in the French corvette "Le Geographe" and Flinders sailing eastwards in command of the sloop "Investigator" unexpectedly met in Encounter Bay to the west of Discovery Bay and so almost simultaneously and quite independently became the second to view and the first to chart accurately the coast of western Victoria.

Exploration and settlement

For the next 26 years, while the settlements at Sydney, N.S.W., and Hobart and Launceston, Tas, flourished, the southern coast and hinterland of what is now Victoria remained the domain of the Aborigine. Although sealers and whalers camped around Portland Bay from time to time, permanent settlement probably dated from the arrival of William Dutton in December 1828. He remained at Portland for 2 months and returned in July 1829 to establish his home.

The Henty family were the next settlers. After three Henty sons had tried unsuccessfully to establish themselves at Swan River, W.A., they moved with their large party of servants and quantity of stock to Launceston. Here their father, Thomas, joined them, arriving from England in 1832. Thomas brought his wife and daughter, five servants, selected horses, cattle, and sheep and three more sons. One of these, Edward, after reconnoitring a part of the southern coast of Australia in 1833, visited Portland Bay and met Captain Dutton. He decided to establish a settlement and crossed from Tasmania in the "Thistle",

landing at Portland Bay on November 19, 1834, bringing a party of five farm labourers, cattle, implements, and seeds.

The final preliminary to the European settlement of western Victoria was at that time being undertaken by Major Mitchell, Surveyor General of New South Wales. In an attempt to resolve problems of the inland rivers arising from Sturt's earlier explorations, Mitchell had explored as far as the junction of the Murray and Darling and was returning up the Murray when he gazed south-westwards over the northern plains of Victoria. He decided to cut across to Encounter Bay, and, leading a party of men with wagons and two boats, he skirted the north of the Grampians as far as Mount Arapiles and turned south through the lakelands of Kowree shire.

He first entered the area described in this report shortly after he crossed the Glenelg River at what is now Harrow on August 1, 1836. It is a fact that at that point his descriptions change to eulogies, and this favourable assessment of the Glenelg basin not only led him to bestow on it the name of "Australia Felix" but also determined him to follow the Glenelg to its mouth in the hope of finding a place suitable for a port. Accordingly he pursued his way through the hills of Casterton, across the heaths of Weecurra, and along the placid Glenelg by boat from Dartmoor - only to disappointment at the shallow estuary at Nelson.

On his homeward way through the Annya forests, he diverted southwards to reconnoitre Portland Bay, and to his immense surprise saw ships and huts and met Henty. He informed the Hentys of the rich nature of the land beyond the swamps and forests around their settlement. The Major then retraced his steps to Annya, and crossed the stony rises to Mount Napier. His surveys established the location of the key features of the area, his wanderings made known the nature of the land, and his meeting with Henty ensured its rapid exploitation.

After Mitchell's favourable report on the excellent pastures inland, Stephen Henty and two men cut a track through the forest north of Portland, crossed the Fitzroy River, and early in 1837 established a station named "North Downs" on Mount Eckersley. That year Edward Henty settled at Muntham and Francis Henty at Merino Downs near Casterton. The Hentys made further settlements at Sandford and Connell's Run. The lower Glenelg area remained undisturbed by Europeans until 3 years after Mitchell, when Edward and Stephen Henty returned to Portland along the coast after visiting the Mount Gambier country in 1839.

During the 1840s, pastoral runs were claimed over most of the country. Even poor grazing land that has since reverted to the Crown was occupied, at least nominally, for some time. Scrub country around Drik Drik was first taken up in

1842, and limestone country around Glenelg about 1845. Sandy land around Dorodong formed part of a run first occupied in 1845. By 1850 very little land remained unclaimed by some station.

The Aborigines

The Aborigines were naturally hostile towards the new settlers and many clashes occurred in the early years. One estimate put the native population of the area at about 3,000 at the time of first European settlement. By 1852 the Portland Bay district Aborigines had declined to about 700, and in 1877 the full-blooded population was only 147. Today that district has no full-bloods.

The local Aborigines were reported to be a strong, well-built people, who led a less nomadic life than others in Australia because of the abundance of food. They could offer stiff resistance to white encroachment because of their strong, aggressive leadership.

The traditional organization of society was into small hunting and foraging groups on a territorial basis. They met to exchange goods and perform ceremonials. But the European settlers soon displaced them from key areas of land, effectively reducing contact between discrete local groups. In addition to the direct effects of fighting and disease, this fragmentation contributed to the decline of Aboriginal society. It became too difficult for local groups to meet for the exchange of marriage partners and the ceremonials that had linked them and formed the cultural basis of their society. In 1842, after much fighting, the settlers petitioned the Government for protection, and a police force of 10 Aborigines and two Europeans arrived at the barracks at Mount Eckersley in July 1843. Conflict continued in the Glenelg River area until after 1846, but by 1850 the Aborigines were able to offer little resistance.

The Chief Protector of Aborigines had established a reserve at Mount Rouse, but this was abolished in 1849 after fighting between the pastoralists and the reserve dwellers. In 1858 new reserves were created near Warrnambool, at Lake Hindmarsh, and at Lake Condah. In 1867 the Lake Condah reserve became a Church of England mission but this finally closed in 1918. The culture of the tribes of western Victoria had been lost, and eventually the people disappeared.

In the study area the remains of Aboriginal fish traps may be found at Lake Condah and Darlot's Creek, and numerous middens containing flakes of flint occur among the coastal dunes. Flint workshops have been reported from the Tarragal area, and backed blades from Descartes Bay foreshore.

Land use

The first cattle were exported from Portland in 1842, when Winter brothers

sent 25 bullocks to Blackmans Bay. However, initial settlement was based on the Merino wool industry and this was to become the major economic activity in the region for more than a century. Following severe drought in 1839-40, general depression prevailed in the early 1840s - land and stock values fell and sheep were hard to sell. Boiling-down works were established and tallow exported, bringing about eight shillings per sheep treated. However, the wool industry had recovered by 1850 and many enterprising squatters made fortunes.

Unsuccessful settlement and bracken invasion - near Kentbruck.

The discovery of gold in 1851 made it impossible for the squatters to retain labour, and the influx of people to the diggings provided a market for wheat and meat. This encouraged some diversification away from wool. Until 1870 the squatters managed to retain their large runs by paying an annual licence fee. However, pressure from former miners seeking land resulted in a series of Acts, culminating in the Lands Act (1869), which allowed the selection of 320 acres of "first-class" land or 640 acres of "second-class" land. From 1870 onwards there was steady pressure for subdivision and "closer settlement".

The selectors began to clear and to crop land. However, drought and poor techniques led to the abandonment of many blocks during the 1880s and 1890s, and these were added to the squatters' runs or taken over by the successful selectors.

Subdivision for sheep, dairying, and mixed farming followed the 1914-18 and 1939-45 wars. More closer-settlement schemes were implemented in the late 1950s and 1960s. The most recent government land development for agriculture occurred at Palpara in the study area.

Only in the last few years has a trend towards the aggregation of properties again become apparent. At the same time, agriculture has also moved away from sheep production towards beef cattle and other enterprises.

PART II NATURE OF THE LAND

GEOLOGY

The study area lies within the major structural units known as the Otway Basin and the Dundas Basement Ridge. The Otway Basin is essentially a deep trough, filled with a maximum of 25,000 ft of Mesozoic and Tertiary sediments, extending from the vicinity of Kingston, S.A., to the eastern side of Port Phillip Bay. The Dundas Basement Ridge, which consists of Palaezoic rocks, runs west from The Grampians to west of the Glenelg River at Dergholm and continues at shallow depth into South Australia. It underlies the Dundas Tablelands and forms the northern boundary of the Otway Basin, which it separates from the adjoining Murray Basin to the north. The Dundas Ridge is a continuation of the Western Highlands at the western end of the Australian Great Divide.

Earliest geological development

The main rock formations and geological events are summarized in Table 2, facing page 14. The oldest exposed rocks of the Dundas Ridge are Cambrian greenstones, cherts, and shales. The next oldest are Ordovician slates and sandstones, associated with metamorphic rocks and Ordovician and post Ordovician granite and granodiorite. Some of these granitic rocks were intruded during a period of intense folding that followed deposition of the Ordovician sediments. A long period of erosion followed until Permian times, when the area was glaciated and tillite and associated glacial

Granite tors on the surface at Baileys Rocks

deposits were laid down. A further long period of erosion then lasted until Upper Jurassic times.

Towards the end of the Jurassic period a series of east-west depressions began to form south of the Dundas Ridge. Then in Lower Cretaceous times a great east-west rift valley or trough formed, extending across southern Victoria and South Australia. This was the first stage of development of the Otway Basin. Great thicknesses of mudstone and sandstone were deposited in this valley under fresh-water conditions. These Lower Cretaceous sediments, which are continuous beneath the surface with the Otway Ranges, are known as the Otway Group (formerly the Merino Group).

The sea's invasion

In the Merino-Casterton-Coleraine area, the Otway Group beds began to rise at the end of the Lower Cretaceous to form the elevated area the Merino Tablelands now occupy. At the same time the Otway trough widened, the sea gained access, and very thick layers of shales, greensands, and sands were deposited under shallow marine and subcoastal conditions in the south of the present study area. These Upper Cretaceous beds do not outcrop, being known only from bores. They have been named the Sherbrook Group.

In the Paleocene and Eocene, the margin of the ocean moved inland and thick beds of sands, silts, and clays of the Knight Group were deposited up to the edge of the area now occupied by the Merino Tablelands.

A major transgression of the ocean occurred during Oligocene and Miocene times. In the Murray Basin the sea advanced until, at its maximum, the coast stood 100 miles north of the present position of the Murray River, and the Dundas Ridge formed a peninsula. Beneath this shallow sea, known as the Murravian Gulf, beds of fossiliferous marls and limestones of the Murray Group were deposited. The corresponding sediments deposited in this sea in the Otway Basin are known as the Glenelg Group, which includes the Portland and Mount Gambier limestones.

The retreat of the sea

The sea began to withdraw at the end of Miocene times due to upwarping of the continent, and this retreat continued in several stages through Pliocene times. In the latter part of the Pliocene and continuing into the Pleistocene, a major event known as the Kosciusko Uplift occurred, elevating the eastern Australian Highlands.

In western Victoria, renewed movement took place along the Kanawinka Fault, which had probably first developed in early Tertiary times. As a result of this movement the sea retreated to the area south and west of the fault escarpment, where it formed a shallow bay.

TABLE 2 GENERALIZED STRATIGRAPHY OF SOUTH-WESTERN STUDY AREA

AFTER P.R. KENLEY 'GEOLOGY AND GEOMORPHOLOGY OF WESTERN VICTORIA' A.I.A.S. SYMPOSIUM HORSHAM 1971

ERA	PERIOD		EPOCH	MAJOR EVENTS	OTWAY BASIN ROCK UNITS	MAX. THICK.	OTWAY BASIN ROCK TYPES	OTWAY BASIN AQUIFER POTENTIAL	DUNDAS RIDGE ROCK UNITS	MAX. THICK.	DUNDAS RIDGE ROCK TYPES	DUNDAS RIDGE AQUIFER POTENTIAL
CAINOZOIC	QUATERNARY	HOLOCENE (RECENT)		MARINE REGRESSION	MALANGANEE SANDS etc.	100′	ALLUVIAL & ESTUARINE SILTS etc LOOSE CARBONATE SANDS SILICEOUS SAND SHEETS & DUNES LUNETTE SANDS & SILTS	LOCALLY FAIR	MALANGANEE SANDS and/or LOWAN SANDS		SANDS, SILTS, GRAVELS CONGLOMERATES, SANDS, SILTS SILICEOUS SANDS.	
		PLEISTOCENE		EPEIROGENIC & EUSTATIC MOVEMENTS VOLCANICITY WHALERS BLUFF SEA FAULTING & EPEIROGENIC MOVEMENT	BRIDGEWATER FORMATION N.V. WHALERS BLUFF FORMATION	B.F 100′–150′ WBF 80′ N.V. 300′	B.F - CROSS-BEDDED SANDY L'STONE WBF - FLAT-BEDDED SANDY L'STONE NEWER VOLCANICS - BASALT, SCORIA, TUFF.	VERY GOOD FAIR	LATERITIZATION DORODONG SANDS	100′	FERRUGINOUS SANDSTONE, & FINE MICACEOUS SAND	
	TERTIARY	PLIOCENE	UPPER	LATERITIZATION	LATERITIZATION							
			LOWER	MARINE REGRESSION FAULTING	DORODONG SANDS	100′	FERRUGINOUS SANDSTONE & FINE MICACEOUS SANDS.	FAIR				
		MIOCENE		VOLCANICITY	GLENELG GROUP: GAMBIER LIMESTONE (V)	2830′	VOLCANICS - BASALT, TUFFACEOUS LIMESTONE, LAMPROPHYRE.	NOT KNOWN	GAMBIER LIMESTONE		LIMESTONE & MARLS LIMONITIC MARLS	FAIR TO GOOD
							G.L. - BRYOZOAL LIMESTONES & MARLS	VERY GOOD				
		OLIGOCENE			GLENELG GROUP: NELSON FORMATION		N.F. - LIMONITIC LIMESTONE & CALCAREOUS SAND.	NOT KNOWN				
		EOCENE		MAJOR MARINE TRANSGRESSION					EROSION			
		PALEOCENE	UPPER	MARINE REGRESSION	KNIGHT GROUP: DARTMOOR FORMATION (V)	2860′	D.F. - SILTS, FINE SANDS, & SANDS	GOOD				
							V - BASALT					
			MIDDLE		BAHGALLAH FORMATION	650′	GREENSANDS & SILTS MINOR FINE CONGLOMERATES	POOR				
			LOWER	MARINE TRANSGRESSION								
MESOZOIC	CRETACEOUS		UPPER	RENEWED EPEIROGENY	SHERBROOK GROUP (INCLUDES 5 MAJOR FORMATIONS & SEVERAL MEMBERS)	6000′ (Onshore) 10000′ (Offshore)	SANDS, GREENSANDS, SILTS SHALES, MINOR COALS	LOCALLY GOOD INLAND				
			LOWER	MARINE TRANSGRESSION FAULTING & EPEIROGENY OF CONTINENTAL MARGIN CONTINUED VOLCANICITY	OTWAY (MERINO) GROUP (INCLUDES 3 MAJOR FORMATIONS)	10000′	MUDSTONES, SILTSTONE, FINE-GRAINED FELSPATHIC, & TUFFACEOUS SANDSTONE (± CARBONATE CEMENT) MINOR COALS & CONGLOMERATES	POOR	OTWAY (MERINO) GROUP	300′	MUDSTONES, SILTSTONES, FINE-GRAINED SANDSTONES, BASAL CONGLOMERATES	POOR
		JURASSIC		E-W BLOCK FAULTING VOLCANIC ACTIVITY INITIAL RIFTING OF OTWAY BASIN.	CASTERTON BEDS	1760′	BASALT, SCORIA, S'STONES, SHALES					
		TRIASSIC		EROSION								
PALAEOZOIC	PERMIAN		UPPER & MID									
			LOWER	GLACIATION	UNNAMED	204′	TILLITE (At depth in bores)	POOR	COLERAINE GLACIALS	300′	TILLITES, SANDSTONE, VARVED CLAYS, SANDS	POOR
	CARBONIFEROUS			FOLDING & FAULTING CONTACT METAMORPHISM								
	DEVONIAN			VOLCANIC ACTIVITY	UNNAMED	?	PORPHYRITIC RHYOLITE (At depth in bores)	NOT KNOWN	CAVENDISH TRACHYTES		TRACHYTES	NOT KNOWN
	SILURIAN			EROSION								
				INTENSE FOLDING & GRANITIC INTRUSION REGIONAL & CONTACT METAMORPHISM					DERGHOLM GRANITE Etc.		GRANITE, GRANODIORITE, PEGMATITE, APLITE.	NOT KNOWN
	ORDOVICIAN		LOWER	MARINE SEDIMENTATION	UNNAMED	TENS OF THOUSANDS OF FEET	SLATE, SHALE, GREYWACKE (At depth in bores)	NOT KNOWN	UNNAMED (INCLUDES GLENELG R. COMPLEX) (MAY INCLUDE UPPER CAMBRIAN)		GREYWACKES, SLATES, SHALES DOLOMITIC SHALES, CORRESPONDING SCHISTS, GNEISSES, & HORNFELS	POOR
	CAMBRIAN			VOLCANIC ACTIVITY	NOT RECORDED			NOT KNOWN	UNNAMED		GREENSTONES, TUFFS, CHERTS SHALES, CHLORITE SCHISTS.	NOT KNOWN

Beneath the waters of this bay about 80 ft of sandy limestones with abundant oyster shells and some clays - the Whalers Bluff Formation - were laid down over the Glenelg Group limestones and marls. Then gradual uplift of the land and retreat of the ocean from the land resumed.

Sandy deposits

During Pleistocene times a pattern of falling and rising sea levels due to the formation then melting of large ice caps (ice ages) was superimposed on the gradual uplift of the land.

Dunes of calcareous sand, similar to those fringing Discovery Bay today, marked the positions of old coastlines being stranded as the ocean retreated. As these dunes weathered, the calcareous material dissolved, moved downwards, and was redeposited as hard secondary limestone, leaving a surface layer of more siliceous sand. During arid periods in Pleistocene and Recent times, this layer of sand was stripped and redistributed over the land in the lee of the dunes by prevailing south-westerly winds. The exposed limestone dunes have been named the Bridgewater Formation. The windblown sands, which are widely distributed as sheets and low dunes over all physiographic units in the study area, have been named the Malanganee Sands.

Thus, on the Follett Plains, the Whalers Bluff Formation lies at shallow depth

The Whalers Bluff Formation exposed near Myaring Bridge (above) contrasts with the Bridgewater Formation's limestone caves

beneath clay, silt, and sand deposited in Recent swamps, lakes, and lagoons, the Malanganee Sands, and the dune limestone of the Bridgewater Formation.

The mouth of the Glenelg River followed the staged retreat of the ocean, and cut a gorge in the soft young sediments of the coastal plain as it flowed into a low-sea-level ocean during the last of the "ice ages". The return of the ocean to about its present position, following the melting of the ice caps, flooded the lower reaches of the Glenelg, partially filling the gorge with alluvium and making the river tidal for 30-40 miles inland.

Weathering

Erosion and deep weathering of the low-lying land on the Dundas Ridge has been in progress since the end of the Lower Cretaceous, and as the Murravian Gulf retreated new areas were exposed to the weathering processes. By mid to late Pliocene times, most of the areas now occupied by the Dundas Tablelands, Merino Tablelands, and Dergholm Platform (see the map facing page 18) had been reduced to a flat surface and had undergone the type of deep weathering known as lateritization. Laterites are distinctive soils formed under conditions of marked seasonal fluctuations of the water table, such as are common in the tropics. They are up to 30 ft thick in this area and are characterized by concentration of iron and aluminium oxides

Stone walls and basalt boulders near Lake Condah

as gravel or hard cemented masses ("ironstone") in the upper part of the profile. This layer is usually a distinctive red-brown colour and overlies mottled and pallid leached zones.

Faulting, tilting, and warping of this old surface in Upper Pliocene to mid Pleistocene times (Kosciusko Uplift) led to the development of a new drainage pattern. The Merino Tablelands, which are underlain by deep soft Cretaceous sediments, were deeply dissected by the Wannon River and its tributaries. On the Dundas Tablelands the Palaeozoic rocks underlying the laterite are much

harder, and dissection by streams flowing off the tablelands has not yet reached an advanced stage. Some sheets and dunes of acid Malanganee Sands were blown on to the western edges of both tableland areas.

Volcanic activity

At about the same time as the movement along the Kanawinka Fault, that is Upper Pliocene times, volcanic activity increased and has continued through a number of phases up to the Recent. Basaltic lavas and tuffs occupy large areas on the Normanby Platform, Mount Clay, and the land south of Hamilton, covering the Tertiary formations and modifying the drainage pattern. The most recent phase of this activity is represented by the basalt and tuff of the "stony rises" and the cinder cones of Mount Eccles and Mount Napier.

The basalts of the earlier phases were partially lateritized during one of the warm humid interglacial periods of the Pleistocene, and a layer of gravelly ironstone was formed over large areas.

The large unconsolidated calcareous sand dunes that fringe Discovery and Bridgewater Bays, and the modern beaches, cliffs, and river alluvium have developed in very recent geological time.

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PHYSIOGRAPHY

South-western Victoria consists of a stepped series of almost horizontal surfaces separated by structural lineaments. The surfaces generally increase in elevation from the south-west to the north-east, and are bounded by scarps on their western edges. Seven major units have been described (see map facing this page).

Follett and Tyrendarra Coastal Plains

These physiographically similar plains, on either side of the Normanby Platform, are the land extension of the continental shelf. The Follett Plains extend into South Australia and are bounded to the north and east by the line of fault scarps of the Kanawinka and associated faults. The Plains rise from sea level to an elevation of 250 ft north-west of Casterton. They are regionally very flat, but a line of calcareous sand dunes fringing the ocean, a series of north-west trending limestone dunes of the Bridgewater Formation, and low dunes of the siliceous Malanganee Sands provide some relief. There are numerous swamps in the interdune corridors, and the drainage system is in a youthful stage of development.

The Glenelg River is the only stream traversing the Follett Plains.

Within the study area the Tyrendarra Plains consist of alluvium derived from rivers, swamps, and former lakes, and some exposures of limestones of the Glenelg group. The Surry and Fitzroy

The Follett Plains viewed from the Weecurra Fault escarpment

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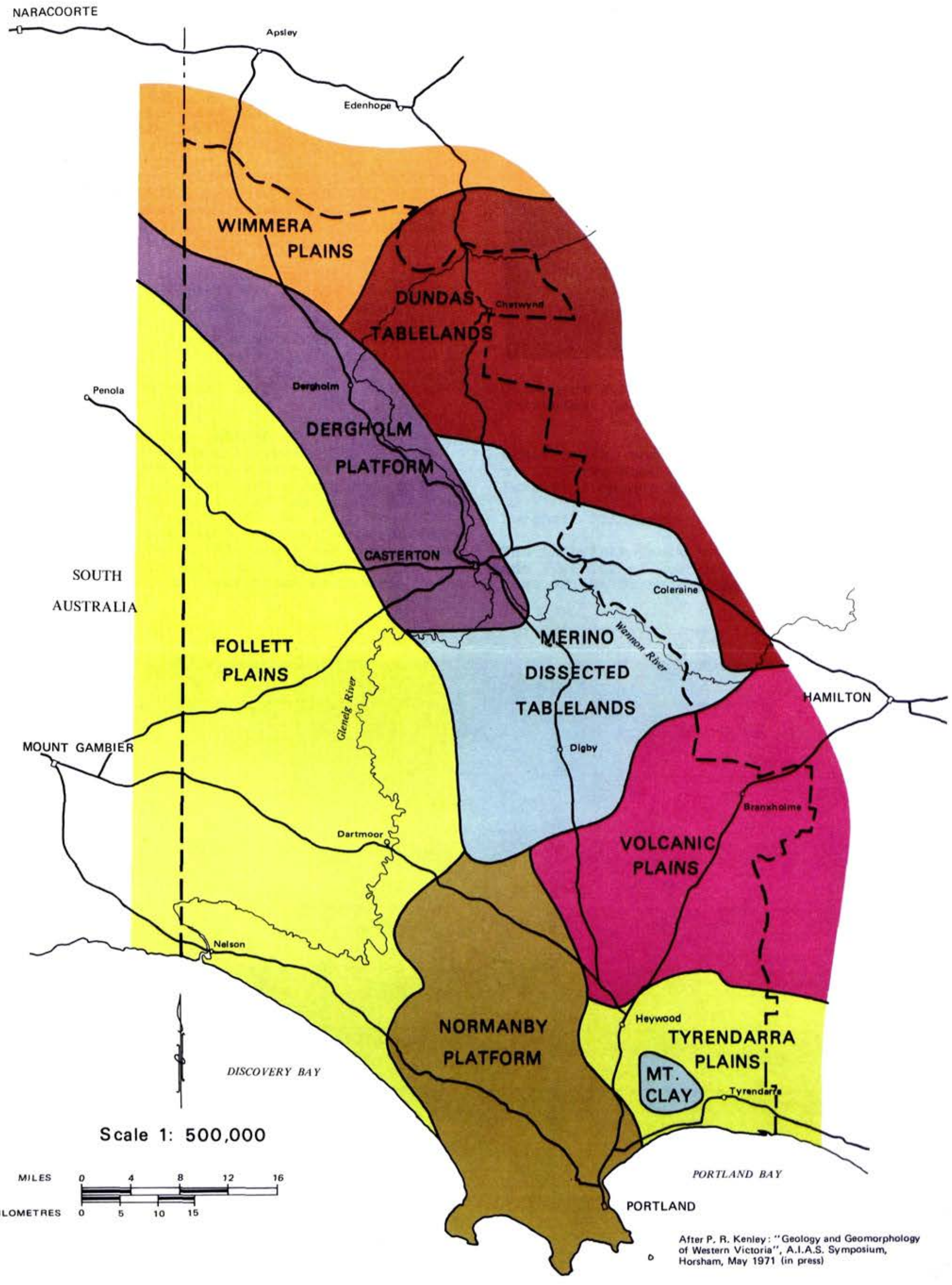
PHYSIOGRAPHY



Scale 1: 500,000

MILES 0 4 8 12 16

KILOMETRES 0 5 10 15

After P. R. Kenley: "Geology and Geomorphology of Western Victoria", A.I.A.S. Symposium, Horsham, May 1971 (in press)

Rivers flow sluggishly between low banks into Portland Bay.

Normanby Platform

Uplift and tilting due to movement along the Jones Ridge, Moleside, Kentbruck, and Swan Lake-Bridgewater faults during Upper Pliocene to Pleistocene times formed the Normanby Platform, which abuts the Merino Tablelands to the south of the Hotspur Monocline.

Along the western scarps, the Platform has an elevation of 450-500 ft, and the surface slopes eastwards at 20 ft per mile until it merges with the coastal plains near Heywood.

Much of the surface consists of late Pliocene-Pleistocene basalts, and in some places swamp deposits and wind-blown Malanganee Sands have covered the basalt. Five low volcanic cones rise above the generally flat surface, and at least one limestone dune of the Bridgewater Formation is perched on its south-western edge.

The drainage pattern of the Platform is not yet fully developed. The Fitzroy and Surry Rivers - streams flowing eastwards - have cut short, deep gullies near the junction of the basalt and the coastal plains. To the west, the Moleside Creek and Glenaulin Creek systems flow into the Glenelg River through low points in the line of scarps. Johnstone's Creek flows south from Kentbruck Heath, and has formed a waterfall as it flows down the Bridgewater-Swan Lake Fault scarp into Swan Lake.

Johnstone's Creek cutting the Bridgewater-Swan Lake Fault scarp

Dergholm Platform

The Kanawinka Fault scarp to the west and a series of low escarpments to the east of the Glenelg River form the boun-

daries of this strip of land, which has a flat surface at an elevation of about 550 ft. Its surface deposits comprise Tertiary limestones, lateritized Pliocene sands, and more recent siliceous Malanganee Sands and swamp deposits.

Drainage is provided by the Glenelg River and its short tributaries and by intermittent streams flowing down the western scarp.

Dundas Tablelands and Merino Dissected Tablelands

These tablelands extend from the scarps overlooking the Follett Plains south of Casterton to the Wimmera Plains and the Grampian Ranges. The elevation of the Merino Tablelands varies from 550 ft in the south to 650 ft near Casterton, and the Dundas Tablelands range from 750 ft to over 1,000 ft north of Coleraine.

On the Merino Dissected Tablelands, only small areas of the mid-Pliocene plain remain as flat, laterite-capped hills above deep valleys. The tableland remnants show a marked northerly to north-westerly orientation. The sides of the valleys are steepest below the laterite capping and have convex upper and concave lower slopes. Landslips are common. The streams, notably the Wannon River, flow in meandering courses through wide flood plains.

On the Dundas Tablelands, dissection is shallower, though steep-sided valleys have been cut into the hard Palaeozoic rocks. Streams draining the Tablelands flow north and west into the Glenelg River and south into the Wannon River.

Wimmera Plains

These plains extend from the edge of the Dergholm Platform and the Dundas Tablelands north to the edge of the Mallee. They consist of marine and fluviatile deposits, with few streams but numerous lakes and swamps.

Volcanic Plains

This unit comprises the western edge of the very large area known as the Western

Landslip at Killara Bluff - the margin of the Merino Tablelands

Volcanic Plains. Its basalts cover the south-eastern boundary of the Merino Tablelands, and extend on to the Tyrendarra Coastal Plains.

The Volcanic Plains consist of numerous basalt flows, aged from late Pliocene to Recent. The older flows are deeply weathered and dissected, while the more recent ones are only slightly weathered and retain typically "stony-rise" topography, with lava blisters, cinder cones, and lava tunnels.

The basalts have modified the regional drainage markedly, forcing some streams into new courses (the Wannon River) and damming others (the Condah Swamp).

Mount Clay

Mount Clay, a triangular block lying 350 ft above the surrounding coastal plain, is ringed by steep scarps that have resulted from faulting or from monoclinal sagging over deep structural blocks.

The basement rock of this area, Miocene limestone, outcrops in the scarps. The limestone is covered by Pleistocene basalt, tuff, and scoria from the Mount Clay volcano, which forms a low cone reaching 600 ft above sea level near the southern edge of the block. On the western half of the block these volcanic rocks are covered by sheets and dunes of wind-blown Malanganee Sands.

The block is drained by short streams flowing into the Fitzroy and Surry Rivers, and by internal percolation through swamps.

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WATER RESOURCES

No large artificial or natural storages of surface water occur in the study area. Only a small proportion of the rainfall reaches streams by means of direct surface run-off - most of the rain that reaches the soil is lost by evapotranspiration, is retained as soil moisture, or passes to the groundwater. The two major streams flowing through the area, the Glenelg and Wannon Rivers, draw about one-quarter of their flow from headwater regions located in the Grampian Ranges. Their average salinity near Casterton is 2,000-2,500 p.p.m., and the maximum salinity (at times of low stream flow) exceeds 5,000 p.p.m. These salinities make the water unfit for human consumption and irrigation, although it is generally suitable for stock.

The Wando, Stokes, and Crawford Rivers maintain low rates of flow during the summer, but most of the remaining streams become dry or are reduced to a series of pools.

However, the study area has substantial reserves in the form of groundwater - water stored beneath the ground in porous, mainly sedimentary, geological formations. Because supplies of surface water in the region are limited, future population growth and industrial and other development will depend heavily on availability of substantial reserves of good-quality groundwater.

Groundwater Resources

Groundwater of one type or another is available throughout the area but aquifers (porous and permeable formations saturated with water) containing large quantities of good-quality water are generally restricted to the Cainozoic sediments of the Otway Basin.

Two types of aquifers are normally recognized - confined and unconfined. Confined aquifers occur in sedimentary basins and consist of porous formations that are covered by one or more impervious formations. Recharge takes place through intake areas where the porous formation outcrops, usually in higher land at the margin of the basin. Unconfined aquifers occur in shallow formations in which the upper surface of the water forms the regional water table, and the water is stored under normal hydrostatic pressure. These

aquifers are recharged by rain falling locally and infiltrating downwards into the porous formations directly beneath the surface.

The following paragraphs describe the groundwater resources of the study area on the basis of groundwater provinces, which correspond broadly with the physiographic subdivisions described and outlined in the map facing page 18. (See also the Stratigraphic Table facing page 14.)

Throughout the Follett Plains, Normanby Platform, and Tyrendarra Plains, the main aquifers are the Gambier Limestone (Glenelg Group) and the underlying sands of the Dartmoor Formation (Knight Group).

The Dartmoor Formation

This Formation is generally a confined aquifer, with intake areas located where the beds outcrop or are covered by thin deposits of porous Malanganee Sands and/or the Whalers Bluff Formation. These intake areas are located along the foot of the Hotspur Monocline from Lower Crawford to Hotspur and in a strip extending along the foot of the Kanawinka Fault and associated escarpments from Naracoorte to east of Dartmoor.

The Dartmoor Formation, which holds large quantities of soft water suitable for urban and industrial use (class 3 - see below) supplies most of the town water for Portland and Heywood and substantial reserves of water are available to service industrial development there. Naracoorte, in South Australia, also obtains its water from sand aquifers in the Knight Group.

(The groundwater quality classes adopted here are taken from the booklet "Quality Aspects of Farm Water Supplies". The classes are defined for irrigation waters, and are based on the total dissolved solids content (TDS) of the water measured in parts per million (p.p.m.). The five classes are:

Class 1:
low salinity, 0-175 p.p.m. TDS

Class 2:
medium salinity, 175-500 p.p.m. TDS

Class 3
high salinity, 500-1,500 p.p.m. TDS

Class 4
very high salinity, 1,500-3,500 p.p.m. TDS

Class 5
extremely high salinity, above 3,500 p.p.m. TDS

Water for stock may contain up to 6,000 p.p.m. TDS, water for irrigation may contain up to 500 p.p.m. where soil conditions are favourable, and water for domestic use should contain less than 1,500 p.p.m.

Classes assigned to the groundwaters are those commonly found in bores drilled to date. Waters of better or worse quality may occur locally due to lateral variations in geological conditions.

"Hardness" in water refers to difficulty in lathering with soap, and the deposition of fatty scum on baths and fabrics. It is caused by the presence of calcium and magnesium as bicarbonates in water, and becomes a problem when the hardness (calcium and magnesium as calcium carbonate) exceeds 150 p.p.m.

Gambier Limestone

This porous fossiliferous limestone contains an extensive system of underground caves and solution channels. The formation behaves as both a confined and an unconfined aquifer in different areas, depending on the presence or absence of overlying impervious clays or marls. Recharge occurs through outcrops on the Dergholm and Normanby Platforms and to an even greater extent through the overlying porous formations (Malanganee Sands, Whalers Bluff Formation, basalt, etc.) that blanket much of the surface of these physiographic units. Where the beds are thick and continuous, as is generally the case, the Gambier Limestone can supply large quantities of good-quality (although hard) water of class 3. However, the formation is thin or absent in some places due to the combined effects of geological structure and erosion.

Limestone cliffs in the Glenelg River gorge.

The towns of Mount Gambier and Penola, in South Australia, obtain their water supplies from this aquifer, and prior to the drilling of the present town supply bores, Portland was also supplied entirely from this source.

Whalers Bluff Formation

An important aquifer over the greater part of the Follett Plains is the Whalers Bluff Formation. It comprises 50-80 ft of sandy limestone and calcareous sand lying at or just beneath the surface, and contains large volumes of good-quality water (classes 2 and 3).

The unconfined water in this formation is available at very shallow depth. For example, at Strathdownie and Ardno, where groundwater has been used for irrigation, the water table is only 9-10 ft below the surface. Since 1968, water from this aquifer has been used increasingly to supplement supplies for the town of Casterton.

In the Rennick-Palpara-Nelson area, the Whalers Bluff Formation thins out over pre-existing higher areas in the surface of the Gambier Limestone, which in this area is a porous (partly cavernous) limestone, and the shallow groundwater passes continuously from one formation to the other. The term Whalers Bluff Formation-Gambier Limestone aquifer system used below refers to this compound aquifer system.

Minor aquifers

Near the coast, the porous dune limestones of the Bridgewater Formation and the Recent unconsolidated calcareous dune sands contain shallow groundwater that, although hard, has a low TDS content (class 2), and is suitable for most purposes.

On the Normanby Platform, groundwater (classes 3 and 4) can usually be obtained at shallow depth from the late Cainozoic basalts. On the Tyrendarra Plains some stock supplies (class 3) occur at shallow depth in sandy alluvial and lacustrine sediments of Quaternary age.

In some parts of the Dergholm Platform and at the western end of the Dundas Tablelands good-quality water (class 3) is available from the Gambier Limestone. However, the limestones occur here in a complex pattern of bands and lenses, and large quantities of water have been obtained only where thick beds of limestone are present. Unfortunately, their sub-surface distribution is difficult to predict.

On the Dundas Tablelands, unconfined groundwater, generally available in small quantities from the fractured Palaeozoic rocks, is saline (class 5, commonly containing up to 4,000-5,000 p.p.m.) and suitable only for stock. The Merino Dissected Tablelands have only small quantities of poor-quality water (mostly class 5, some class 4) present in limited sandstone aquifers in the Otway Group sediments. Both confined and unconfined aquifers occur.

Conservation of Groundwater

The basic principle of groundwater conservation is that recharge should, in the long run, balance the sum of natural and artificial discharge from an aquifer. In the study area, the present rate of use of groundwater falls safely below the rate of recharge, and immense volumes of groundwater discharge naturally at and near the coastline in Victoria and South Australia. However, the future value of the groundwater resource will depend on maintaining sufficient

rates of recharge. These rates can be markedly affected by land use and management.

The formations and aquifers present in the Dergholm Platform and Follett Plains extend into adjacent parts of south-eastern South Australia, and the entire region - known as the Gambier Embayment of the Otway Basin - is a single groundwater province with common hydrological problems. Intake areas located in Victoria undoubtedly contribute to the groundwater resources of the border regions of South Australia.

Aquifer recharge

The Whalers Bluff Formation-Gambier Limestone system of unconfined aquifers is recharged by ephemeral streams draining the escarpments bounding the Follett Plains to the north and east, and by rain percolating from the surface of the plains through a thin veneer of sand and silt into the underlying beds. This aquifer system is an important resource capable of supplying large quantities of good-quality water at low cost, but its shallowness and unconfined nature present several problems in the management and conservation of supplies.

The rate of recharge depends on the amount of rain falling in the area and on the rate at which it percolates through the soil and root zone into the underground storage.

Glenelg River and fresh-water lakes

Shallow aquifers, notably the Whalers Bluff Formation-Gambier Limestone aquifer system, play an important part in the hydrology of this region. With the exception of some areas of local perched water table, the water levels in the

Swamps of the Follett Plains contribute to groundwater recharge.

Lagoon and mouth of the Glenelg River at Nelson.

swamps and surface streams generally maintain a dynamic equilibrium with the water table in these shallow aquifers. Downstream from the Kanawinka and Wee-curra escarpments, groundwater from the Whalers Bluff Formation and the Gambier Limestone seeps into the Glenelg River from numerous small streams, springs, and soaks and is probably the main cause of the observed improvement in river water quality between Sandford and Dart-moor. Fresh groundwater from springs also flows into the Glenelg River in its tidal reaches, from Drik Drik to the coast, and provides an important component of the estuarine environment in that area.

Groundwater exploration

The Mines Department currently has two large drilling rigs operating in the Shires of Portland and Glenelg. The primary aim of this investigation, which will be completed in about 2 years, is to obtain preliminary data on the sub-surface distribution and character of the deeper aquifers. Investigations to this stage have enabled an initial qualitative assessment of the ground-water resources to be made, and this will be refined as new information be-comes available. A comprehensive quan-titative evaluation of the complete aquifer system-involving the determin-ation of rates of recharge, safe yields and aquifer storage and transmissivity - will require a considerable input of geological and drilling effort and will extend over a number of years.

Reference

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CLIMATE

Western Victoria has a temperate climate with warm dry summers, predominantly winter rainfall, and mild temperatures throughout the year. Distance from the coast is the most important factor causing variation in the climate, although in the case of rainfall topography modifies this basic pattern.

The Glenelg Region Resources Survey (Central Planning Authority, 1960) contains a detailed analysis of the climate of the study area.

This report quotes meteorological statistics from three key recording stations - Portland, Casterton, and Apsley.

Rainfall

Average annual rainfall is greatest near the coast, and decreases steadily from south to north as distance from the coast increases. The map facing this page shows isohyets at 2-inch intervals. Portland, on the coast, receives 34 in., Casterton receives 28 in., and Apsley, just to the north of the study area, receives 22 in.

The ridge of higher rainfall west of Heywood and its extension to the north-west is due to uplift of moist south-westerly winds by the Kentbruck-Kanawinka line of scarps. Similarly, the edge of the elevated Dundas Tablelands has produced the small ridge of higher rainfall north-east of Casterton.

The distribution of rainfall throughout the year for three stations appears in Figure 1, which shows that the heaviest falls occur in winter. At Portland the rainfall has a definite peak in August, while for inland stations with lower totals it tends to spread over July and August. Summer rainfalls at the three stations are of the same order - 1-2 in. per month.

Temperatures

Table 3 shows average mean monthly temperatures for Portland, Casterton, and Apsley. These temperatures reach their lowest values in July and their highest in February for most of the region. In the north-west of the study area the maximum temperature occurs in January.

The ocean exerts a considerable moderating influence on temperature in coastal areas. Portland's highest monthly maximum and lowest monthly minimum are

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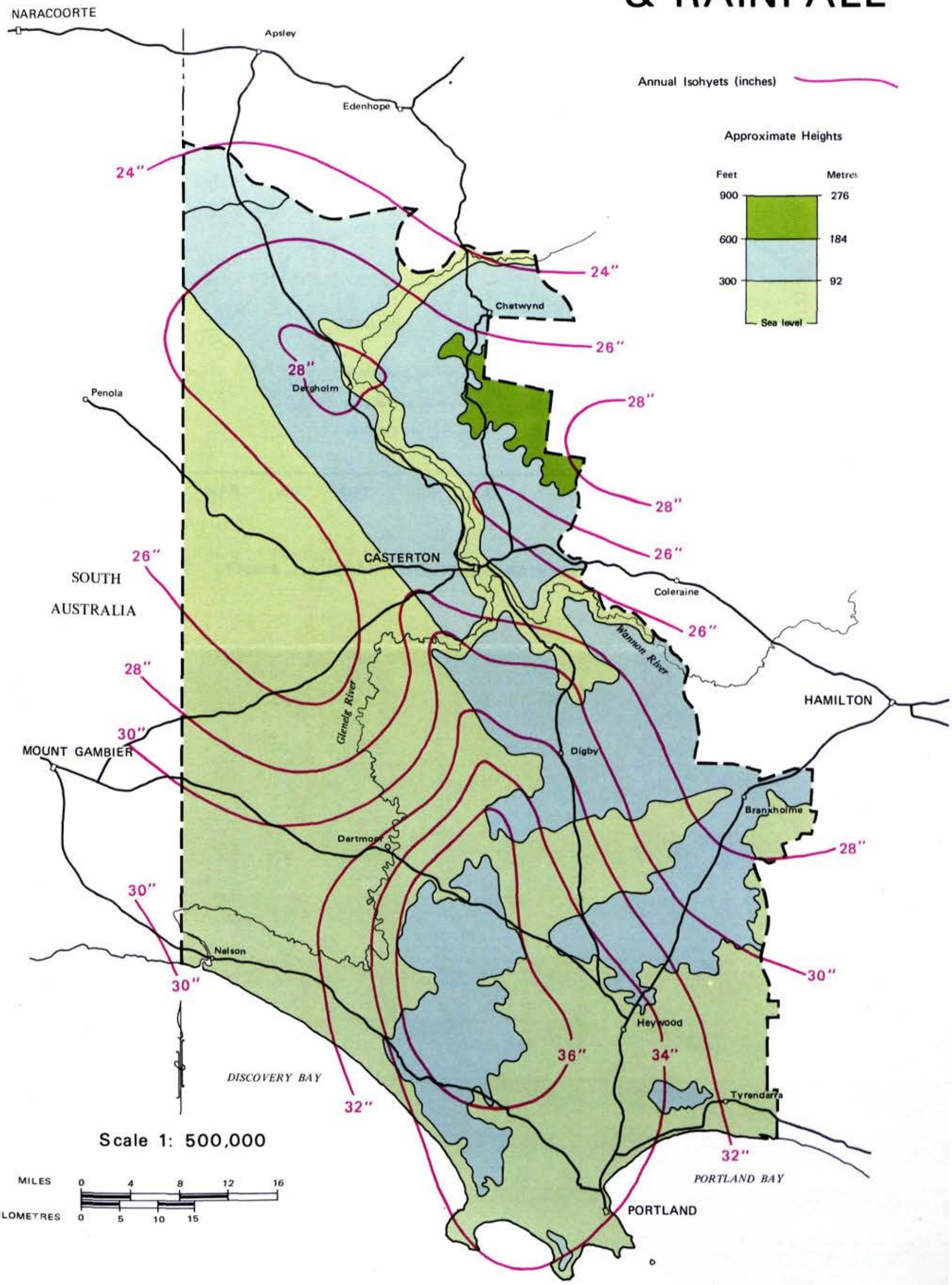
SOUTH WESTERN STUDY AREA

TOPOGRAPHY & RAINFALL



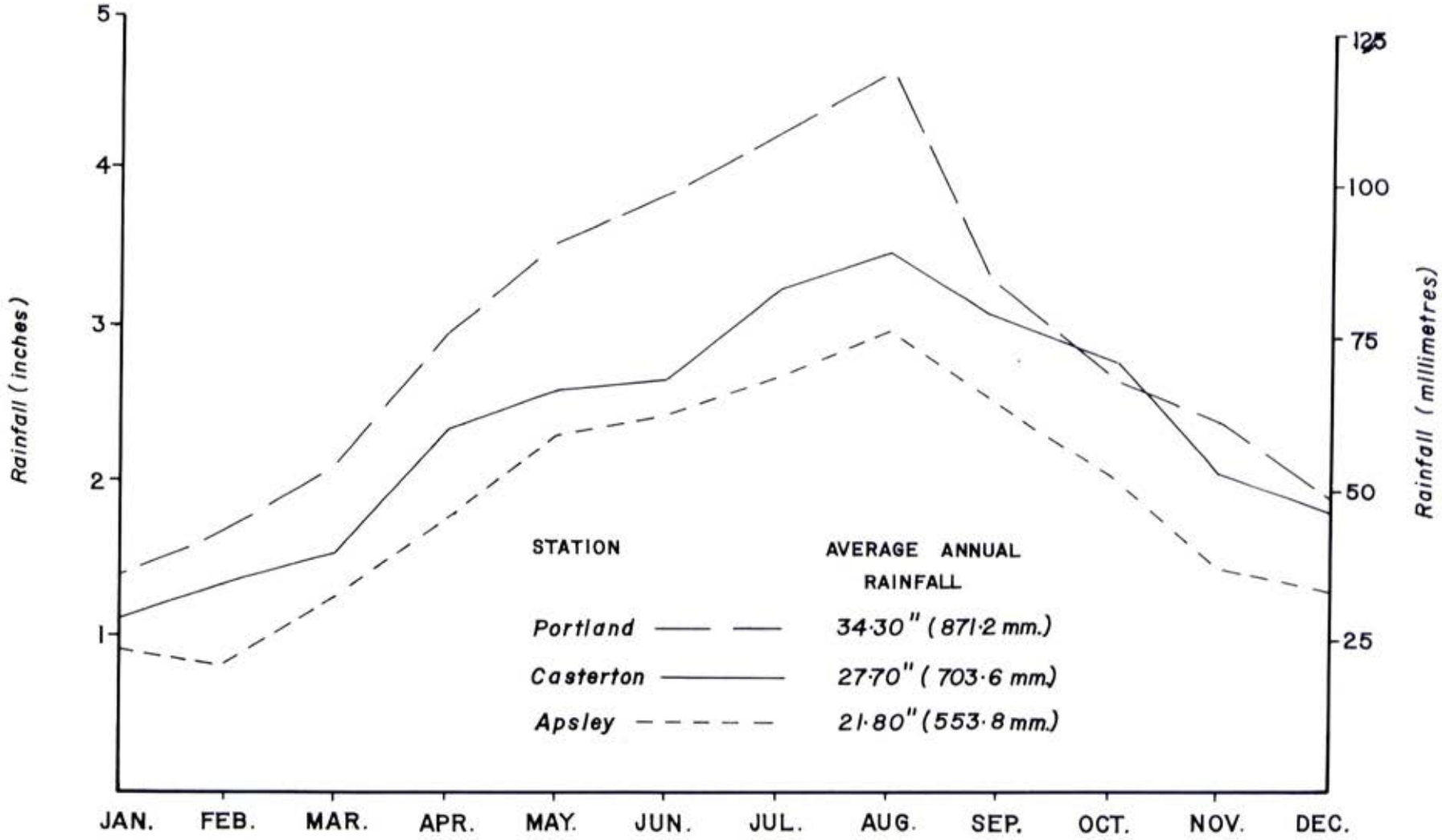


Figure 1. MEAN MONTHLY RAINFALL (1931-1960)

TABLE 3 AVERAGE MEAN MONTHLY TEMPERATURES

	Portland		Casterton		Apsley	
	°F	°C	°F	°C	°F	°C
January	63.1	17.2	67.7	19.8	69.3	20.7
February	63.6	17.6	65.9	18.8	67.8	19.8
March	61.5	16.4	63.3	17.4	62.1	16.8
April	58.0	14.4	58.2	14.5	58.5	14.7
May	54.2	12.3	52.9	11.6	53.0	11.6
June	51.7	10.9	50.5	10.1	49.0	9.4
July	50.0	10.0	47.6	8.7	48.0	8.9
August	51.2	10.6	49.7	9.8	49.9	9.9
September	53.2	11.8	52.0	11.1	52.6	11.4
October	55.6	13.2	56.0	13.4	56.7	13.7
November	58.4	14.6	59.7	15.4	61.3	16.3
December	60.8	16.0	63.0	17.2	65.7	18.7
Yearly average	56.8	13.8	57.2	14.0	58.2	14.5

71.4°F in February and 43.9° in July respectively, while Apsley ranges from 84.8°F in January to 39.8° in July.

Frosts are more frequent in inland areas - Hamilton has an average of 26 light and 13 severe frosts a year while Portland experiences an average of 9 light and 3 severe ones. Severe frosts occur from June to August. Daily maximum temperatures greater than 100° occur over the area in summer, but with greater frequency in inland areas.

Wind

Prevailing winds throughout the study area blow from the south-west in winter and the north-west in summer. Coastal areas experience high wind velocities, and vegetation on exposed sites suffers wind distortion and salt-burn. South-easterly breezes are common along the coast in summer.

Evaporation

Annual average evaporation from a free-water surface ranges from 33 in. near the coast to 42 in. near Apsley. During summer, values range from 5 in. per month near the coast to 7 inland. Values fall to 1 in. per month over the whole area in winter.

Climate and Plant Growth

Two major climatic factors limit plant growth in this area - inadequate rainfall in summer and excessive cold in winter.

Effective rainfall

A widely accepted measure of the availability of moisture to plants as affected by rainfall and evaporation is the calculation of effective rainfall. This is the amount necessary to start and maintain plant growth. It has been calculated for each month for key stations, together with the probability of receiving rainfall equal to or exceeding the effective amount, based on long-term rainfall records (see Table 4).

The growing season is defined as the number of months for which this probability exceeds 50%, plus one month. The additional month allotted at the finish of the growing season makes allowance for moisture stored in the soil.

Table 4 shows that on this basis the growing season is 11 months at Portland (March to January), 9 months at Casterton (April to December), and 8 months at Apsley (April to November).

The concept of effective rainfall must be modified to suit local conditions, particularly where deep-rooted perennial native vegetation has been removed. For example, the amount of soil water available to plants is affected by factors such as the slope of the ground and the type of soil. The significance of soils is discussed in Chapter 9.

The actual length of growing season also depends on the type of plant being grown - for example deep-rooted species can exploit reserves of soil moisture better than shallow-rooted species, and so extend their growth into the dry season.

Soil moisture may be conserved by farming methods such as clean cultivation, which aims at increasing the amount of moisture available to the cultivated plant by removing all unwanted vegetation. The estimates of growing season given above do not apply in areas where these techniques are used.

Temperature

Low temperatures can restrict or completely stop plant growth. The commonly accepted temperature limit for active growth is 50°F (10°C) average monthly temperature, and plant growth is negligible below an average of 42°F (5.6°C).

On this basis, Table 3 shows that low temperatures restrict growth for 1 month (July) at Portland, 2 months (July and August) at Casterton, and 3 months (June, July, and August) at Apsley.

Summary

The climatic conditions that produce most plant growth occur near the coast, where the growing season, with respect to moisture availability, is longest, and temperatures are less restrictive in winter.

Table 4

PROBABILITY OF EFFECTIVE RAINFALL

(Percentage chance of receiving as much as or more than the "effective" amount)

(from Central Planning Authority, 1960)

Month	Apsley	Casterton	Portland
Jan	11	15	33
Feb	15	28	38
Mar	20	34	55
Apr	76	79	94
May	91	97	100
Jun	96	99	100
Jul	99	100	100
Aug	97	99	100
Sep	96	99	100
Oct	75	86	95
Nov	33	55	73
Dec	21	36	54

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SOILS

Interactions between climate, parent materials, topography, and organisms determine the chemical and physical properties of virgin 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. For example, in humid areas peats occur in low topographic positions where waterlogging has limited the decomposition of dead plant material. However, soils usually result from quite complex interactions between the features of the environment.

One of the most important soil-forming processes in regions of adequate rainfall such as south-western Victoria is leaching. As rainwater soaks through the soil, it dissolves and carries away minute amounts of soluble material. The effect is to lower the nutrient level of the soil and increase its acidity. Water passing through the soil may also move fine particles of clay, which gradually filter down through the profile to form a denser, more clayey subsoil.

The greatest source of variation in soils of the area is that caused by variation in parent materials. These include such diverse geological formations as acid sands, calcareous sands, fluviatile clays, basalt, and limestone.

Classification

Almost all classifications of soil are basically intrinsic, i.e. soils are recognized by the features that distinguish one soil from another, rather than by features preselected according to their relevance for a particular form of land use. At the same time, many characteristics used to differentiate soils are known by experience to be relevant to a wide range of uses. This is a fortunate circumstance where the suitability of land for alternative uses is being considered.

Gibbons and Downes have described the soils of the study area in detail for the Soil Conservation Authority, and this book provides the data on which the following account is based.

The detailed soil units of this book have been grouped and given descriptive names, incorporating features that can be readily observed in the field, as set out in Table 5.

Table 5

SOIL GROUPINGS

Principal profile form (Northcote 1960)	Descriptive name	Groupings of Gibbons and Downes (1964)
Organic	Peats	Peats
Uniform texture	Undifferentiated calcareous sands	Regosol
	Leached sands	Nomopodsol Iron leptopodsol
	Red to black soils on limestone	Terra rossa Rendzina
	Brown soils on basalt	Chocolate soil Brown earth
	Dark structured clays	Prairie soil Chernozem
	Brownish gleyed* soils	Meadow soil Marsh soil
Gradational texture	Weakly bleached gradational soil	Clay leptopodsol
	Friable brownish gradational soil	Acid brown earth
	Friable reddish gradational soil	Krasnozem Transitional krasnozem
Duplex texture	Red, yellow, or brown duplex soils	Solod Solodic Solonetz Solodized solonetz

* Gley - a soil horizon containing bluish or blue-grey material, developed under the influence of waterlogging.

In this classification the principal profile form laid down by K. H. Northcote in 1960 has been used. It divides soils into three classes on the basis of the texture pattern of the profile: uniform, gradational, and duplex. Gradational soils become more clayey with depth without any sharp change, while in the duplex soils texture suddenly changes to clay. An additional class is the organic soils, which contain large amounts of organic matter.

Descriptions

This description of the soil groups discusses nutrient levels in terms of the soils' ability to support the growth of improved pastures.

Peats

The peats in the study area are unusual, being derived from woody material rather than mosses and sedges. The profile is dominated by organic matter in which botanical features are partly visible. The organic matter gives the soil a distinctive greasy feel. Colour is dark brown to black.

The peats are fertile, although they are acid and somewhat saline.

Undifferentiated calcareous sands

These sands (regosols) are derived from finely broken-down sea shells and weathering of limestone on the continental shelf. They are yellowish brown, friable, and structureless, and show no horizon differentiation. Nutrient content is low, but not as low as in the leached sands. The sands are extremely alkaline - the pH throughout the profile can be as high as 9.5.

They occur on the extensive mobile dunes fringing Discovery and Bridgewater Bays. As they have little vegetative cover, organic matter, or clay, they are susceptible to wind erosion.

Leached sands

These soils (nomopodsols and iron leptopodsols) 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, although in many cases an impeding horizon of sand cemented with organic matter and iron ("coffee rock") is found at depth.

Gibbons and Downes recognize two groups: the nomopodsols are heavily leached, extremely acidic, and grossly deficient in nutrients (including trace elements such as copper and zinc); the iron leptopodsols are less leached, less acidic, and more fertile, although still poor.

The leached sands are widespread in the study area, and occur on a large proportion of the public land. They are most common in the Kanawinka and Nelson Land-Zones.

Red to black soils on limestone

Profiles of these soils (terra rossa and rendzina) usually have uniform sandy loam texture but may sometimes be gradational, with clay loams at depth. Usually a weakly to moderately developed crumb structure at the surface grades to blocky at depth. The soils are friable throughout. Horizon differentiation is weak and limestone is usually found at shallow depth.

Despite greater fertility than that of the leached sands, these soils are still deficient in many nutrients, especially in the sandier profiles. The black soils (rendzina) may be alkaline, with pH as high as 8.5. They are restricted to the dune limestones of the Nelson Land Zone.

Brown soils on basalt

The brown earth and chocolate soils - brown to reddish in colour - tend to become yellower with depth. Their loam to clay loam textures show little or no change with depth. They are crumb or blocky structured, with friable to hard consistency.

As these soils have developed on recent flows of basalt, large boulders of undecomposed rock are common and prevent mechanical clearing and working of the land.

Generally fertile, these soils contain an exceptionally high level of available phosphorus. They are found in the southern part of the Hamilton Land Zone. Morphologically similar soils occur on other parent materials, but have very restricted distribution.

Dark structured clays

The prairie soils and chernozems have dark brown to black profiles at the surface, which may become yellowish with depth. They have heavy clay textures and distinct blocky structure. Supplies of plant nutrients are adequate, with the exception of phosphorus.

They occur mainly on the Mesozoic sediments of the Casterton Land Zone, with limited occurrences on basaltic tuff and alluvium of the Hamilton Land Zone.

Brownish gleyed soils

Marsh and meadow soils form a variable group characterized by a gleyed subsoil, indicating permanent or intermittent waterlogging.

They may be light to heavy textured, and in some cases profiles may be gradational. Analyses indicate deficiencies of several plant nutrients in the marsh soils, but the meadow soils are probably more fertile. Profiles are moderately to slightly acidic.

These soils are confined to swamps and other low areas subject to a high water

table. They occur most commonly in the Heywood and Kanawinka Land Zones, but also in low topographic positions throughout the study area.

Weakly bleached gradational soils

Clay leptopodsols are characterized by a greyish surface over a weakly bleached clay loam horizon. Acid throughout, they are deficient in phosphorus, nitrogen, and potassium.

The yellowish brown or orange to reddish heavy clay subsoil may be mottled. A layer of ironstone gravel often occurs on the top of the clay. The structure of these soils is generally poorly developed and consistency varies from friable to hard.

They occur on a variety of parent materials in areas where the average annual rainfall exceeds 30 in. Under lower rainfalls, soils in similar situations are duplex. The major occurrence of the soils is in the Portland and Heywood Land Zones.

Friable brownish gradational soils

The soil profile of the acid brown earths resembles that of the weakly bleached gradational soils, except for greater organic matter accumulation at the surface and the lack of a bleached horizon. Textures are sandy loam to sandy clay loam.

These friable soils have well-developed structure. They are acidic and are deficient in phosphorus, nitrogen, and potassium.

Their distribution is restricted to rises in the Kentbruck Heath (Kanawinka Land Zone).

Friable reddish gradational soils

In krasnozems and transitional krasnozems, texture changes gradually from clay loam to heavy clay with depth. The moderate to well-structured profile is friable throughout. The acid soils have a fairly high content of available potassium, but low available nitrogen and very low available phosphorus.

They are confined to basalt where annual rainfall exceeds 30 in., and thus occur in the Portland Land Zone.

Red, yellow, and brown duplex soils

In a typical solodic or solonetzic soil profile, the light-textured topsoil abruptly overlies a clay subsoil of variable colour and structure. This is often a shallow bleached horizon above the clay. Generally, these acid topsoils and alkaline subsoils have poor reserves of phosphorus and often nitrogen. Reserves of potassium are low in the A horizons.

Characteristically, the subsoils contain high levels of sodium and magnesium.

The soils occur on a variety of parent materials in areas with average annual rainfall below 30 in., and are most common in the Dundas, Hamilton, and Lowan Land Zones.

This profile of a duplex soil clearly shows the sharp change between the sandy loam upper horizon and the darker clay

Chemical Properties

A convenient way of discussing the soils is to group them into four categories based on texture profiles as follows:

Category A: soils with uniform-textured sandy profiles - undifferentiated calcareous sands, leached sands, and red to black soils on limestone.

Category B: soils with gradational textured profiles - weakly bleached, friable brownish, and friable reddish gradational soils.

Category C: soils with duplex profiles - red, yellow, and brown duplex soils.

Category D: soils with uniform-textured clayey profiles - brown soils on basalt and dark structured clays.

Some of the red to black soils on limestone may fall into Category B. The brownish gleyed soils exhibit variable texture, and so may fall into Category A or B.

Although chemical properties have been briefly mentioned in the descriptions of each soil group above, this section summarizes the main chemical features of the soil in the study area. Of the many elements plants require for satisfactory growth, nitrogen, phosphorus, and potassium are highlighted here because they are the elements most commonly lacking in Australian soils.

Cation exchange capacity

The ability of a soil to hold nutrients in available forms for plants - cation exchange capacity - generally corresponds with the clay and organic matter contents of the soil.

Category A soils have a low average capacity that is highest near the surface due to the accumulation of organic matter. In Category B soils it increases with depth, and in Category C it increases suddenly with depth because of the sudden increase in clay content in the subsoil. Category D soils have a moderate to high capacity throughout.

Available potassium

Category A soils contain little available potassium. In Category B soils the levels are moderate in the topsoil and low in the subsoil, and in Category C they are low in the topsoil and moderate in the subsoil. Moderate levels occur throughout the profile of Category D soils.

Available nitrogen

The ratio of nitrogen to organic carbon in a soil provides a rough estimate of its ability to supply nitrogen to plants. Carbon:nitrogen ratios of less than about 20 seem to be desirable for pasture growth. They vary widely within the soil categories described above - being generally moderate to high for Categories A and B, moderate for Category C, and low to moderate for Category D. This indicates that most soils in the study area have available nitrogen contents below acceptable levels.

Available phosphorus

Like most Australian soils the majority of those in the study area are deficient in phosphorus. The brown soils on recent basalt flows are an exception, but have very limited distribution.

Soils and Land Use

The growth of plants depends primarily upon the following five factors: the amount of light received, a range of suitable temperatures, and the availabilities of air, water, and plant nutrients. The physical properties of soil, in conjunction with climate and topography, affect the availability of air and water, while the availability of plant nutrients is affected by the soil's chemical properties, such as the amount and types of clay minerals and organic matter and the degree of alkalinity or acidity.

The physical properties of soils include texture, structure, particle size, and bulk density. They are interrelated and affect the way the soil behaves when wet and dry, its capacity to store moisture for use by plants, and its degree of aeration. These physical properties are as important as chemical properties.

Stock terracettes near Casterton

Most nutrient deficiencies can be corrected simply by adding the necessary fertilizers. However, it is far more difficult to overcome poor physical properties.

Texture and structure of each soil horizon affect the infiltration of water and air and the water-storage capacity of the soil. Sands are permeable and thus well drained, but retain little water for use by plants during the dry season. Many clays, on the other hand, can store larger amounts of water and, in the climatic conditions of the study area, are the more productive soils, except where poorly drained.

In addition to impeding layers of clay, sandy horizons of coffee rock at depth influence the storage and movement of water.

The nutrient status of the soils is also related to texture. The clays have greater chemical reserves than the sands and so require simpler fertilizer treatments.

The following section discusses these interrelations within the most common soil groups in the public land of the study area - the leached sands, the weakly bleached gradational soils, and the brown duplex soils.

The leached sands

Chemical and physical data show that these soils are infertile, with a low potential for development. The experience of farmers and agronomists supports this assessment.

The very heavily leached sands (nompodsols) are highly acid and, before pasture can be established, deficiencies of phosphorus, nitrogen, potassium, copper, and zinc must be rectified and the acidity reduced with lime. The less heavily leached sands (leptopodsols) are similar except that, being less acid, they do not require lime.

Once the addition of fertilizer overcomes the nutrient deficiencies of these soils, their low water-storage capacity becomes limiting. They dry out rapidly in late spring and early summer, and the growth of pasture plants rooted in the top few inches ceases. This problem becomes more serious where annual rainfall decreases, in the northern part of the study area.

Plantations of radiata pine (*Pinus radiata*) have grown successfully on leached sands that are yellow, slightly loamy in texture, and of low to moderate fertility. Plantations may be grown on the grey, heavily leached sands only if these contain a moisture-impeding layer within 48 in. of the surface and if phosphorus fertilizer is added.

Discovery Bay sand dunes and farmland

Weakly bleached gradational soils

These soils contain moderate amounts of nutrients, and can be brought to a satisfactory status by adding phosphorus and growing clover. Most of them have loam to clay loam textures, with a moisture-impeding heavy clay subsoil.

They occur in cool areas of high rainfall and store much soil moisture. They appear to be suitable for plantations of pines if phosphorus is added, although some sites may not be sufficiently well drained.

Brown duplex soils

The brown duplex soils common on the public land consist of grey-brown sand to loamy sand over a heavy clay subsoil. Where plant roots can reach this subsoil they seldom lack any nutrients except phosphorus. In wet positions these soils may become waterlogged in winter - they then have good moisture reserves for summer but cannot support the growth of pines or other plants that will not withstand waterlogging. However, they are suitable for development of pastures.

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VEGETATION

In temperate climates vegetation dominates our impression of natural land - it is everywhere, displaying infinite variation as species, form, density, and height change across the landscape. It constitutes a major part of what we regard as scenery, naturalness, or wilderness, and profoundly influences our evaluation or characterization of an area of land.

Plants provide for many of Man's needs - food, clothing, timber, fuel, and chemicals - and protect other values such as soil stability, grazing, hunting, various forms of wildlife, water yield, and water quality. The role vegetation plays in recreation is becoming more important as urban populations grow.

This chapter is divided into two parts. The first deals with the importance of vegetation in conservation and with general principles of its ecology, description, and classification. The second describes the vegetation of the study area, using the legend on the vegetation map as a scheme of classification.

With a few exceptions the descriptions refer to vegetation on public lands, as very little native vegetation remains on private land in the study area.

General Principles

The food chain

Photosynthesis is the process by which green plants convert water, carbon dioxide, and certain simple minerals into organic compounds, releasing oxygen to the atmosphere. The energy necessary for the process comes from sunlight.

With the minor exception of some specialized bacteria, all the activities of all living organisms are based on the consumption of the products of photosynthesis, because of the flow of energy through the so-called food chain. For example, insects that feed on plants provide the food of the brown phascogale and, in turn, this creature is preyed on by hawks or owls. The food from which all these animals draw their energy for growth, movement, and reproduction ultimately depends upon the material and energy formed and stored by plants. Thus plants are primary producers in the truest sense of the word.

Study of vegetation

The importance of vegetation to land use and conservation can be summarized under three broad headings.

Firstly, plants are a group of organisms of intrinsic interest and beauty. The study of plants is a prerequisite for agriculture and forestry, and in the field of pure science has contributed to our knowledge of genetics, evolution, biochemistry, pharmacology, and ecology. The need to preserve as many as possible of the species and communities of the biosphere is set out in chapter 14. Vegetation merits special attention because of its unique position as the first link in the food chain.

Secondly, vegetation is important for the conservation of animals, birds, and insects, as all these organisms depend directly or indirectly on plants for their food, and often for shelter, nesting places, and protection. Most animal habitats can be described in terms of vegetation, and in the absence of detailed knowledge of the distribution of many animals, preservation of as many types of vegetation as possible should result in the preservation of the full complement of animals. The habitats of the birds and animals of the study area are described in chapter 11.

Thirdly, since the physical factors of a site - soils, climate, and topography - largely determine the natural vegetation on the site, the nature of the physical environment can be judged from the type of vegetation present. Assessing site factors in this way has the advantage that, while the factors that are usually of interest, such as soil fertility and degree of natural drainage, are hard to measure directly, vegetation can be readily mapped in the field and from aerial photographs. Field evidence and, if possible, experimental evidence should be available to show that the species or group of species does in fact accurately indicate a specific site condition. Within the study area, the relations between native vegetation and the land's potential for growing pasture or pine plantations have been elucidated and are used later in this report to classify land for these purposes.

Growth and development

Three factors are responsible for the great diversity in the form and composition of natural vegetation:

* the differing tolerances of plants to environmental factors
* the great differences that occur in the factors - temperature, light, soil fertility, and moisture - that make up the environment
* the availability of species (and their dispersal efficiency) in the particular area under study

Tree ferns in Little Moleside Creek, Kentbruck Heath

The plants present on any site are those whose requirements are met by the site. If the features of the site change rapidly, a correspondingly rapid change in the plant communities present will occur.

Plant succession

While the nature of the habitat basically determines the type of plant community, the community in turn determines many of the characteristics of its habitat. As plants colonize a previously bare area, they alter the original conditions of the site and impose new ones, and the modification of the environment in turn allows other, different species to become established. This process is called succession. For example, the first plants to colonize the bare sand blown onto beach ridges are grasses, such as marram grass. These trap further blown sand and grow through it, raising the level of the dune and changing the conditions.

Other grasses, herbs, and eventually scrub species now replace the pioneers and eventually stabilize the dune, adding organic matter to the sand; in time succession leads to the formation of dune-scrub and in some places dune-woodland.

In the early stages of succession the vegetation changes rapidly, but as the community develops the rate of change slows, till a stage is reached where the vegetation is in equilibrium with the environment and changes only as climate or soils change. Attainment of this stable phase may take several hundred years, and under conditions where the vegetation is periodically disturbed by fire, as is the case throughout most of Victoria, the final stage, or climax, is never reached.

However, secondary or deflected succession still takes place and vegetation develops and changes rapidly after fire. A community that is not the true climax but is maintained by Man's activities, such as grazing or frequent burning, is called disclimax.

In some cases, communities that appear to be stable since they are not undergoing directional change may be undergoing cyclic change - the vegetation passes through a number of phases that represent fluctuations about an average condition.

For scientific reasons, conservation of stages in succession is as important as conservation of climax communities.

Competition and dominance

These two processes play a major part in shaping the development of communities. Competition is the interaction between two species that have similar requirements, usually space, light, moisture, and nutrients. It may result in a balance being struck between individuals,

or the partial or complete displacement of one. Other interactions that may occur are parasitism and commensalism. Succession occurs when changes in the environment enable one species to gain a competitive advantage over an established species and so displace it.

The nature and function of a community is not determined equally by all the plants present. Some plants exert a controlling influence by virtue of their size or numbers, and these plants are known as dominants. Over much of the south-west, trees are dominant and condition the habitats of all associated species. Dominance may be regarded as a result of competition - for example, for a time eucalypt seedlings must compete with scrub species, but if they can overcome this competition they can grow and eventually dominate these rivals. Dominants exert their influence by creating shade, changing the microclimate, and creating water stress.

Influences on vegetation

The activities of Man have caused major changes to the environment and these have had many direct and indirect effects on the natural vegetation. Activities that have had major effects are grazing, logging, mineral extraction, introduction of weeds and rabbits, construction of roads and tracks, burning, and pollution with fertilizers and pesticides. The effects of these activities include initiation of new plant successions, loss of plant species, changes in wild animal and bird populations, and changes to the water table. All these factors act to change the natural ecosystems rather than destroy them. Natural communities react to imposed changes in a manner that, in the long term, tends to minimize change and bring about a return to stability.

Fire

Fire is mentioned above as a Man-induced factor that has resulted in change to the natural vegetation. This is an oversimplification; the existence of so many fire-resistant species shows that fire has been an important part of the Australian environment for thousands of years, originating from lightning strikes and, more recently, from the activities of Aborigines.

The relation between fire and vegetation is quite complex. The frequency of fire, its intensity, and the season of the year in which it occurs are important. The type of vegetation is also important, particularly the presence of physiological and morphological adaptations to fires such as epicormic buds, lignotubers, and thick bark. The minimum age to flowering and seed set and the sensitivity of seeds to fire are also important. Eucalypts are well adapted to escape the deleterious effects of fire, and frequent burning probably helps them competitively. Vegetation influenced by repeated fires never

reaches a mature or stable stage of succession.

Fire is a most important tool in the management of vegetation, and we already have techniques for controlling the intensity and rate of spread of low-intensity fires. The most important requirements now are a fuller understanding of the effects of fire on the different parts of the environment and clearly stated aims for the management of vegetation.

Management

Since neither the composition nor the form of vegetation is ever static, preservation must consist of managing change. It is essential to establish clear aims in the management of vegetation and to determine how much and what kind of change can be tolerated.

Aims will vary according to the specific land use required and the nature of the vegetation. For areas of near-climax forest managed as wilderness, one aim would be to keep fire to an absolute minimum. However, maintenance of most forest and heath communities in Australia demands prevention of destructive wild fires and this may best be accomplished by controlled fuel-reduction burning.

The presence of plant or animal species sensitive to frequent fire may demand modification of burning practices in certain areas. Some communities in successional stages after fire are particularly rich in species, and these cannot be conserved by the complete exclusion of fire. Similarly, conservation of a mosaic of communities created by grazing may require the retention of grazing. In some cases, rapidly expanding populations of native or introduced animals may have to be controlled by shooting.

Management is impossible without clear aims, and aims must be carefully examined to ensure that they are compatible. Preservation of a favoured dominant species, or of a particular stage of succession, may not be compatible with the preservation of some animal and bird populations.

Development of management techniques involves an understanding of the processes of succession and population dynamics, and manipulation of these processes to achieve aims.

Description and classification

The description and classification of vegetation require first a knowledge of the species present, or floristic composition, and the structure. However, the ecologist is rarely satisfied with this approach and usually endeavours to measure and describe as many as possible of the features of the environment of each vegetation type recognized.

Structure

The structure of a plant community is defined in terms of three components

* the vertical arrangement of the species into strata

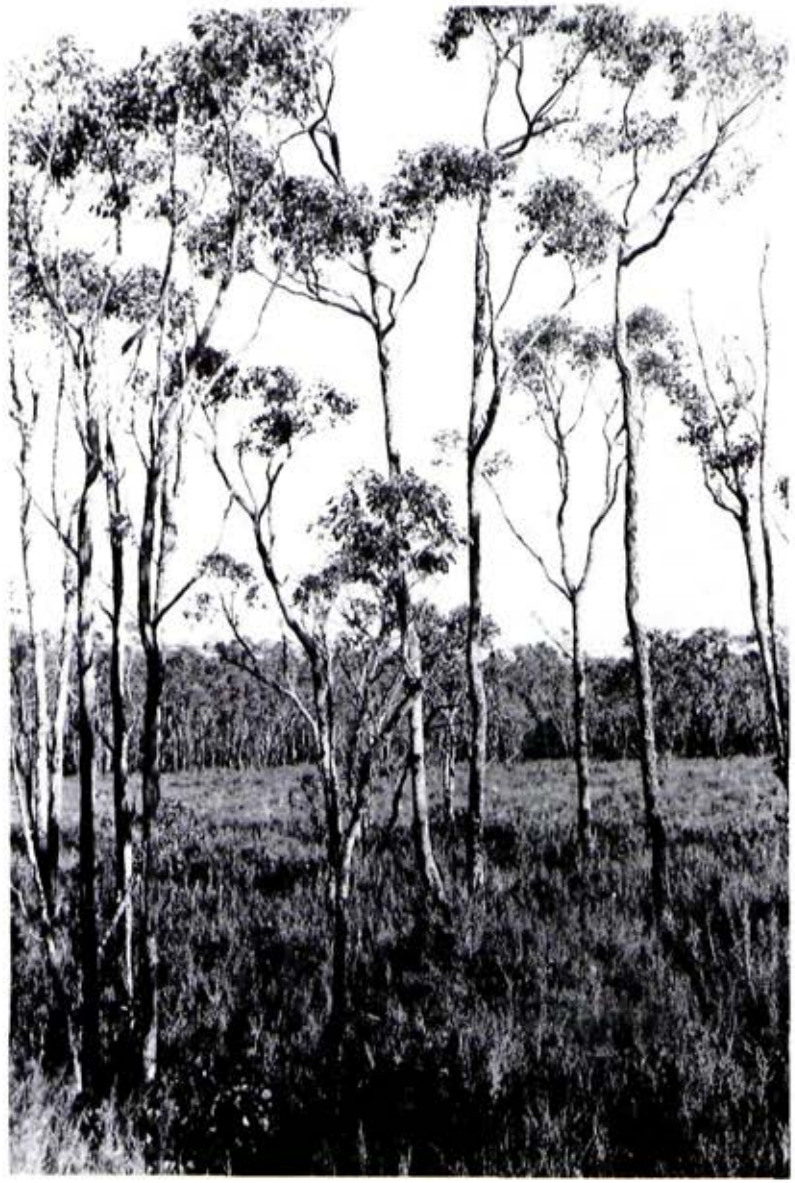
* the horizontal arrangement of plants, or spacing

* the abundance of each species

The stratification or layering of a stand of vegetation is readily seen. For example, the vegetation on certain sites in the Cobboboonee block consists of a layer of tree canopies (messmate and swamp gum) at a height of about 70 ft, an open small tree layer (blackwood) at 25 ft, a layer of bracken at 3 ft, and a layer of grasses and herbs at ground level.

The horizontal arrangement of a stand of vegetation refers to the position or distribution of plants in each layer. The distribution of individuals in a community is seldom random. Rather, individuals of a species are often grouped, and it is necessary to describe the size and pattern of the groups.

The abundance of a species can be described in several ways. These include subjective assessment using terms like common and rare, counts of the number of individuals within an area, and measurement of crown cover, which is the



Brown stringybark and heath, Kentbruck Heath

proportion of the ground that a vertical projection of the crowns of the plants under consideration occupies.

Floristics

When describing a large area of vegetation, a list of the species present may be helpful. However, floristic information means more if the species are grouped into units of those that usually occur together. The continuously varying nature of vegetation makes the description and delineation of discrete associations of species difficult.

Ecologists have made many attemps to define homogeneous floristic units and now little doubt remains that such units can be defined within certain limits.

In 1952, Beadle and Costin published the method of classification now most common in Australia. Its major floristic unit, the association, they defined as a "climax community in which the dominant stratum has a qualitatively uniform floristic composition, and which exhibits a uniform structure as a whole". The dominant stratum is "that which, because of its physiognomy and relative continuity, dominates the rest of the community in the sense that it conditions the habitats of the other strata".

Floristically similar associations of similar structure may be grouped into alliances. Associations may be subdivided on the basis of variation in the most important subordinate stratum, to form sub-associations.

This method of classification has been criticized on the ground that the groupings are determined subjectively, and that it places too much importance on the dominant species.

An alternative method aims at defining homogeneous species units by collecting data from carefully set-out plots, or quadrats, and processing these data statistically in a computer. This method delineates groupings of species that are truly associated, which form extremely useful units for defining habitats and as indicators of site conditions.

However, the method has the disadvantage that data collection is a painstaking and slow process, and the key species in any grouping may be a small plant that would be very difficult to map. These techniques are impracticable for mapping and describing the vegetation of the study area.

South-western Study Area

The inland plains of south-western Victoria were originally covered by grassy woodlands, with low stringybark forests and heaths on some areas of sandy soils. The lands closer to the coast carried dense forests and large

tracts of lowlands carried swamps and heath.

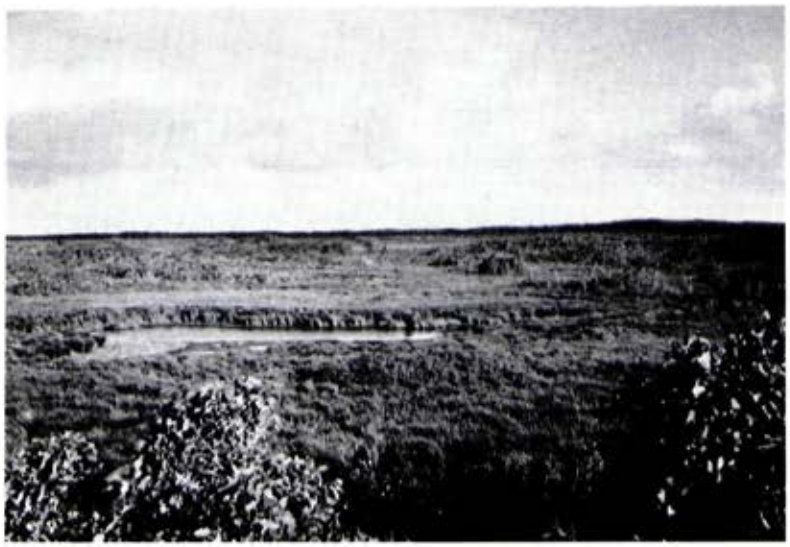
After a century of European occupation, the picture has changed considerably. The woodlands have been cleared or thinned out and the grasslands fertilized and new species sown for grazing. The only communities in the inland areas that have not been drastically altered are the stringybark forests, with a few woodland remnants. Near the coast the large areas of dense forest have been logged for many years, and most of the lowlands have been cleared for agriculture. Large areas of stringybark forests in the south-western corner of the study area have been cleared for pine plantations.

While the vegetation on most of the public land can be called natural, the effect of Man is apparent in the presence of weeds, thick scrub resulting from frequent fires, and other changes due to grazing and logging.

Mapping and classification

A classification of the vegetation has been drawn up and appears overleaf as Table 6. It provides a legend for mapping and a scheme for description. A map of the study area showing distribution of the vegetation may be found in the pocket at the back of this report. The description and detailed mapping were undertaken because of the importance and usefulness of vegetation in

Woodland of yellow gum (Eucalyptus leucoxylon) *and pink gum* (E.fasciculosa) - *Roseneath block.*



The natural heath and swamp vegetation in the Kentbruck Heath.

planning for conservation, as discussed earlier in this chapter.

The map was compiled from a series of maps supplied by the Forests Commission, and some aerial photograph interpretation and field checking. The Forests Commission maps use a variety of legends and scales, and the form of this material influenced the choice of mapping units used in this report.

The major subdivision divides the vegetation into structural formations, and Table 7 defines the terms used, which were established by Specht.

Specht's classification has been modified to the extent that one height class has been divided into two classes, which better suit the vegetation of the study area, and several formations defined by projective foliage cover have been grouped due to lack of field measurements of this parameter.

Each formation contains one or more floristic units - in concept these units resemble the associations and alliances of Beadle and Costin.

The units were chosen because they can be used with the existing information and can be mapped from aerial photographs. Mixtures are recognized when no one species comprises more than 75% of the individuals on an area. The units are readily identifiable in the field, and have considerable value in indicating variation in habitats and site conditions in the study area.

The classification and mapping describes vegetation as it is now, and no attempt has been made to distinguish successional communities. The few cases of obvious successional types within the study area are referred to in the description below.

Complexes have been mapped where the distributions of two or more formations are so irregular or small that they cannot be conveniently mapped individually.

Table 6 CLASSIFICATION OF VEGETATION

FORMATION	FLORISTIC UNIT	UNDERSTOREY VEGETATION
OPEN–FOREST II (>60 ft. height)	1a Messmate	Bracken and grasses, scattered shrubs; heathy plants
	1b Brown Stringybark	Bracken, Yacca; heathy plants
	1c Manna Gum	Bracken and grasses, scattered wattles
	1d Peppermint	heathy plants and low wattles; bracken and grasses
	1e Swamp Gum	tea tree, sedges, Sword Grass; wattles, grasses
	1f Messmate-Brown Stringybark	as for the corresponding species above
	1g Messmate-Peppermint-Swamp Gum	
	1h Manna Gum-Peppermint-Swamp Gum	
	1i Swamp Gum-Peppermint	
OPEN–FOREST I (30–60 ft. height)	2a Brown Stringybark	Bracken, Yacca, Grasstrees, low hardleaved shrubs, heathy plants
	2b Brown Stringybark-Manna Gum	Bracken, low shrubs, grasses
	2c Swamp Gum-Peppermint	Sword Grass, low tea tree, low shrubs
WOODLAND	Red Gum	grasses, herbs and low sedges
	3b Yellow Gum	grasses and low shrubs
	3c Pink Gum	open heathy plants
	3d Manna Gum	Bracken, grasses, low shrubs
	3e Red Gum-Yellow Gum	as for the corresponding species above

Table 6 CLASSIFICATION OF VEGETATION (Continued)

WET SCRUB		Brown Stringybark-Peppermint	Yacca, heathy plants
DRY SCRUB		*Brown Stringybark-Messmate*	*dense heathy plants*
LIMESTONE DUNE COMPLEX (Bulley Ranges)	Low Open-forest	Brown Stringybark and Manna Gum	Bracken, shrubs, grasses
	Dry Scrub	Coast Beard-heath and Coast Wattle	
	Dry Heath	Yacca and Grasstrees	scattered low shrubs
SAND DUNE COMPLEX (Coastal)	Dry Scrub	Coast Wattle, Coast Beard-heath, Daisy Bush	grasses, succulent plants, some emergent Moonah, Drooping She-oak
	Grassland	Wallaby Grass, other grasses and sedges	
COASTAL SWAMP COMPLEX (*Long Swamp*)	Open water	Bulrush, Common Reed	
	Sedgeland	Numerous species of sedges and grasses	
	Wet Scrub	*Woolly Tea Tree and Scented Paperbark*	
HEATH		Many species including Dwarf Sheoak, Silver Banksia, Yacca, Common Heath, Sedges, Button Grass	Includes formations with sparse emergent trees or shrubs
SWAMP COMMUNITIES	Sedgelands	Rushes, sedges and grasses	
GRASSLAND		Includes farm land purchased for pine planting, the Palpara Settlement Scheme, some land under grazing licence, some grassland of native species, and fernland	
PINE PLANTATIONS		Predominantly Pinus radiata, with some P. pinaster and some land cleared but not yet planted	

Table 7

STRUCTURAL FORMS OF VEGETATION

Life form and height of the tallest stratum	Projective foliage cover of tallest stratum*		
	Dense (70-100%)	Mid-dense (30-70%)	Sparse (10-30%)
trees 60 ft *		Open forest II	
trees 30-60 ft		Open forest I	Woodland
shrubs 6-30 ft	scrub		
shrubs 0-6 ft	heath		
grasses, sedges		grassland	
ferns		fernland	

* Projective foliage cover is defined as the percentage of area covered by foliage, measured by a vertical point quadrat technique

* No large areas of vegetation in the study area contain trees more than 100 ft high

Description of the Vegetation

The following section defines and describes the formations as they occur in the study area, then the distribution, site conditions, and associated species for each floristic unit.

Where a species forms part of floristic units in more than one formation, it is fully described where it is first encountered. Some formations and floristic units that are characteristic in parts of the study area, but are too small in area to be mapped, are also described.

The map does not show vegetation on narrow stream and coast frontages, and small isolated blocks (gravel and water reserves).

Appendix I lists the common plants of the study area, with the formations or habitats in which they usually occur.

Open Forest II

In this community the dominant stratum consists of trees more than 60 ft high, with close or interlacing crowns, over an understorey stratum of sparse sclerophyllous shrubs, and a grassy, heathy, or ferny ground cover.

Open forest II occurs where rainfall exceeds 28 in. and where soils are well drained and moderately fertile. It is the most common formation in the Annya, Hotspur, Homerton, and Cobboboonee blocks.

On sites with moist, well-drained soils, the understorey stratum is well developed and in a few places - the beds of parts of the Stokes, Crawford, and Fitzroy Rivers and the Little Moleside Creek - it consists of tree ferns *(Dicksonia antarctica)*, hazel *(Pomaderris)*, and other mesomorphic plants, similar to the vegetation of mountain fern gullies. This type of vegetation is commonly referred to as wet sclerophyll forest, and the small areas described above are the westernmost occurrences of this type in eastern Australia.

Messmate *(Eucalyptus obliqua)*

Distribution: while it is common in the Cobboboonee, Narrawong, Annya, Homerton, and Hotspur blocks, messmate also has isolated occurrences in the gully of the Moleside Creek in the Kentbruck Heath

Open forest II of messmate (E. obliqua) *on Cobboboonee block*

block and in the gully of a creek southwest of Digby in the Weecurra block. A low spreading form of the species grows near the South Australian border between Nelson and the Glenelg River.

Form: this tall forest tree usually has a straight, branchless trunk. Bark is typical thick stringybark to the tips of

the fine branches. The unusual form of the species occurring north of Nelson consists of a low, heavily branched, and spreading shrub, with thick foliage where the stands have not been heavily burnt.

Site: messmate grows on a wide range of sites - however always with rainfall greater than 30 in. and on moderately fertile well-drained soils. The most common of those supporting the species are the weakly bleached gradational soils, with some brown duplex soils in the Homerton block. North of Nelson, messmate grows on shallow red soils on limestone. It reaches its best development on brown, weakly bleached gradational soils in the Cobboboonee and Annya blocks, where the best stands exceed 100 ft at maturity.

Associated species: messmate usually occurs in pure stands, although mixtures with peppermint *(E. nitida)*, swamp gum *(E. ovata)*, manna gum *(E. viminalis)*, and brown stringybark *(E. baxteri)* are common. It is usually associated with a sparse understorey of blackwood *(Acacia melanoxylon)*, sweet bursaria *(Bursaria spinosa)*,prickly moses *(A. verticillata)*, and tea tree *(Leptospermum juniperinum)*. Two types of ground flora are commonly found - bracken *(Pteridium esculentum)* and grasses with some sclerophyllous shrubs, or low heathy plants, such as common heath *(Epacris impressa)*, sword grass *(Gahnia radula)*, and silver banksia *(Banksia marginata)*.

Brown stringybark *(E. baxteri)*

Distribution: this species has a very wide distribution in the study area, and is found in every block with the exception of Discovery Bay. It is the most common tree species in blocks located on the Kanawinka and Nelson Land Zones.

Site: it can tolerate a wide range of soil moisture conditions, from the deep sands, which are the driest soils in the study area, to sites where the dominant vegetation is wet heath. It can also tolerate very low nutrient levels and is

Open forest I of brown stringybark (E. baxteri) - *Youpayang block.*

the only tree species found on the deep, acid, infertile sands. The species also grows on more-fertile sands in the Nelson Land Zone. Brown stringybark is normally found on sandy soils, but in a few places in the Cobboboonee block it occurs on very gravelly variants of the clayey, weakly bleached gradational soils.

Form: in form, brown stringybark varies widely according to the site conditions. On well-drained soils of moderate fertility in areas receiving more than 30 in. annual rainfall, the species grows as a tall forest tree. This form is mapped as Open forest II. On excessively dry or infertile sites the species assumes a stunted spreading form, and is mapped as Open forest I or dry scrub. In areas of the Lower Glenelg and Mount Richmond blocks near the coast, brown stringybark grows as a low tree on well-drained, moderately fertile soils. The low form of the species here appears to be due to proximity to the coast and the effects of salt-laden onshore winds. On wet sites, the species assumes a mallee-like form and this has been mapped as wet scrub.

Associated species: brown stringybark grows in pure stands over wide areas. On moderately fertile sites manna gum forms a minor part of the stand, and peppermint and swamp gum are found in mixtures with brown stringybark on wet sites. Understorey species include black wattle *(Acacia mearnsii)*, blackwood *(A. melanoxylon)*, and coast beard-heath *(Leucopogon parviflorus)* on fertile sites, while heathy vegetation - grasstree *(Xanthorrhoea australis)*, yacca *(X. minor)*, sword grass, banksia, guinea flower *(Hibbertia spp.)*, conebush *(Isopogon sp.)* - is usually found on infertile soils. Bracken is a noticeable understorey species on well-drained sites.

Manna gum *(E. viminalis)*

Distribution: although very widely distributed throughout the study area, manna gum does not occur in large pure stands but rather in mixtures with many other eucalypts. Small areas of pure manna gum occur at Lyons in the Cobboboonee block and in the Lower Glenelg and Homerton blocks. Manna gum woodlands occur in a distinctive formation in the Tooloy block.

Site conditions: manna gum grows on sites that are well drained, although wetter than those for brown stringybark or messmate, and relatively fertile. In the Cobboboonee block, it is found on friable reddish gradational soils and in Lower Glenelg block on red soils on limestone. In the Tooloy block the species occurs on red silty and sandy soils over ironstone and clay at shallow depth. In the Homerton block, it grows on brown gradational soils and on stony red-brown loams derived from Recent basalt flows. Large areas of these flows just outside the study area (The Stones)

carry pure stands. In the northern part of the study area, manna gum occurs with brown stringybark on sandy soils with impeded drainage and on the fringes of stands of red gum.

Form: manna gum displays a wide range of forms depending on site conditions. On moist, well-drained, fertile soils the species grows into a tall tree with smooth bark that decorticates in long ribbons - this form is normally mapped as Open forest II. Poorer sandy soils produce a shorter tree, with heavy branching and rough scaly bark almost to the tips of the branches. This form, which is found in the northern part of the area (e.g. Tooloy) and has sometimes been confused with scent bark *(E. aromaphloia)*, is mapped as Open forest I or Woodland. On wet sites the species can exhibit a low shrub or mallee form.

Associated species: on clayey soils in the south-eastern part of the study area, manna gum grows with peppermint and swamp gum over bracken, grasses, and scattered sclerophyllous shrubs. In the Lower Glenelg block the species occurs with blackwood over bracken and grasses. The manna gum woodlands in Tooloy have a tall shrub layer of silver banksia and blackwood over bracken and grasses.

Peppermint *(E. nitida)*

Peppermint is common throughout the south-eastern part of the study area. A small stand occurs in the Youpayang block, and the species is present in the Drajurk and Wilkin blocks, but grows more commonly south of this, especially in the Annya, Homerton, Cobboboonee, and Narrawong blocks.

Site conditions and form: this species grows as a tall forest tree where soils are moderately fertile and have slightly restricted drainage - its drainage requirements lie between those of manna gum and swamp gum. On wet sites the species rapidly assumes a low spreading habit and on extremely wet sites it becomes a mallee-type shrub. It is common on the Kentbruck Heath in this form.

Associated species: as a forest tree, peppermint is associated with scent bark over myrtle wattle *(Acacia myrtifolia)*, sclerophyllous shrubs, and heathy plants. As a low tree it is associated with brown stringybark and a heathy ground flora.

Swamp gum *(E. ovata)*

Distribution: swamp gum occurs widely in the study area, being found in all blocks except Discovery Bay. Pure stands grow in the southern blocks with rainfall exceeding 30 in., but in drier areas, although still common, each occurrence covers only a small area. Swamp gum is one of the most common species in the Homerton, Annya, and Cobboboonee blocks.

Site conditions and form: the species is found on sites that are wet in winter and experience little moisture stress in summer. Their soil fertility status varies widely. Swamp gum occurs throughout the area in drainage lines and around heaths and swamps. In the wetter southern blocks, it also grows on heavy clay soils in a semi-woodland formation, or in Open forest II with peppermint. It grows as a tall forest tree on moderately fertile soils with partially restricted drainage in the Homerton, Annya, and Cobboboonee blocks. Swamp gum assumes a mallee form on shallow red soils on limestone along the Glenelg River north of Nelson, and on shallow duplex soils around heaths in the north of the area.

Associated species: the tree form of swamp gum occurs in mixtures with peppermint, and as a minor component in stands of manna gum, messmate, and brown stringybark. These stands usually have an understorey of sparse blackwood over bracken, grasses, and low shrubs. On wetter sites swamp gum is usually associated with peppermint over sedges or heathy plants. The mallee forms occur with woolly tea tree *(Melaleuca lanceolata)* in the Lower Glenelg block, and with heath species such as cone bush, yacca, sheoak *(Casuarina sp.)*, and silver banksia in the northern blocks.

Open Forest I

In this community, the dominant stratum consists of trees 30-60 ft high, over a sparse stratum of sclerophyllous shrubs and a ground flora of ferns or heathy plants. The trees tend to be more heavily branched than those in Open forest II. The formation covers large tracts in the study area where rainfall is less than 30 in. per annum, and is the most common one on the acid white sands north of the Stokes River. It occurs in the southern blocks on sites where drainage is excessive or restricted, those with low soil fertility, or those exposed to onshore winds.

The species that make up the floristic units in this formation have been described above.

Woodland

The dominant woodland stratum consists of trees with deep rounded crowns, which form an open canopy. As mapped in this report, it includes the formation commonly known as heath woodland - fairly widely spaced trees over low open heath.

Woodlands occur in the northern blocks where rainfall is less than 30 in., growing on moderately fertile duplex soils on the clayey or silty flats in the Kanawinka Land Zone where the sand sheets are thin or absent. They contain gum-type eucalypts, most commonly red gum.

Large areas of gum woodlands have been cleared for agriculture in the inland parts of the study area.

Red gum *(E. camaldulensis)*

Distribution: the species occurs commonly in the northern half of the study area although only sparsely on public land. Small isolated occurrences are found south of the Stokes River - about 100 acres in the north-eastern corner of the Cobboboonee block, a few trees in the Homerton block, and a thin sparse line of trees fringing the Glenelg River as far as the South Australian border.

Site conditions: red gum occurs chiefly on the wetter duplex soils. It is always found on relatively fertile soils, never on sandy, shallow, or stony ones. Sites are often flooded or waterlogged in winter.

Form: the species displays a consistent woodland form throughout the study area. The tree usually has a short bole, with heavy branching and a wide thin crown.

Associated species: red gum typically occurs in pure stands. However, where sites are reasonably well drained, mixtures with yellow gum *(E. leucoxylon)* or manna gum may occur. Swamp gum may occur with it on wet sites. The understorey usually consists of low grasses, herbs, and sedges, with very sparse sclerophyllous shrubs.

Yellow gum *(E. leucoxylon)*

Distribution: this species is restricted to the Kanawinka, Roseneath, Bogalara, and Youpayang blocks in the north of the study area, with the exception of small occurrences in the Weecurra and Annya blocks, and near Nelson. It is common throughout the Wimmera.

Site: yellow gum occurs on duplex soils, especially those without acid sandy top-

Pink gum (E. fasciculosa) *over duckbush* (Hakea rostrata) *and yacca*(Xanthorrhoea minor) - *Woodland, Roseneath block.*

soils. It has more tolerance of wet conditions than brown stringybark and less than red gum, and so it often occupies a position between these two species. Its occurrences in the wetter blocks in the south of the study area are regarded as remnants of a former wide distribution during a period of lower rainfall.

Form: like manna gum, peppermint, and brown stringybark, yellow gum shows a range of form according to the moisture status and fertility of the site, from a spreading woodland tree to a mallee shrub form.

Associated species: the woodland form of yellow gum occurs with very sparse black wattle over low scattered sclerophyllous shrubs such as duckbush *(Hakea rostrata)* and gold dust wattle *(Acacia acinacea)*, and yacca and sparse grasses. On sites with restricted drainage, it grows with pink gum *(E. fasciculosa)*, swamp gum, and manna gum over an open heath of duckbush, yacca, and silver banksia.

Pink gum *(E. fasciculosa)*

Distribution: the Victorian distribution of this species is restricted to the north-west corner of the study area in the Roseneath, Kanawinka, and Bogalara blocks. It has a wider distribution in South Australia, where it is known as hill gum. Most of the land that originally carried pink gum in Victoria has been cleared for agriculture.

Site: it appears to have the same site requirements as yellow gum - brown solodic soils, with clay within 24 in. of the surface.

Form: pink gum is difficult to distinguish from yellow gum and hybrids have been found. In form it varies from a medium-size woodland tree through stunted rough-barked forms to a mallee-like form, according to the severity of the site.

Associated species: it grows with yellow, manna, and swamp gums, usually over an open heath of yacca, duckbush, and silver banksia.

Wet Scrub

This community of shrubs 6-30 ft high with dense to open canopy, is restricted to wet areas in the southern part of the study area. In the case of the brown stringybark-peppermint floristic unit, the formation consists of an open community of stunted shrubs over a dense layer of wet heath. This type occurs in and around heaths in the Kentbruck Heath, Mount Richmond, and Hotspur blocks.

Woolly tea tree - scented paperbark *(Leptospermum lanigerum - Melaleuca squarrosa)*

This community occurs in Long Swamp, in short gullies leading to the Glenelg River, in swampy depressions in the Lower Glenelg block, and in the bed of

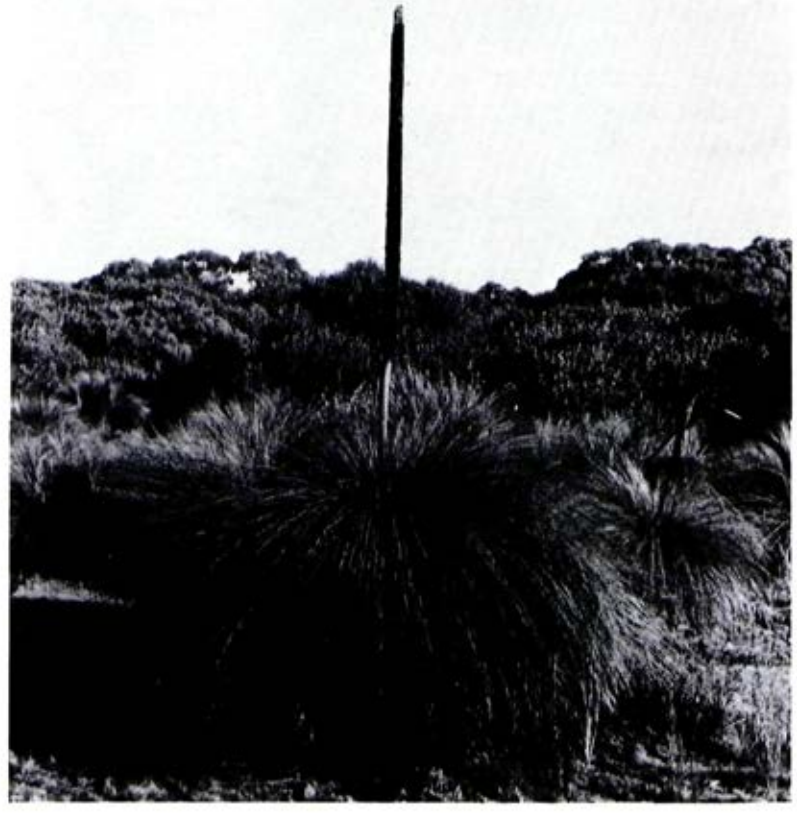
the Crawford River. Soils are sandy or peaty, and are waterlogged for most of the year. The community forms a very dense canopy, and ground cover consists of sparse sedges. Although it is not rare, most of the areas are too small to be shown on the map.

Dry Scrub

Shrubs 25-30 ft high, with wide deep crowns, cover an understorey of sparse sclerophyllous shrubs and a ground flora of grasses or heath. The formation occurs on very shallow soils on limestone north of Nelson and in the Lower Glenelg block, and appears to be subject to extreme moisture stress in summer.

Limestone-Dune Complex *(Bulley Ranges)*

The Bulley Ranges are a group of steep limestone dunes in the Lower Glenelg block about 10 miles east of Nelson. Grazing and burning had reduced the vegetation from what was probably Open forest I to a grassland with a few pockets of forest and scrub. With the removal of cattle and protection from fire, scrub and forest are rapidly recolonizing the area. At present three formations occupy most of the Ranges. Open forest I, dominated by brown stringybark with some manna gum, occupies swales and the lower ridges, where a reasonable depth of leached sands covers limestone. The shallow soils of the crests and upper slopes of the dunes support a dense dry scrub, 6-15 ft high, comprising coast wattle *(Acacia sophorae)*, coast beard-heath with golden wattle *(A. pycnantha)*, and some emergent drooping sheoak *(Casuarina stricta)*. The middle and lower slopes carry an open dry heath of grasstrees 2-5 ft high with sparse grasses and herbs between them.



Grasstree (Xanthorrhoea australis) *and dry scrub - Bulley Ranges.*

A few small areas of grassland remain in swales in the northern part of the Ranges. The most common species are wallaby grasses *(Danthonia spp.)* tussock grass *(Poa sp.)*, and sedges. A few large moonah trees *(Melaleuca lanceolata)* grow in the north-eastern part.

The scrub and forest formations are spreading rapidly into the areas of dry heath. It appears that the distinctive appearance of the area will be retained only by slowing down the advance of the scrub formations. This can probably best be done by burning. Grasstrees are capable of very rapid recovery after fire, and burning would give the heath a competitive advantage over the coast wattle scrub.

Sand Dune Complex (Coastal)

This complex occurs on the sheltered inland parts of the large areas of calcareous sand fringing Discovery and Bridgewater Bays. The community consists of low shrubs, grasses, sedges, and herbs. Density varies considerably, depending largely on the degree of exposure to wind.

The most common species are coast beard-heath, daisy bush *(Olearia axillaris)*, coast wattle, and other shrubs, with a ground cover of softer herbs. Grasses and sedges *(Scirpus sp.)* also grow in the swales between the dunes, where organic matter has accumulated and the moisture regime is better.

Dry scrub of coast beard-heath (Leucopogon parviflorus) *and coast wattle* (Acacia sophorae) - *Sand Dune Complex, Discovery Bay.*

Some drooping sheoak trees grow on sites that have been stabilized for some time, and moonah trees occur on the adjacent limestone dunes. The vegetation has been subjected to grazing and firing for many years.

Coastal Swamp Complex (Long Swamp)

The very varied vegetation of the Long Swamp area contains a large number of species of sedges, rushes, grasses, and

herbs. It is restricted to a line of swamps behind coastal dunes south-east of Nelson and contains three formations, which reflect the degree of wetness of the site.

Open water is being colonized by common reed *(Phragmites communis)* and bulrushes *(Typha spp.)* Extensive sedge meadows are choked with numerous sedges and grasses. Slightly drier sites carry dense wet scrub of woolly tea tree, scented paperbark, and twiggy daisy bush *(Olearia ramulosa)*. The complex is changing slowly: the area of open water decreases as the edges are colonized and the level of the peaty soil builds up. In several places the complex is threatened with inundation with sand from the line of unstable dunes between it and the sea.

Heath and low swamp gum (E. ovata) - *Roseneath block*

Heath

The heaths form a community of sclerophyllous shrubs 1-6 ft high. Those in the south of the area grow densely, but those in the drier north are more open. They are found on very infertile wet soils, although some dry heaths on deep impoverished sandy soils (Kentbruck Heath block) occur in the study area. While common in all blocks, they are most common in low areas among the sand sheets of the Kanawinka Land Zone. They often form the understorey beneath forests and scrubs on infertile sites.

Two reasons for the great scientific interest in the heath formation are its ability to flourish on very impoverished acid soils and its amazing regenerative power after fire, from underground rootstocks or from seed. Fire is a constant feature of the formation, and the vegetation changes and develops rapidly after burning. Repeated firing at short intervals may prevent the

stunted eucalypts present in many heaths in the area from developing into trees.

The heaths of the study area are very rich in species - representatives of the genera *Banksia, Casuarina, Leptospermum, Acacia, Xanthorrhoea, Melaleuca, Lepidosperma,* and *Leptocarpus* are common. Attractive or showy species include golden spray *(Viminaria juncea),* button grass *(Gymnoschoenus sp.),* geebung *(Persoonia sp.),* purple flag *(Patersonia sp.),* various paperbarks *(Melaleuca spp.),* tea trees *(Leptospermum spp.),* heaths *(Epacris spp.),* beard-heaths *(Leucopogon spp.),* and fairies apron *(Utricularia spp.).*

Swamp Communities

These communities are described and classified on the basis of habitat, rather than structure. They occur in low areas where the water table is above the soil surface for most of the year. Swamps are common throughout the study area. Most support sedgelands of numerous species of reeds, sedges, and grasses. Where the floor of the swamp has been built up by accumulation of peat, a low grassland or herb field may flourish in summer - such swamps in the Lower Glenelg block are being colonized by woolly tea tree.

Grassland

This formation includes pasture on farm land that has been purchased for pine planting in the Hotspur, Cobboboonee, and Mount Richmond blocks, and the Palpara Settlement Scheme in the Lower Glenelg block.

Some land under grazing licence in the Discovery Bay and Mount Richmond blocks carries native and improved pasture.

Small areas of grasslands comprising native species occur in the Lower Glenelg block near Wanwin and in the Bulley Ranges. Although we do not know the history of the areas near Wanwin, it seems likely that the grasslands are the result of burning and grazing in the past. These areas are being rapidly colonized by manna gum - old aerial photographs show that the extent of the grassland was formerly much greater.

Some small areas of bracken fernland have been placed into this formation for convenience of mapping. They occur in the Homerton block near Tyrendarra and Lake Condah, and are the result of burning and grazing.

Other Communities and Species

Soap mallee *(E. diversifolia)*

A small stand of soap mallee occurs at Cape Nelson south-west of Portland, and is the only occurrence of the species in Victoria. Parsons has suggested that the present distribution of the species, in widely scattered stands along the southern coast of Australia, represents

relics of a former wide distribution during a period of lower rainfall and lowered sea levels.

The area of soap mallee at Cape Nelson has been reduced by clearing for agriculture, and much of the remaining stand is on private property.

Salt marsh

A small area (about 12 acres) of salt marsh occurs on the south-western edge of the estuarine lagoon at Nelson. The typical salt marsh species are present - beaded glasswort *(Salicornia quinqueflora)*, Seablite *(Suaeda maritima)*, brookweed *(Samolus repens)*, swamp-weed *(Selliera radicans)*, sea rush *(Juncus maritimus)*, and water buttons *(Cotula sp.)*. Mangroves are not present, nor is the common Victorian salt marsh species grey glasswort *(Arthrocnemum halocnemoides)*.

Unfortunately a road has recently been constructed along the edge of the salt marsh, and disturbance of the vegetation will probably result from this.

Survey

The vegetation map shows that most of the public land north of the Stokes River consists of Open forest I of brown stringybark, interspersed with heaths, some swamps, and gum woodlands. A survey of the plant species present in these blocks was undertaken by Mr. A.C Beauglehole of Portland, with the aim of collecting data from which estimates of the floral richness of each block could be obtained. He recorded species in broad habitat types within each block, and noted their abundance. The survey covered the Weecurra, Wilkin, Drajurk, Tooloy, Roseneath, Youpayang, Bogalara, and Kanawinka blocks. The Kentbruck Heath block was also surveyed.

The very large number of species involved makes it hard to summarize the results. Mr. Beauglehole compiled a list of the rare and interesting plants in each block, based on subjective assessment. The Kentbruck Heath stood out, containing by far the greatest total number of species and the most rare and interesting plants - this is not surprising, as the block contains diverse habitats. Assessment of the northern blocks, on the basis of total number of species and number of rare and interesting plants recorded, shows that the Wilkin, Weecurra, and Youpayang blocks are the most floristically diverse.

Endangered species

In a table of Victorian plants in danger of extinction, Willis listed the following as occurring in the study are, and they were referred to Mr. Beauglehole for further comment.

1. *Prasophyllum diversifolium* - recorded from two developed properties at Gorae West, and is now presumed to be extinct.

2. *Calochilus herbaceus (saprophyticus)* - nearly all the habitat has been converted to pasture, but the species can be found at Kentbruck Heath, and there is an isolated patch in the Weecurra block.

3. *Amphibromus recurvatus* - isolated occurrences in swamps in the study area - Kanawinka, Bogalara, Youpayang, Weecurra, and Kentbruck blocks.

4. *Baumea laxa (Cladium laxum)* - occurs in Long Swamp, on private property near Portland and near Mount Richmond, Eaglehawk Bend on the Glenelg River, Johnstone's Creek, and in the Wilkin block.

5. *Choretrum spicatum* - not known.

6. *Eucalyptus fasciculosa* - common in Kanawinka, Roseneath, and Bogalara blocks.

7. *Haloragis exalata* - at Swan Lake Falls, lower reaches of Moleside Creek.

8. *Orthrosanthos multiflorus* - not known at Cape Nelson.

9. *Pterostylis celans* - known from private property, now presumed to be extinct.

10. *Thismia rodwayi*- occurs on private property in sown pasture.

11. *Pterostylis tenuissima* - known from private property near Portland. Long Swamp, Lake Bong Bong, Salt Creek (Bogalara block), and on private property. Not at Johnstone's Creek.

12. *Caustis flexuosa* - incorrect record.

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FAUNA

Each species of animal is adapted to a certain environmental range, and only within a habitat that provides these conditions can the species survive. So the preservation of suitable habitat is fundamental to conserving wildlife.

Birds and Mammals

Habitat

The most essential requirement the habitat provides for the bird or mammal is food. The type of food available in the habitat depends on the plants growing there, for even though the animal may not feed directly on plants it will feed on others that have previously fed on plants. The term animal is used here in its widest sense and includes invertebrates, amphibians, and reptiles as well as warm-blooded animals.

The habitat must also provide suitable cover for concealment from predators and shelter from the weather. For most birds and mammals plants also provide these requirements. Plants thus occupy a very basic role in nature as producers and because of this the classification of vegetation is a very convenient way of describing different habitats.

Each vegetation type is the home of a different community of birds and mammals. Some species are restricted to one vegetation type, as only that one can fulfil their particular requirements for food and shelter. For example, the ground parrot only lives in heath, and the yellow-bellied glider in open forest. Other more versatile species live in several vegetation types: the white-eared honeyeater and the echidna for instance, are found in open forest, woodland, scrub, and heath.

Although many different species of birds and mammals can usually be seen in any particular vegetation type, they do not all eat the same food or build nests in the same sites. Each species occupies a separate habitat within the vegetation type, where it has relatively little competition from other species for food and other needs. For example, in the

stringybark open forest, striated thornbill and yellow-faced honeyeater feed in the crowns of the trees, the white-throated tree-creeper on the trunks of the trees, the satin fly-catcher and the grey fantail in the air between the trees and the ground, the brown thornbill in the crowns of the undergrowth, and the white-browed scrub-wren in the low ground cover.

Similarly, the various mammals present utilize different parts of the forest environment to provide their specific habitats.

Birds and mammals thus play a very significant regulatory role in maintaining a balance in their particular habitats.

Behaviour

Preservation of habitat, although the dominant factor, is not the only aspect that must be considered in the conservation of birds and mammals. Various aspects of animal behaviour are also important.

Breeding

A knowledge of the breeding habitats of birds and mammals is important for their conservation. The environmental factors that initiate the breeding cycle of a species, the requirements of the species for nest sites, and its reproductive capacity are all important.

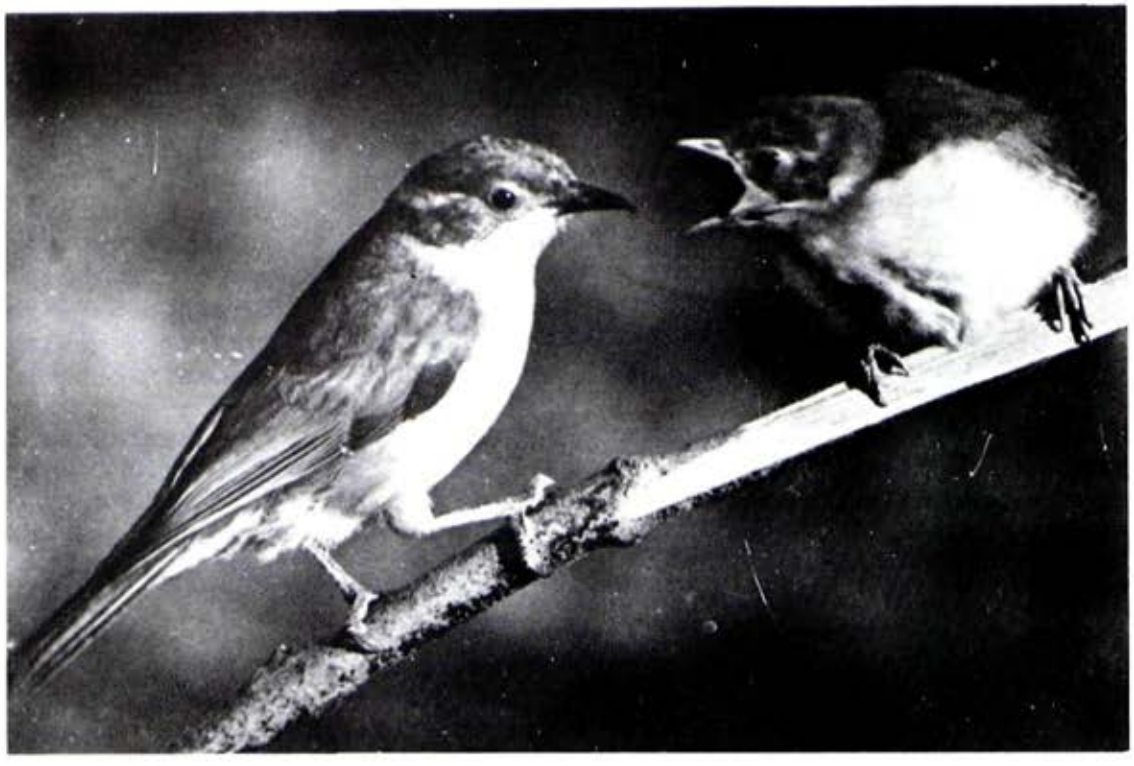
Studies of Australian birds and mammals indicate that the breeding season for many of them is greatly affected by such factors in the habitat as rainfall, temperature, and day length. Local variations in climate may cause the peak breeding season of a particular species to vary from place to place, and from year to year in a particular place.

The response to environmental stimuli varies between species. For example, the yellow robin starts breeding in August, the crimson rosella in October, and the yellow-footed phascogale in July.

Sometimes breeding fails to occur even when, to human eyes, conditions seem ideal: some factor vital for the species is missing. The yellow-tailed black cockatoo will not breed unless trees are available with suitable nest hollows even though food and other requirements are adequate. Such factors influence not only breeding but also the distribution of a particular species. The reproductive capacity of a species is important when considering its ability to colonize or recolonize areas of suitable habitat.

Territories

Many birds and mammals require a particular area in which they can establish themselves, which will provide their needs. This territory, as it is



Brown-headed honeyeater with young

called, is defined as an area defended against intruders. A pair, family, or clan of animals will occupy a territory and defend it against any intruder of the same species or a closely competitive species that crosses its boundary. The territories of different species may overlap when the animals are not in close competition for food or cover.

The territory meets some or all of the requirements of the occupants, depending on the species. Some species require territories that will provide them with food, water, shelter, and nesting sites throughout the year. Others require territories only during the breeding season. Breeding is often timed so that the period of greatest nutritional demand by the offspring coincides with a flush of food.

Territorial requirements are quite specific and may vary substantially between closely related species. Two species very similar in appearance with

Spotted pardalote - common in timbered country

quite different territorial requirements are the Australian raven and the little raven.

A pair of Australian ravens occupies a large territory of about 300 acres throughout the year. It must include some tall timber in which the bird can find nesting sites at least 40 ft above the ground. The birds forage, roost, and breed in their territory, and force each brood of young birds to leave it to join nomadic flocks before ultimately taking up their own territories. The little raven does not require a clearly defined territory at all. These birds defend the immediate area around the nest against intruders, but forage widely and merge into loose flocks. Both the parents and young birds leave the breeding area in autumn and travel extensively. This species rarely nests above 30 ft.

It is known that female brown phascogales live in permanent territories, whereas males are partly nomadic - particularly in the mating season, when they may traverse large distances between the territories of several females.

Movement

Birds and mammals may move from place to place to find the environment they require. Their movements may be regular migrations, nomadic wanderings, or dispersion from over-populated areas.

Intercontinental migration is shown by nine species of wading birds regularly seen in the study area. These birds, of which the sharp-tailed sandpiper and Japanese snipe are good examples, breed at very high latitudes in the northern hemisphere and migrate to the southern hemisphere for their non-breeding season in the southern summer. The short-tailed shearwater is the only

intercontinental migrant seen in the study area that breeds in the southern hemisphere (for example, on Lady Julia Percy Island).

Latitudinal migration is shown by many ocean and land birds in the study area. The black-browed albatross and giant petrel are examples of the ocean birds that breed in the Antarctic areas during the southern summer and move north to the Australian latitudes during winter.

The many land birds that migrate latitudinally include the pallid cuckoo, rufous songlark, and satin fly-catcher. These species breed in southern parts of Australia during summer and move north - sometimes as far as New Guinea and Indonesia - during the winter months.

A few species exhibit altitudinal migration. The flame robin breeds outside the study area during summer at places of high elevation such as the Otways and Grampians and moves to the study area and other low-lying areas during the winter.

Nomadic wanderings are characteristic of some mammals and many bird species, notably the lorikeets and some honey-eaters. These species have a restricted diet and must follow their food supply. More versatile species or those with a reliable food source can reside permanently in the one locality, but even these have some movement, known as dispersion.

Under normal circumstances any particular area of land can support only a fixed number of animals of any one kind. The surplus number produced each year must move on to a new area or die. These young animals mainly require food and shelter, and they can occupy ecological niches that are unsuitable for breeding pairs.

Passage of Time

Time brings changes to any area. These are obvious in places where bare ground becomes available to plants for colonization, for instance abandoned farm land or a severely burnt forest. Closely following the succession of plants on an area comes a succession of birds and mammal species.

Studies of the skeletal remains of mammals found in various caves in the study area clearly indicate that considerable changes in the local fauna have taken place over the last 20,000 years. Evidence accumulated from the study area, and from other parts of south-eastern Australia, shows that these have been brought about by climatic changes and the consequent changes in the vegetation.

The sequence appears to have been an early wet sclerophyll forest, followed by an arid mallee-type vegetation,

Red-necked wallaby with joey

then woodland, and finally the dry sclerophyll vegetation that dominates the area today. Species that inhabited the former wet sclerophyll vegetation included the long-nosed bandicoot, black wallaby, and smokey mouse. Inhabitants of the former arid vegetation included the bettong, toolache wallaby, and the bridle nail-tailed wallaby. The brown hare-wallaby, plains rat, and New Holland mouse are examples of the species that abounded in the woodland vegetation. None of these species are known to live in the area today.

Other living species that have become extinct in the study area over the last thousand years include the Tasmanian devil, thylacine, red-bellied wallaby, broad-tooth rat, white-footed tree-rat, and the rufous rat-kangaroo. The quoll (or native cat) and dingo have apparently disappeared from the area during the last 100 years.

Conservation

Birds and mammals not only have a very high value to the community for aesthetic and sentimental reaons, they also play a significant regulatory role in the natural environment. Their habitat requirements mainly involve the structure and species composition of vegetation. Any management practice or natural ecological process that affects a plant community also affects the birds and mammals inhabiting that community. Thus clearing, logging, fire, and the passing of time all affect bird and mammal populations. None of these practices or processes destroys habitat; each simply changes it, to the advantage of some species and the disadvantage of others.

Similarly, any regeneration process that perpetuates a particular plant community

tends to perpetuate the bird and mammal community dependent on it.

Changes to the present use of land will result in changes to the bird and mammal population. The desirability of land use changes can be judged only if their impact on birds and mammals is known, and can be assessed in terms of an aim.

At the present time the aim of conserving as many species as possible is widely accepted. However, formulation of more specific aims must await further research.

In the south-west study area we know the distribution of the major plant communities and something of their ecology. We know a great deal about the general distribution of birds and something of their more obvious migratory habits, but not nearly enough of their exact habitat requirements, movements, and population densities. Distribution of mammals in the south-west is poorly understood, while for a number of the smaller fauna cataloguing and classification of species is still in progress.

An immediate aim is to recognize, classify, and conserve the widest possible diversity of species. Single purpose reserves can readily be justified in certain cases, for example, where species are rare or endangered, and these reserves must be actively managed if they are to serve their purpose.

In many areas conservation of birds and mammals need not conflict with other forms of land use. In fact much of the present bird population in the south-west depends on private property and uncleared roadsides for its habitat requirements. Land use on these areas may be changed at any time. Conservation of wildlife can be a by-product of good management of not only public land but also private land.

Significant Species

This section discusses the species of birds and mammals that have significance in the study area because of their rarity, or scientific interest. Appendix II lists all the birds and mammals recorded from the study area, together with their habitats and status.

Sea birds

Many sea birds nest on the islands off the coast of south-eastern Australia. Lawrence Rocks, a State faunal reserve in the study area, is an important breeding area for three of these species.

Eudyptula minor: The little penguin is the smallest of the world's 18 species of penguin, all of which are confined to oceans of the southern hemisphere. It is the only one to breed in Australia

and forms large colonies on offshore islands from Perth to Brisbane. One of the Victorian colonies is on Lawrence Rocks, where about 100 birds breed annually.

Pachyptila turtur: The fairy prion is the smallest of the six species of prion, all of which are peculiar to oceans of the southern hemisphere. It breeds on the islands of Bass Strait and New Zealand. One of the known breeding islands is Lawrence Rocks.

Morus serrator: Australian gannets, an Australian and New Zealand species of sea bird, breed in dense colonies on offshore islands. About 600 pairs nest annually on Lawrence Rocks, one of only five known breeding colonies in Australian waters.

Coastal fauna

The coastal vegetation complex of heathland and scrub has never been a very extensive habitat, but it has been greatly reduced by clearing for settlement and agriculture, and in recent years by development of recreation activities.

Excalfactoria chinensis: The king quail occurs widely from India and China to coastal districts of northern and eastern Australia - from the Kimberleys to near Adelaide. It is very rare in southern Australia, the south-west being one of the few areas where it has recently been observed. Its habitat is swampy heathland and long grass bordering swamps.

Neophema chrysogaster: The orange-bellied parrot, a rare and localized bird, inhabits tidal flats, dunes, and adjoining grassland in Tasmania and coastal areas of the mainland, from south-eastern South Australia to as far east as Melbourne. It visits the study area in winter from breeding grounds thought to be on offshore islands.

Pezoporus wallicus: The ground parrot, a terrestial species, has a very discontinuous and scattered distribution along the coast of southern, western, and south-eastern Australia, including Tasmania. Its habitat of coastal and adjacent montane heathland, 1-2 ft high, has been largely destroyed. Consequently, the species has suffered greatly and is now extremely rare in all mainland areas.

Dasyornis broadbenti: The rufous bristle-bird occurs in the very narrow coastal strip westwards from Torquay to the mouth of the Murray River, and again in a very narrow coastal strip 50 miles long from Cape Leeuwin to Cape Naturaliste in Western Australia. Its habitat is dense coastal vegetation and tea-tree thickets. Although rare in Western Australia, the species is not uncommon in its very limited Victorian range, where it occurs most densely in the southern part of the study area.

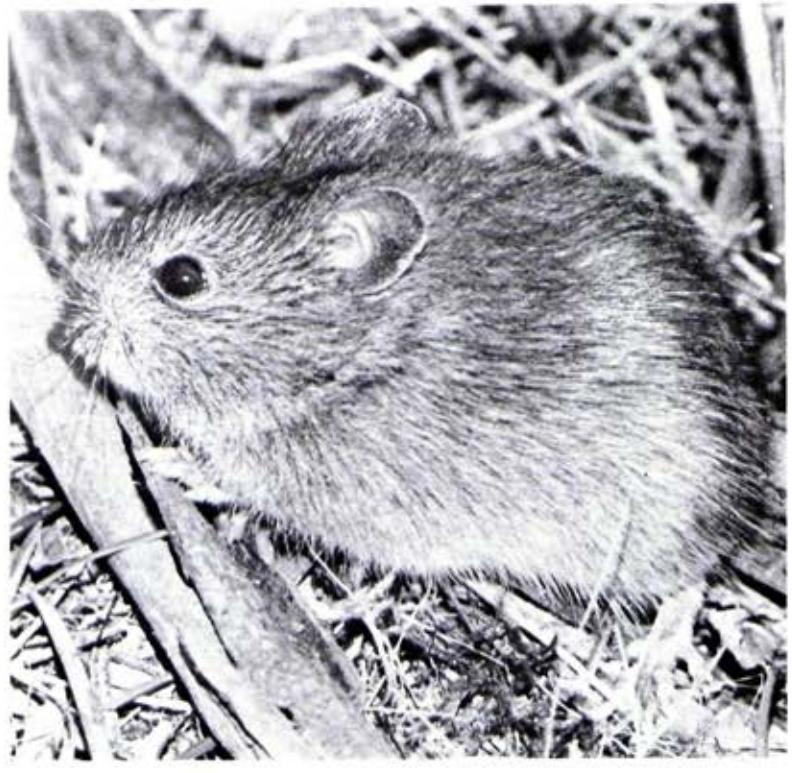
Emblema bella: The beautiful firetail lives in the coastal and adjacent mountain areas, from Newcastle to Kangaroo Island and Tasmania. Its habitat includes thick belts of coastal scrub and tea-tree and thickly wooded gullies. This shy species appears to have decreased considerably in recent years and is now considered rare. However, it has a stronghold in the south of the study area.

Heathland species

The heathland habitat is rather limited in extent and its structure and floral composition (and therefore its value for birds and mammals) are extremely sensitive to the frequency of firing. Clearing for agriculture has greatly reduced the area of this habitat.

Stipiturus malachurus: The southern emu-wren lives in coastal and adjacent mountain areas in south-western and south-eastern Australia, including Tasmania. Its habitat is the damp scrubby heathland of coastal and mountain areas. It is a shy sedentary species and as few areas of its habitat remain undisturbed in Victoria, it has become rather rare.

Hylacola pyrrhopygia: Heath wrens frequent heathland and some forested areas with dense ground cover, from north-eastern New South Wales to the Mt. Lofty Ranges in South Australia. Regarded as rather rare in Victoria, the



The heath rat, a rare species

species probably has its greatest population density in the Grampians and the southern part of the study area.

Pseudomys shortridgei: The heath rat, a very rare species, inhabits scrub and tree heath. Its only known colonies live in the Grampians and in the study area at Bat's Ridge and Kentbruck Heath, although it formerly occurred in Western Australia.

Locally centred species

Distribution of these species is restricted to western Victoria and south-eastern South Australia, although they sometimes occur in south-western Australia also.

Cacatua tenuirostris: The long-billed corella, an uncommon bird, frequents open woodland, semi-cleared, and cultivated areas, seldom ranging far from water. It occurs only in western Victoria and adjoining areas of South Australia and New South Wales, except for an isolated population in south-western Australia. Its main breeding area lies in south-western Victoria.

Neophema elegans: The elegant parrot has a limited distribution, from the Mallee and western Victoria to the Flinders Ranges, with another pocket in south-western Australia. It is regarded as rare in Victoria, and flocks of non-breeding birds are seen in coastal, lightly timbered, and cultivated areas in the west of the State. It particularly favours clover and paspalum seeds.

Neophema chrysostoma: The blue-winged parrot is the least specialized of the seven species of *Neophema,* being found in a range of habitats from forest to grassland and cultivated areas. Its main breeding area is southern Victoria (including the south-west) and Tasmania, but in winter nomadic flocks extend into northern New South Wales.

From eastern areas

The study area forms the very western limit of these species' distribution, which usually extends along the coastal side of the Divide, often as far as northern New South Wales or Queensland.

Ninox strenua: The powerful owl inhabits the wetter more heavily forested areas of southern Queensland, New South Wales, and Victoria. Its western limit lies in the wetter forest country to the west of Heywood.

Petroica rodinogaster: The pink robin, a rather rare species, breeds in the higher-rainfall forests of southern Victoria and Tasmania. It has been recorded breeding in the Cobboboonee and Kentbruck Heath blocks. In winter it is nomadic and spreads out into drier forest country, and has been seen across the border in South Australia.

Petroica rosea: The rose robin breeds in dense forest from the Otways to Queensland. Although rather rare in Victoria, it is occasionally seen in the study area. It has been recorded near Adelaide.

Rhipidura rufifrons: The rufous fantail regularly migrates from the rainforests of northern and eastern Australia to the forest gullies of New South Wales and southern Victoria, where it breeds during summer.

Olive-backed oriole - a summer visitor to the south-west

Myiagra rubecula; M. cyanoleuca: The leaden and satin flycatchers have similar distribution and movements to the rufous fantail but both species are less common in the study area. The leaden flycatcher occupies coastal scrub as well as forest. Both species have been seen in Adelaide on isolated occasions.

Pachycephala olivacea: The olive whistler is a rather rare species inhabiting densely forested areas of Queensland, New South Wales, Victoria, and Tasmania. It regularly breeds in the study area and adjacent parts of South Australia, where its habitat includes dense coastal tea-tree.

Oriolus sagittatus: The olive-backed oriole is moderately common in forested areas of northern and eastern Australia, migrating to the southern part of its range in summer. It regularly breeds in the study area, but is rare further west, to the limit of its range near Adelaide.

Antechinus stuartii: The brown phascogale is a very common marsupial inhabiting forested areas from Townsville to Portland, mainly on the coastal side of the Divide where annual rainfall exceeds 25 in. It does not occur in South Australia.

Antechinus swainsonii: The dusky phascogale, a much less common species, inhabits the dense low vegetation of forests in areas with at least a 40-in. annual rainfall. It is found from north-eastern New South Wales to the Portland area and also in Tasmania.

Petaurus australis: The yellow-bellied glider occurs in tall (mainly mountain) forests from Bundaberg to west of Portland (Cobboboonee block) in the study area. It has ranged into the extreme south-east of South Australia (Donovan's Landing) within the last few hundred years and may still occur there.

Macropus giganteus: The eastern grey kangaroo lives in all eastern States including Tasmania. The western limit of its range lies in the study area, where it occurs south of a line running roughly through the Lower Glenelg and Hotspur blocks. Dry sclerophyll forest, woodland, and forest margins provide its habitat.

Macropus rufogriseus: The red-necked wallaby is found in all eastern States including Tasmania. The western limit of its range extends through the study area, generally to south of the Glenelg Highway, and into the extreme south-east of South Australia. Its habitat includes dry sclerophyll forest, woodland, coastal scrub, and forest margins.

Potorous tridactylus: The potoroo inhabits Tasmania and southern Victoria, possibly extending into the extreme south-east of South Australia. Despite disjointed mainland distribution and generally low population levels, it may be locally common. It usually prefers forested country with moist areas and dense low ground cover.

The potoroo - found in heathland and forest in the Kentbruck area

The azure kingfisher - an uncommon bird of wetlands

Migratory wader species

Five of the wader species recorded in the study area are regarded as rare or uncommon in south-eastern Australia. Unlike some other waders that are also regular summer migrants to the region, these species are found at only a few favoured localities along the coast.

Charadrius leschenaultii: The large sand-dotterel comes as a summer visitor from its breeding grounds in Asia. Its habitat is ocean beaches and coastal marshes. There are no Tasmanian records for this species.

Pluvialis squalorola: The grey plover can be found in small flocks on ocean beaches, tidal flats, and coastal marshes during the summer months. It breeds in Arctic regions.

Numerius phacopus: The whimbril leaves its breeding grounds in the northern hemisphere to spend the southern summer

on tidal flats, estuaries, and salt marsh. Although uncommon in Victoria and South Australia, it is found in good numbers along the east coast.

Tringa hypoleucos: The common sandpiper breeds in Europe and Asia. Locally, it inhabits edges of coastal and inland pools, lakes, and rivers, particularly where rocks and snags protrude from the water.

Calidris alba: The sanderling comes from breeding grounds in the Arctic to local sandy ocean beaches. It has not been recorded in Tasmania.

Waterfowl

The numerous swamps, potholes, and lakes of south-western Victoria and south-eastern South Australia are vital in the conservation of waterfowl. They provide important refuge in times of inland drought for all eleven species of duck found in southern Australia, and also provide breeding habitat for significant numbers of most of them. Special efforts are required to conserve waterfowl habitat, as drainage has decreased it greatly. In many cases the vegetation surrounding the remaining swamps has been destroyed by domestic livestock grazing to the water's edge.

Strictonetta naevosa: The freckled duck, one of the world's rarer ducks, breeds in fresh-water swamps that are heavily vegetated with either cumbungi or tea-tree. It occurs in the study area, but is not common.

Tadorna tadornoides: The mountain duck uses the study area and adjoining regions as a most important breeding ground. It prefers muddy shorelines of estuaries and large open lakes of fresh or brackish water. It nests in trees, often far from water.

Anas gibberifrons: The grey teal is the most widespread and probably the most numerous duck in Australia. The study area and surrounding districts provide a very important summer refuge for birds from the main breeding grounds, which are situated on the flood plains of the Murray-Darling system. Small numbers breed in the study area annually. It is one of the most important game species.

Anas castanea: Chestnut teal prefer coastal lagoons, salt-water estuaries, and brackish tea-tree swamps. Tasmania, especially, and the south-eastern coastal districts of the mainland are the strongholds of this species. It is favoured as a game bird, and will require special conservation measures if it is to survive, as it needs habitats quite different from those of the other game species. It breeds regularly in the region.

Anas rhynchotis: The blue-winged shoveler prefers permanent fresh-water swamps heavily vegetated with cumbungi or tea-tree. Never plentiful, this

species has apparently declined in numbers due to destruction of habitat, particularly in coastal areas where it was formerly most abundant. The shoveler nests more commonly on the ground than other species and, therefore, has suffered more from trampling by livestock and predation by foxes. It breeds regularly in the region.

Oxyura australis: The blue-billed duck is seldom observed. It breeds in deep fresh-water swamps with a dense cover of either cumbungi or tea-tree. Significant numbers regularly breed in the region. Its habitat requirements differ from those of the common game species and special measures will have to be taken for its conservation.

Other species of significance

Calyptorhynchus banksii: The red-tailed black cockatoo inhabits a wide variety of forested and sparsely wooded habitats over most of Australia, but is absent from southern and south-eastern parts except for a small population of several hundred birds in the area bounded by Casterton, Harrow, Bordertown, and Naracoorte. The breeding area of this population is not known.

Meliphaga virescens: The singing honeyeater is widespread over most of Australia. In Victoria it occurs commonly only in the coastal scrub areas in the west and some parts of the north-west of the State.

Dasyurus maculata: Tiger cats are widespread in Victoria, but nowhere is the population dense. The species lives in forested areas and shelters in logs and rock piles scattered throughout the study area, with a strong colony in the Stones faunal reserve.

Sminthopsis leucopus: The white-footed dunnart has a scattered distribution from south-western Victoria to Cape York. It is apparently rare in Victoria, but in the study area is known to occur at Bat's Ridge, Heathmere, and Mt. Clay.

The white-footed dunnart - a rare species found at Bat's Ridge.

Perameles gunii: The barred bandicoot occurs in south-western Victoria and Tasmania. Formerly common over most of the western basalt plains, where its habitat was woodland and open country with good ground cover, it now seems to be confined to the Hamilton area. One occurrence was reported from Bourke's Bridge in the Youpayang block.

Vombatus ursinus: The common wombat inhabits forested country from south-eastern Queensland to south-eastern South Australia. In recent years the wombat population in western Victoria has declined dramatically for no known reason. It is now only found in isolated colonies (such as at Baileys Rocks in the study area), and the viability of these colonies appears doubtful.

Macropus fuliginosus: The black-faced kangaroo occurs in south-western Australia, South Australia and the adjoining parts of New South Wales and Victoria. The south-eastern limit of its range lies in the study area, north of a line running roughly through the Lower Glenelg and Hotspur blocks. It prefers dry sclerophyll forest, woodland, mallee, and forest margins.

Miniopterus schreibersii: Bent-winged bats form large populations each centred upon a single maternity colony. At least four such populations are represented in Victoria. Individuals disperse and travel as far as 200 miles from the maternity site but return annually to breed. The population inhabiting the Fern Cave and the caves along the Glenelg River and Bat's Ridge appear to be based on a maternity colony at Naracoorte.

Myotis adversus: The large-footed myotis, a cave-dwelling bat, has a wide distribution over Australia. It has been recorded from only a few localities in Victoria. In the study area it is known to occur at Kates Slide Cave, Amphitheatre Cave, and Dry Creek Cave in the lower Glenelg block.

Reptiles

Reptiles rely on environmental factors to maintain their body temperature as, unlike birds and mammals, they have no internal control. Because of this, reptiles select conditions that enable them to maintain relatively constant body temperatures. When environmental conditions become either too hot or too cold, they seek out a suitable microenvironment, such as under a rock or log, and remain inactive until conditions become favourable once more. Oviparous species also need a warm dry site for laying eggs.

Appendix II lists the species known to occur in the study area. Their rarity or otherwise is difficult to determine, as they are not well known. But their conservation usually depends entirely

on the level of general environmental conservation. No species are known to be of particular significance in the study area.

Amphibians

Frogs and toads are the only amphibians in the study area. They belong to the Order *Anura* and have a complex life cycle, typically involving an aquatic larva (usually herbivorous) and a terrestrial carnivorous adult. Anurans are strongly influenced by the amount, effectiveness, reliability, and seasonal distribution of rain, as they require fresh water or sustained high humidity for the development of embryo and larva. They are intolerant of salt water, and the draining of swamps can cause extensive loss of habitat.

No full list of the species in the study area has been compiled, but none is known to be significant.

Fish

The greatest threat to fish species is probably stream pollution. Apart from obvious forms caused by some industrial and sewerage effluents, pollution can be caused by the misuse of pesticides and fertilizers on adjoining land. Construction of dams, with consequent reduction of water temperatures and flooding, and "river improvement" schemes designed to remove snags and bank vegetation can both adversely affect the habitat for fish. Poor agricultural and timber-harvesting practices on adjoining land can lead to severe erosion and increased turbidity.

No full list of species for the study area has been compiled, however, the following species are known to be of significance in the area.

Percalates novemaculeatus: The bass is an excellent sporting fish that breeds in the Glenelg and Hopkins Rivers of western Victoria.

Brachygalaxias pusillus pusillus: The native trout is known only from the Glenelg and Eumerella Rivers, from small streams draining into Westernport Bay, and from a single record in north-eastern Tasmania.

Acanthopagus butcheri (southern black bream), *Sciaena antarctica antarctica* (mulloway), *Aldrichetta forsteri* (yellow-eye mullet), and *Arripis trutta* (Australian salmon) are all important sporting fish found in the estuary and tidal reaches of the Glenelg River. The river is an important breeding area for the black bream.

Arthropods

A number of arthropods of special interest have been recorded in the study area and these are described below. More intensive collecting is required over the whole of the area before its entire arthropod fauna can be determined, and further unique species could be expected. As with the vertebrates, the area appears to be at the junction between species typical of the wetter areas of south-eastern Australia and those typical of the drier areas to the west. It also appears to have some affinities with the Tasmanian arthropod fauna.

Crustaceans

A number of freshwater crayfish (mainly of the Order Decapoda, Family Parastacidas) have been described from the area. One species (*Engaeus strictifrons*) is only recorded from the lower reaches of the Glenelg River, while *Euastacus bispinosois* is principally from the lower Glenelg River, below Dartmoor. A number of other interesting species, not solely confined to the area, also occur.

Insects

Hemiptera (bugs)

The National Museum has taken a large range of leaf-hoppers from along the lower reaches of the Glenelg River, among which new species are expected when the material is finally classified.

Mecoptera (scorpion flies)

Scorpion flies are common in the swamps, particularly those surrounded with light forest, although little work has been done on this group in that area.

Plecoptera (stone flies)

One rare stone fly has been recorded from the Glenelg River and is otherwise known only from Tasmania.

Hymenoptera (bees and wasps)

Very interesting series of native bees are found at the sand dunes along Discovery Bay, and others at Gorae and Gorae West. The whole of the sandy areas along the coast of the study area are good collecting localities for the burrowing bees and wasps.

Coleoptera (beetles)

A number of cave-dwelling carabs such as *Notospeophonus castaneus* (Family Carabidae) have been described from the limestone caves near Portland.

Lepidoptera (butterflies and moths)

Family Satyridae-(Browns): *Oreixenica lathoniella herceus* is represented in a very light form significantly close to the Tasmanian race, in various scrub areas behind Portland. *Heteronympha*

penelope alope is locally a very light form too, taken in forest along the Dartmoor-Nelson Road. It shows a continuation of the coloration development in the Otways. This colony has females with more rounded wings than typical *alope* from Lorne and also approaches the Tasmanian race *panope*. This would represent the most westerly extension of the species.

Two most interesting "Browns" are restricted to the Dartmoor-Nelson area. They are *Heteronympha cordace wilsoni* whose nearest races appear to be at the Grampians and Mt. Cole, and *Oreixenica kershawi kanunda* whose closest form comes from the Otways. The former is associated solely with *Carex* sedge species growing in swamps and the latter with wire grass (*Tetrarrhena* sp.) in open forest areas. No other locations have so far been found for these two races.

Hesperiidae (skippers): *Hesperilla donnysa delos* is common at Dartmoor and nearby localities in association with various species of *Gahnia*. This would represent the most easterly extension of this race, which is typically from South Australia.

Similarly, *H. chrysotricha leucosia* is found in the swamps associated with *Gahnia trifida*, having been taken at Dartmoor, Nelson, Heywood, Portland, and Yamtuck. This would probably represent the most easterly extension of this race's range. A separate race occurs from the Otways west to Gippsland.

Two very rare "skippers" have been recorded from Nelson in coastal grasslands, *Anisynta cynone cynone* (probably a new race) and *Motasingha atralba atralba*. The latter is associated with the sedge *Gahnia lanigera* and represents the most easterly record of this species which spreads west as far as Perth and occurs more commonly in South Australia.

Lycaenidae (blues and coppers): The absence of records of this family is probably due to lack of intensive collecting, but some of the heathland areas will doubtless yield some species.

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LAND ZONES

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

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

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

Using this system of land classification, Gibbons and Downes, of the Soil Conservation Authority of Victoria, mapped and described the land in the study area, and their descriptions form the basis of this account.

Mapping units

In their survey of south-western Victoria, they used four scales of mapping units.

The smallest-scale, most detailed, and fundamental unit for mapping and description is the land COMPONENT, in which the climate, parent materials, soil, and vegetation are uniform within close limits. Components usually occur in a limited number in a consistent, repetitive sequence, and an area containing such a sequence is termed a LAND-UNIT. This, the smallest scale of pattern, is also the smallest scale of mapping used for the land in south-western Victoria.

A grouping of land-units that has common land forms, vegetation, or other significant characteristics is termed a LAND-SYSTEM. Gibbons and Downes used this as the mapping unit in south-western Victoria, and described eighteen land-systems for the present study area.

The largest mapping unit, the LAND-ZONE, is composed of similar land-systems. The boundaries between land-zones always coincide with major changes in one of the main features of the environment. Eight land-zones have been described for the study area. Table 8 sets out the characteristics of each of these and this, together with a map showing their distribution, has been bound in between pages 90 and 91.

Most of the land-zones are oriented in a north-westerly or north-nor-westerly direction, because the landscape features that define the mapping units have been strongly influenced by the Kanawinka-Kentbruck line of faults, and by the staged retreat of the ocean from the fault scarps during Pleistocene times. The most strongly oriented zones are those near the fault or between it and the coast, which is sub-parallel to it. These are the Kanawinka, Casterton, Nelson, and Portland Zones, and the western part of the Heywood. The remainder, in the east of the area, show no particular alignment. The Dundas Zone had evolved before the main period of faulting, and the Hamilton Zone is the western extemity of a very large area of similar country to the east.

Discussion

It is noteworthy that very little public land remains in those land-zones that originally supported grasslands or grassy woodlands suitable for grazing Merino sheep. The whole of the Casterton and Lowan and most of the Dundas and Hamilton Land-Zones have been used for grazing for more than a century, and have become privately owned.

A large proportion of the public land in the study area is in the Kanawinka, Nelson and Portland Zones. The Kanawinka and Nelson Land-Zones contain sandy soils with a low agricultural potential, and the Portland Land-Zone contains tall forest that has been used for hardwood timber production.

Reference

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

Table 8 - LAND ZONES IN SOUTH-WESTERN VICTORIA

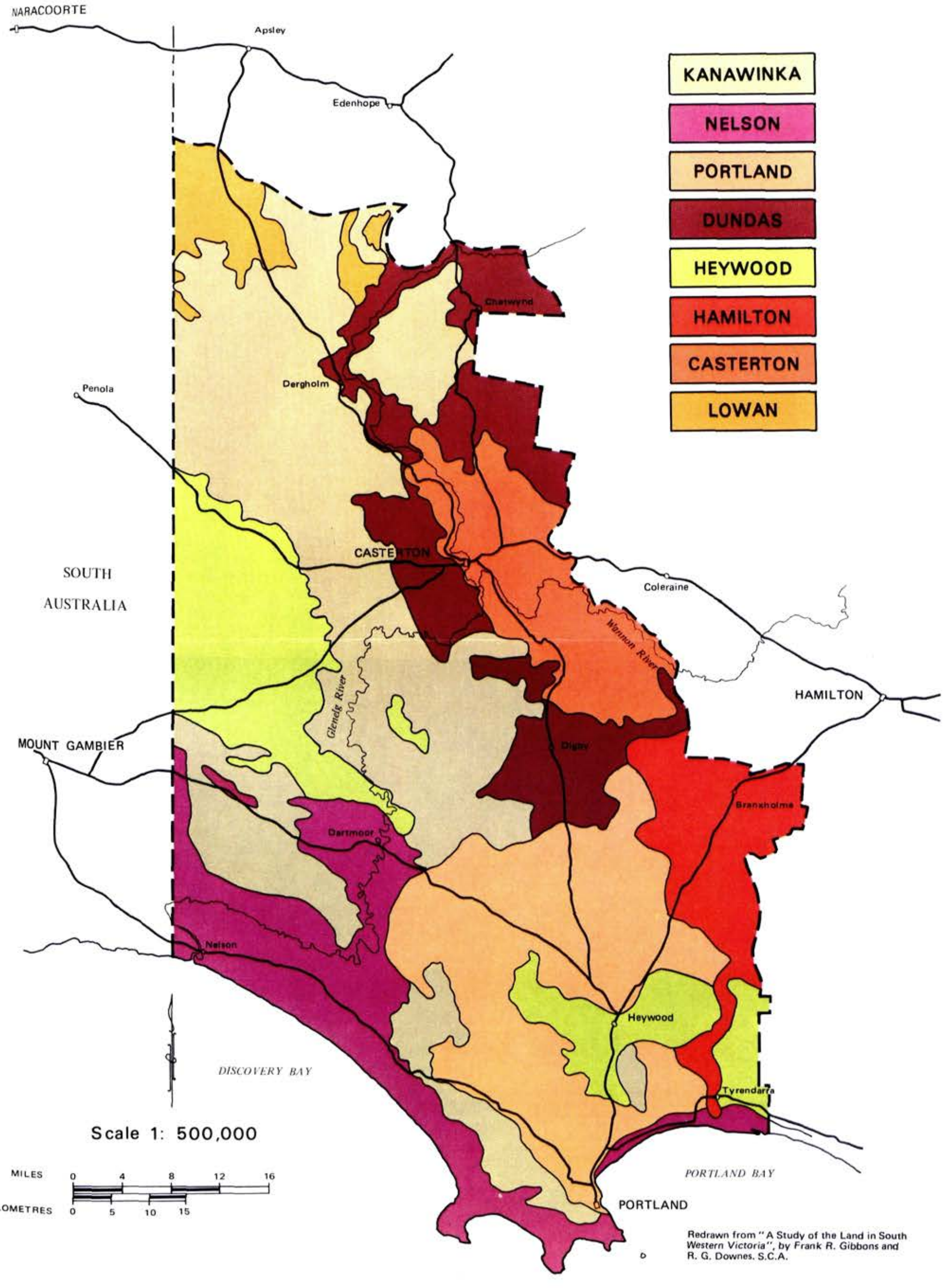
ZONES AND LANDSCAPE	SOILS	NATIVE VEGETATION
KANAWINKA Low dunes and sheets of acid white sands overlying swampy coastal plains or lateritized tablelands, which are exposed in a few places where the sand sheets are thin or absent.	Strongly leached sands, some brown duplex soils.	Low forests and scrubby woodlands of brown stringybark, with heaths on the lowest sites; woodlands of red gum and other gums on the clayey flats.
NELSON High and steep yellow-brown calcareous dunes on the coast; behind the dunes a narrow zone of swamps; inland rolling limestone dunes, and low dunes and sheets of orange and yellow sands.	Undifferentiated calcareous sands, friable brown gradational soils; peats, greyish soils with a gleyed subsoil; red and black soils on limestone, weakly leached sands.	Coastal complex - dry scrub of she-oak, coast wattle, coast beard-heath; rushes and reeds, wet heath, wet scrub of woolly tea-tree; near the coast, dry scrub of moonah; inland, forests and woodlands of brown stringybark and manna gum.
PORTLAND Flat to undulating surface of basalt, mildly dissected, covered in some places by a veneer of acid white sands; some cinder and tuff cones; areas dissected beneath the level of the basalt surface exposing Tertiary sediments.	Clayey weakly bleached gradational soils, some leached sands; friable reddish gradational soils, some brown duplex soils.	Tall forests of messmate, peppermint, swamp gum, manna gum, some brown stringybark, heaths, swamps.
HEYWOOD Flat coastal plains of clayey and sandy deposits; wet and swampy in many places.	Weakly bleached clayey and sandy gradational soils, greyish soils with gleyed subsoil, brown duplex soils.	In the east, shrubby woodlands of swamp gum, forests of messmate and manna gum; in the west, grassy woodlands of red gum and swamp gum; heaths and swamps throughout.
DUNDAS Lateritized tablelands, and areas dissected below the level of the tabelands exposing various hard acidic rocks.	Red and brown duplex soils, weakly bleached gradational soils.	In the south, tall forests and woodlands of manna gum, messmate, and peppermint; in the north, grassy woodlands of red gum, swamp gum, and manna gum.
CASTERTON Deeply dissected areas generally below the level of the lateritized tablelands, exposing soft rocks of the Otway Group and calcareous Permian rocks.	Dark well-structured clays.	Originally a grassland of wallaby grass and tussock grass with some red gum woodlands - now cleared.
HAMILTON Weathered surface of late Pliocene basalt; areas dissected beneath the level of the basalt exposing Miocene and Cretaceous sediments; "stony rise" lava flows; valleys in this volcanic landscape infilled with peat and alluvium.	Red and brown duplex soils; stony brown gradational soils; peats, dark clays.	Originally woodlands of swamp gum and red gum - now cleared; tall woodlands of manna gum; wet scrub of woolly tea-tree, reeds, rushes.
LOWAN Plain of thin Quaternary swamp and lake deposits underlain by Miocene limestone; large swamps.	Brown duplex soils; grey-brown gleyed soils.	Woodlands of red gum; reeds and rushes.

LAND CONSERVATION COUNCIL

VICTORIA

SOUTH WESTERN STUDY AREA

LAND ZONES



Scale 1: 500,000

MILES 0 4 8 12 16

KILOMETRES 0 5 10 15

Redrawn from "A Study of the Land in South Western Victoria", by Frank R. Gibbons and R. G. Downes. S.C.A.

PART III LAND USE

HAZARDS

Changes in land forms and soils may occur as the result of normal geological processes. In south-western Victoria, as in many parts of the continent, it appears that they occurred relatively rapidly during short periods of instability and relatively slowly in the long intervening periods. European settlement came during such a period of slow change when the Aborigines' activities formed part of a fine ecological balance. European Man's activities altered this balance, and many soil features have changed over most of the area.

Generally, a new balance has been reached in which the usefulness and productivity of the land for Man's purposes have greatly increased. However, in some localized areas an imbalance has been created, erosion and compaction of surfaces have changed soils and land forms, and productivity has fallen. These changes and deterioration have resulted from the combined effects of clearing, grazing, introduced pests, and inherent weaknesses in the land.

This chapter briefly describes the incidence of erosion, salting, vermin, weeds, and bushfires in the study area, together with the existing and potential hazards in the areas of public land. More detailed assessments appear in Part IV of the report.

Physical Hazards

Soil erosion

Wind and water erosion and mass movement of soil occur within the study area.

Strong winds erode coarse-textured or poorly aggregated soils in the absence of vegetation. Such wind erosion occurs on the calcareous dunes of Discovery and Bridgewater Bays, but has little significance elsewhere in the region. On large areas of sands that would be subject to it, either pasture or bracken growth has usually followed quite rapidly after clearing, thus protecting the sands.

The mobile dunes of Discovery Bay pose a threat to the swamps and fresh-water lakes immediately behind them, and ultimately to the terrain further inland. Their movement since settlement has resulted from the removal of vegetation through fire and grazing by rabbits, sheep, and cattle. Their stability depends upon their vegetative cover, and restoration of cover has been successful

Wind erosion at Discovery Bay (left) has exposed dune limestone. The south landslip at Glenaulin (right) shows Glenelg Group sediments.

at several sites. A study of the area commissioned by the Land Conservation Council produced evidence that a 100-ft high dune near the Bridgewater Lakes has advanced 17 ft in 2½ years.

Water erosion - the removal of soil by running water - has four forms: sheet, gully, stream-bank, and tunnel erosion. All result in siltation.

Sheet erosion is common on undulating country with duplex soils and can be seen along the eastern fringe of the study area from Branxholme to Chetwynd. A further extension of this process has led to gullying here, but the most severe gully erosion is around Casterton, where gullies up to 40 ft deep occur in the soft and poorly consolidated sediments. The same area suffers severe stream-bank erosion as streams cut and widen their courses in the alluvium of the lower slopes and flats. More recent gullying and mass movements are apparent along the lower Crawford River to the east of Dartmoor. Tunnel erosion is found in a few places near the edge of the Dundas Tablelands.

Most streams in the area carry heavy loads of soil particles after rain, and deposit these as silt wherever the grade of the stream-bed declines sharply. Severe stream siltation can be expected below gullied areas of sandy

soils, and the lower reaches of the Wando and Chetwynd Rivers are characteristic examples.

Mass movement involves large volumes of soil rather than individual particles. The movements may be considered in two groups, one involving flows and the other slips. Both are common on soils developed from Otway Group sediments throughout the Merino Tablelands.

Soil erosion on public land in the study area is restricted to the calcareous sand dunes of the coast. While serious erosion has occurred on alienated land, the hazard on most of the remaining public land is low, principally because of the flatness of the land and the readiness with which areas of disturbed soil revegetate. Slopes in excess of 10^{0} face a significant erosion hazard, and such slopes occur in the Youpayang block, along the Kanawinka-Kentbruck line of scarps, along the Hotspur Monocline near the Crawford River, and around Mount Clay. The hazard here would be serious if the land were cleared.

Foreshore erosion

Erosion of beaches and foreshores by the action of the sea creates a problem in two places in the study area. On the Dutton Way and the Henty Bay Estate, north-east of Portland, the sea has destroyed the beach and is actively eroding roads and residential land.

Foreshore erosion of a different type is occurring at the Bridgewater Bay surf beach and nearby Shelley Beach. Here the cause appears to be destruction of the vegetation of the primary dune by the trampling of people using the beach.

In both locations expensive barriers of stone rubble have been erected to prevent further erosion.

Salting

Salting occurs in a soil when the amount of soluble salts rises to the level where plant growth becomes depressed. If the level of salt (mostly sodium chloride) continues to rise, plant growth becomes impossible.

The build-up in salt concentration results from the replacement of deep-rooted trees by pasture plants that use up less water. This causes perched and regional groundwaters, with the salt they contain, to rise towards the surface as seepage, in valleys, at the base of slopes, or even on hillsides. The salt becomes concentrated as the water evaporates and produces areas of salted soil in these locations. Examples occur along the north-eastern margins of the area and near Branxholme.

Where saline water discharges into streams, these also become salted. The streams that drain the Palaeozoic areas of the Dundas Tablelands and the Glenelg

and Wannon Rivers all owe their high salinities to this source.

Some mortality in radiata pine plantations on the Follett Plains has been associated with high foliar chloride levels. The chloride comes from connate salt retained in Pleistocene marine or lagoonal deposits. The mortality was also associated with low levels of available soil moisture.

Salting is not serious in most parts of the study area, but in certain localities, such as the Youpayang block, clearing the native forest vegetation could result in severe stream salting.

Fire

Climatic conditions in summer and the flammable nature of the vegetation result in a high fire risk in the study area, which has a history of frequent fires. We know that fires have formed part of the environment for thousands of years, but not the frequency or intensity of those lit by lightning or Aborigines before European settlement. However, certainly their frequency and severity, and the area burnt annually, increased in the following 100 years. Settlers used fires to clear land, and to burn old growth and encourage new shoots on grazing runs. Often these burned uncontrolled through thousands of acres of bush.

The frequency of wild fires has fallen during the last two decades due to the introduction of mechanized land clearing, a reduction in forest grazing, better public education, and the efforts of fire control organizations. In the spring and autumn each year, officers burn large areas of public land to reduce fuel. These planned, low-intensity fires remove part of the build-up of scrub and litter fuels on the floor of the forest, and so lessen the likelihood of high-intensity fires in summer.

However, despite all precautions, a high bushfire hazard on the public land persists. Under "blow-up" conditions of high temperature, low humidity, strong winds, and dry fuel, fire control is almost impossible. Fires burning under these conditions can destroy or damage hardwood and softwood timber stands and wildlife habitats, and can invade farmlands and residential areas. Fires of this nature are a hazard to all forms of land use.

Fuel reduction or controlled burning is widely practised in Australia, and the technique is recognized as a necessary part of any programme aimed at minimizing the risk of destructive wild fires. However, nobody knows what long-term effects regular low-intensity fires at intervals of 5-7 years would have on plant and animal communities, and on soil and hydrology. In the long term regular firing could remove much of the diversity of the environment and

produce unwanted soil and hydrological properties.

In the short term, adverse effects can be minimized at the operational level by leaving a mosaic of unburnt forest within areas to be burnt. However, more research is needed to determine the long-term effects.

Hazards Affecting Groundwater

On the Follett Plains the Whalers Bluff-Gambier Limestone aquifer system is an important resource capable of supplying large quantities of good-quality water at low cost, but its shallowness and unconfined nature present several problems in the management and conservation of supplies.

Recharge

The rate of recharge to this system depends on the amount of rain falling in the area and on the rate at which it percolates through soil and roots into the underground storage. The intake area for any bore is essentially the land immediately around it, and during a run of dry seasons high rates of discharge from a bore could cause the water table to fall markedly. Under these conditions the water levels in a number of bores concentrated in a small area could fall, leading to increased pumping costs. However, the permit and licensing provisions of the Groundwater Act 1969 now safeguard against this possibility.

A second problem is the interception of water before it reaches the aquifer. Extensive drainage schemes such as those of south-eastern South Australia, Strathdownie, and the Ardno-Dartmoor area remove large volumes of water from the area before significant downward percolation into the underlying aquifer can occur.

Similarly, mature pine plantations can lower the regional water table. Holmes and Colville investigated a pine plantation on the coastal plains near Mount Gambier. Their hydrological measurements showed that in most years the trees intercept and use all the rain that falls on the plantation, leaving none to recharge the groundwater. Pines may also directly tap the water table with their deep root systems.

The combined effects of drainage and large-scale plantation establishment could seriously affect water levels in the Whalers Bluff-Gambier Limestone aquifer system and reduce the usefulness of this valuable resource.

Lowering of the regional water table - as a result of artificial drainage, large-scale pine plantations, or greatly increased use of groundwater for irrigation - would tend to have the effect of draining the remaining swamps and reducing the accession of fresh groundwater to the lower reaches of the Glenelg River and the coastal and littoral regions.

Pollution

In common with surface water storages, shallow aquifers are vulnerable to contamination from soluble and suspensible materials (oil, detergents, agricultural pesticides, and fertilizers) deposited on the surface within the catchment area. Available evidence suggests that bacteria would be removed after a comparatively short distance of travel in sandy formations such as the Whalers Bluff Formation, but could constitute a serious problem with cavernous limestones such as the Gambier Limestone. The aquifers could also remove other materials to a greater or lesser degree, but this capacity is limited and depends on the aquifer composition and the nature of the materials introduced. Some stable soluble materials tend to persist, and for this reason development and use of land near bores supplying water for human consumption should be carefully controlled.

Clearly, the hydrological regime in this region is complex in character and potentially sensitive to major interference. The effects of any changes made to the system would tend to develop slowly and cannot all be predicted from present knowledge. However, they would probably eventually lead to subtle, and to some extent irreversible, changes in the environment that would affect the flora, wildlife, and fish of the area.

Biological Hazards

Diseases and pests have a minor impact on agriculture, forestry, and the native flora and fauna in the study area at the present time.

The insect population of the region has not been studied, but few harmful effects have been reported.

Red-legged earth mites sometimes damage pastures, and blowfly strike can be troublesome in the sheep industry, but they cause little harm, and husbandry practices usually provide adequate control. Insect vectors have helped to control rabbit populations.

On the other hand, the sirex wasp poses a potentially serious threat to the softwood plantations of the area. It was first found east of Melbourne, but the area of infestation has slowly extended, and it has been recorded as far west as Camperdown. Its future westerly spread is also expected to be slow.

Biological control appears to have been successful in keeping the population of the species at a low level. Sirex wasp larvae were detected at Portland in May 1972 in a crate containing wood-processing machinery from Europe. The shipment

was fumigated before being transported to its destination in Mount Gambier.

Wide ranges of pathogenic fungi, bacteria, and viruses doubtless occur in the area. Current land use and management techniques have not upset host-pathogen relations to the extent that widespread plant or animal disease outbreaks are common. The fungus *Phytophthora cinnamomi* exists in the area and killed radiata pine windbreaks in 1969/70, but no attacks on native vegetation have been reported in this area. However, marked disturbance of the forest environment, especially in poorly drained zones, could conceivably upset the current plant-pathogen balance.

The weed African feather grass (*Pennisetum macrourum*) grows primarily on agricultural lands, roadsides, and river banks. It has spread throughout the northern half of the area and as far south as Dartmoor. However, research conducted by the Vermin and Noxious Weeds Destruction Board has established control methods. Small patches of blackberries (*Rubus fruticosus*), boneseed (*Chrysanthemoides monilifera*), and bladder campion (*Silene cucubalus*) also grow in the study area, but weeds cannot be considered a substantial environmental problem here.

The area has a low rabbit population, although large numbers are present where control is difficult, notably on the stony rises running from Lake Condah to Tyrendarra.

Small native animals are subject to attack by introduced predators. Foxes are common throughout the area and feral dogs and cats are found in some localities. Populations seem to be in reasonable balance and predation is not regarded as a substantial hazard here.

Man's hunting and trapping activities appear to be limited and exert only minor influence upon the animal populations of the area.

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NATURAL AREAS

In Australia, in less than 150 years of extensive settlement, we have established a viable and prosperous nation, but in the process we have greatly changed the whole environment. It is now difficult to find any large tract of country in its virgin state.

Fortunately the worst excesses of land exploitation, such as uncontrolled logging, overgrazing, and frequent burning, are now over. Now a rapidly growing demand has developed, here as elsewhere, for land still carrying natural vegetation and wildlife to be set aside in special reserves in which further development is kept ot a minimum.

The Need for Natural Areas

Natural areas are required for a number of reasons.

Recreational

Many forms of outdoor recreation, including those related to enjoying and understanding natural environments and those requiring solitude, need natural reserves. These give modern sophisticated people an opportunity to renew contact with the natural world where their ancestors once struggled for existence.

Aesthetic

The preservation of the incredible beauty and regional diversity of the natural landscape should supplement our proper concern for the preservation and display of Man's own finest creations - art, music, buildings, and writing. Thus we must preserve characteristic Australian scenery and wildlife within an economic system that necessarily encourages the import and spread of exotic plants and animals, often in monocultures.

Ethical

Preservation of the species that have evolved on earth over more than 500 million years involves the recognition of the right of innumerable species, which may contribute nothing directly to Man's welfare, to co-exist with him.

Economic

Tourism has become one of the world's most valuable industries, and natural areas that give a country its individual

character are a major factor in attracting tourists.

Scientific

We need to preserve undisturbed samples of natural ecosystems, which provide basic data of value in understanding and improving the artificial ecosystems on which we rely for food, water, timber, and other natural products. We must also preserve species and varieties (a "gene-pool") that one day may have profound value to Man, either directly or through his domesticated plants and animals. We must conserve a bank of parental material for improving our agricultural and forest species and for medicinal and pharmacological purposes.

Educational

Biology is the science of tomorrow and for education in biology (including animal behaviour) we need outdoor laboratories and an abundant and renewable supply of species and individuals. A large natural area gives opportunities not only for enjoying natural scenery, but for every variety of study, from simple natural history observation to the most sophisticated non-destructive experiments.

Viability of Natural Areas

Viability is influenced by a number of factors, the most important of which are discussed below.

Type of community

Viable populations of plant species could generally be maintained on much smaller areas than populations of large mammals.

Frankenberg has suggested that a minimum of 10,000 acres is required for Victorian plant communities. Research in Western Australia indicates a minimum of 50,000 acres is required to maintain a full complement of the local macropod species.

Proposed uses

The area must be large enough to absorb the impact of proposed uses. Natural areas set aside primarily to provide opportunities for solitude and primitive unconfined forms of recreation must be very large. In Canada it has been suggested that such an area should require 2 full days to cross, on foot, at its narrowest point. This could involve more than 100,000 acres. But 100 acres or less may be quite sufficient to preserve a particular small plant species.

Use on adjoining land

Aerial top-dressing and pesticide spraying may have influence for half a mile outside the area of application. It follows that a buffer area at least this deep is required around natural areas if they are to be safe from such effects.

Susceptibility to hazards

As well as hazards caused by Man's use of the area itself or adjoining areas, there are natural hazards such as fire, flood, and disease. The larger an area is the more likely it is to survive these . Protection may also be achieved by setting aside several separate examples of the particular type of land.

Degree of management

"Natural" areas should be "managed". Although seemingly a contradiction in terms, this is often necessary as nature is dynamic. Management may take the form of altering fire regimes, culling animal populations, strictly controlling the number and activities of visitors, fencing to exclude introduced animals, or eradicating introduced species. The degree of management possible depends upon objective knowledge of the environment, the techniques available, and the cost of implementing them. Careful management enables small areas to remain viable.

Choosing Areas

In selecting natural areas for reservation in the study area we must bear in mind the following considerations:

* the great diversity of interests of the population, including residents and visitors
* long-term claims of all land users, especially where natural vegetation has survived on the most fertile and well-watered land
* the possibilities of multiple use of a single area
* cost of essential management
* biological content and diversity of the area (In the absence of current information on the fauna, it may be necessary to select, in the first place, for vegetation and habitat.)
* the migratory and nomadic habits of some animals, especially the birds, with reference to the need for safe natural corridors or flight paths linking feeding and breeding grounds etc.
* scenic considerations - of special value in recreational parks
* the need to conserve communities of the common species rather than concentrating only on the preservation of varieties in very small non-viable reserves (Nevertheless we must not neglect consideration of remnant patches of vegetation, the last surviving examples perhaps of once important communities.)
* the desirability of having compact areas with natural boundaries

The Kentbruck Heath

(Compact areas are usually the easiest to manage and maintain. Watersheds often form good boundaries, as they ensure the natural unity of the area and the integrity of its water regime.)

In practice, it is likely that the best system will include a few fairly large areas (exceeding 50,000 acres) in which the major communities are represented, supplemented with a greater number of smaller, more intensively managed areas.

The Study Area

Though large parts of the study area are still in a relatively natural condition, certain types of land that are well suited to agriculture have been almost totally cleared. Remnants of the natural vegetation that once covered these areas still remain in scattered pockets. If a sample of each type of land is to be preserved in its natural state, any viable remnants need to be reserved. There may not be any land carrying natural vegetation in the Casterton Land-Zone and in most of the Hamilton and Dundas Land-Zone.

The higher-rainfall parts of the study area have a high value as natural areas because they support the most westerly occurrence of the open forest and wet heath communities typical of south-eastern Australia, and are separated from similar areas to the east by a distance of 80 miles. Many plants and animals are at the extreme western limit of their distribution.

The Glenelg River gorge, one of the outstanding natural features of the area, has a high value as a natural area from recreational as well as from scientific points of view, while the sand dunes of Discovery Bay offer the best opportunities for coastal solitude in western Victoria.

Although reserves established in the study area may be little used over the next few years because of its small population and remoteness from major cities, they will have great potential for the future as population increases and its distribution changes.

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RECREATION

Recreation involves activity that provides a release from the everyday stresses of life. Obviously it takes a multitude of forms, and individual preferences vary.

This chapter concerns recreation on public land, which can involve such activities as skiing, hiking, trail-bike riding, picnicking, or simply sight-seeing. Some of these may require large tracts of land. However, it is not always necessary or desirable to prevent such land being used for other purposes at the same time. Often uses such as timber production, cattle-grazing, or mining can occur together with recreational activities, provided restrictions are imposed.

Factors Affecting Demand

The increasing demand for land for recreation can be attributed to a number of factors.

Population

The size of the population as well as its density in particular areas will determine the demand for land for recreation. Victoria's population has doubled in the past 35 years and is now about 3,500,000. An overwhelming proportion is concentrated in the metropolitan area.

Income

In general, the bulk of the population has more money to spend after paying essential expenses. Many spend some of this money on recreational activities.

Leisure time

As working conditions improve, individual periods of leisure such as weekends, annual holidays, and retirement years are lengthening.

Transport and communications

Improvements in transport increase the mobility of populations, making areas more accessible and increasing the effective length of individual periods of leisure. More efficient communications disseminate information and ideas more freely and increase people's knowledge of places to go and things to do.

Location of cities and towns

The geographic locations of cities and towns in relation to available natural features of recreational interest, such as beaches and snow fields, influence the types of activities pursued.

Life style

Life style cannot really be considered in isolation from the factors outlined above. However, additional factors such as education, age, and fashion can influence the degree of participation in outdoor recreation.

Evidence indicating the increasing demand for outdoor recreation in recent years can be obtained from the few Victorian figures available. These indicate that while the population has been increasing at 2% per year (doubling every 35 years), the number of people using developed areas of national parks, the number of car and motor-boat registrations, and similar indices are all increasing at 10%-15% every year (doubling in less than 7 years).

Although it may be clear that the demand for outdoor recreation is increasing, the nature of this increase is difficult to predict. Activities that are popular now may not be so in the future and completely new types are certain to emerge. All that can be done is to plan for an increased demand for outdoor recreation and keep the plan as flexible as possible to cope with changes in its nature.

Choosing land for outdoor recreation

As was previously mentioned, outdoor recreation is often compatible with other forms of land use. However, sometimes areas must be set aside specifically for recreation.

The area and nature of the land chosen will depend upon the type of recreation to be pursued. At one extreme, small areas that retain little of the natural environment are used for such activities as tennis, golf, and picnicking. Major usage occurs after work and at weekends, and they are invariably located close to the population that uses them.

At the other extreme, areas of thousands of acres are used for such activities as hiking, sight-seeing, camping, fishing, and nature study, mainly during vacations. Development is usually limited to a small part of the area, the rest being undisturbed. These areas are located where outstanding natural features occur, often far from the population using them.

Obviously a complete range exists between these extremes. American statistics indicate that the greatest increase in demand will be for the intermediate areas that are outside large urban centres but within about 2 hours' driving time of them.

Area of land required

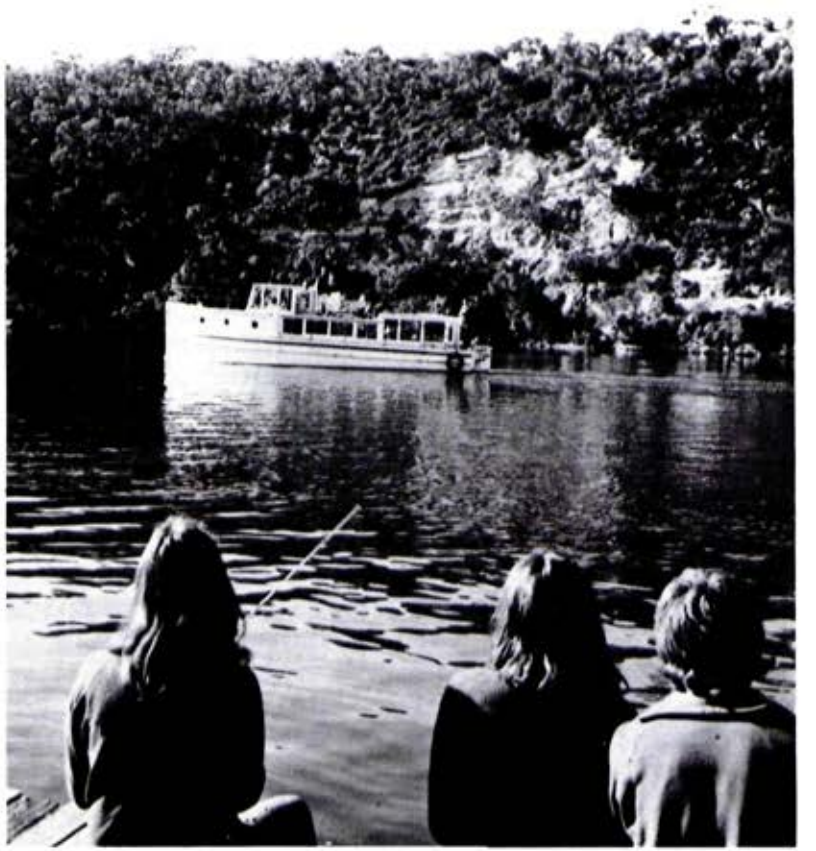
In many respects, an area's carrying capacity for outdoor recreation can be assessed in physical terms in the same way as a farmer determines the optimum stocking rate for his farm. A particular site can accommodate a certain number of cars and people, and above this level damage to the vegetation and soil will occur, leading to deterioration of the land.

Moreover, a psychological element must also be considered: overcrowding detracts from people's enjoyment of the area although the land may not suffer physical damage.

The analogy with the determination of stocking rates on a farm over-simplifies the case to some extent, because attractive and accessible parts of a recreational area tend to be used extensively while large parts are little used. An added complication is that people use these areas intensively for brief periods and not at all for longer periods. This results from the interaction of available leisure and weather conditions with the distance of the recreational area from the population.

In the Study Area

Outdoor recreation activities in the study area are concentrated mainly along the coast at Nelson and near Portland, and along the lower reaches of the Glenelg River. They include driving for pleasure and sight-seeing, fishing, boating, walking for pleasure, picnicking, swimming and sun-bathing, nature walks, water-skiing, and duck-shooting. Table 9 lists these activities and their requirements for land.



Fishing and boating on the Glenelg River

Table 9

Main types of outdoor recreation in the south-west and their land requirements

Type of recreation	Land requirements
Passive outdoor pursuits	
Driving for pleasure	General protection of diversity in the landscape.
Sight-seeing	Preservation of historic points, scenic lookouts, and outstanding natural features.
Picnicking	Provision of suitable facilities in open-space surroundings readily accessible from urban centres.
Nature walks	Preservation of natural areas, provision of walking tracks and interpretative services, and exclusion of vehicles.
Walking for pleasure	General protection of diversity in the landscape, and provision of access to areas of public land, including stream frontages and coastline. Exclusion of vehicles from some areas.
Recreation on developed sites	
Organized outdoor sport	Some areas of public land may be required for golf courses, football grounds, and airfields close to urban centres.
Caravanning	Provision of facilities in pleasant surroundings

Table 9 (contd.)

Type of recreation	Land requirements
Open-country recreation	
Hiking	Preservation of extensive areas of open space, particularly areas with diverse landscape and outstanding natural features; exclusion of vehicles from some areas.
Camping	Provision of suitable facilities in areas of open space close to water and outstanding natural areas.
Hunting	Preservation of habitat for game species.
Cross-country driving	Provision of open space areas that can withstand this type of recreation, some distance from areas being used for other forms of recreation.
Horse-riding	Provision of open space with paths.
Water-based recreation	
Swimming or sun-bathing	Provision of access and suitable facilities at safe beaches and other swimming areas, particularly those close to urban areas.
Boating	Provision of access and suitable facilities along stream frontages and shorelines.
Fishing	Provision of access to stream frontages and coastline, protection of stream banks and aquatic habitats.

The coastal and southern sections receive most use because these contain the most outstanding natural attractions, such as beaches, cliffs, sand dunes, tall forests, and the tidal part of the Glenelg River, and because more people live in and around that area, in Portland and Mount Gambier, than further north.

Surfing beaches at Bridgewater Bay and at the mouth of the Surry River at Narrawong are popular, and surf and rock fishing takes place at numerous points along the coast. The lighthouse and cliffs at Cape Nelson attract visitors, and a scenic drive runs along the cliff tops of Nelson Bay, but it is in poor repair and is not heavily used.

The Discovery Bay dunes are used quite intensively for dune-buggy riding, and water-skiers use the Bridgewater Lakes during the summer months.

Mount Richmond is a popular picnic place for Portland people and a look-out tower has been constructed there. The wildflowers of the Kentbruck Heath, the nearby Cobboboonee forest, and the Bulley Ranges attract visitors in spring.

The lower reaches of the Glenelg River provide fishing, boating, water-skiing, and sight-seeing, and the area around Nelson is more intensively used for picnicking and camping as well. The Princess Margaret Rose Caves receive many visitors, who drive to the caves

The Princess Margaret Rose Caves

from the Princes Highway or travel by boat from Nelson.

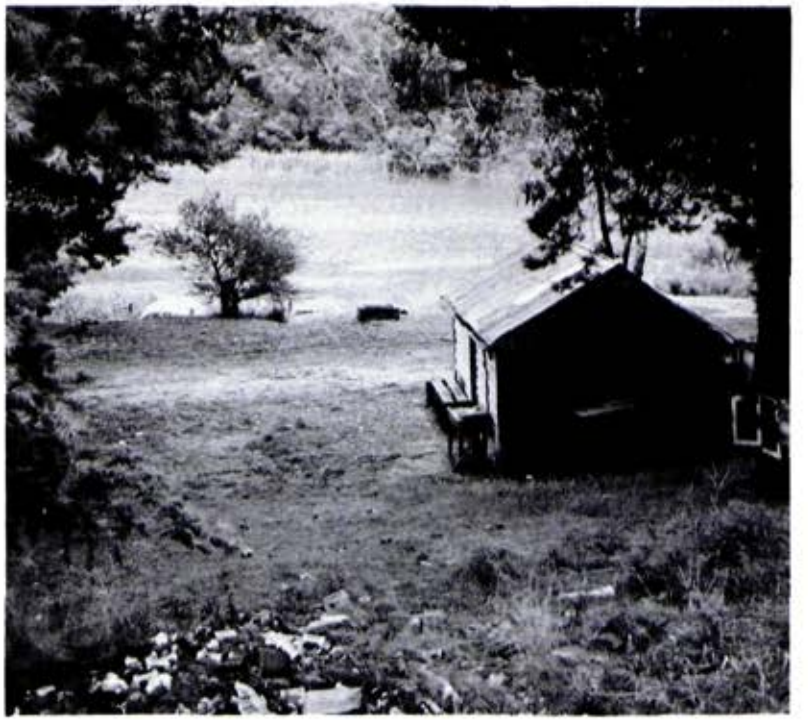
Other locations used for outdoor recreation at present are the Crawford River west of Hotspur and Bailey's Rocks north of Dergholm. People drive for pleasure throughout the area, and the many swamps attract duck-shooters.

Recreation survey

On behalf of the Land Conservation Council, Monash University School of Geography surveyed the lower Glenelg region during the period Christmas 1971 to January 1972 in order to determine the numbers of people using the recreation areas for various activities. They selected this region as the most heavily used in the study area, and timed the survey to coincide with the summer-holiday period of peak usage. They interviewed 783 groups, comprising 2,868 people.

Their results revealed a relatively low present level of recreational use. On the most heavily used area, the Nelson foreshore, they interviewed 189 groups over 4½ sampling days (each of these days was sunny and three of them were either week-ends or public holidays).

A study of the home addresses of those interviewed showed the marked degree to which the region at present has local rather than State-wide significance. Almost 40% came from the area bounded



The use of natural areas may spoil them

by Naracoorte, Hamilton, and Port Fairy, and almost 70% of the 104 lessees of the permissive-occupancy dwellings along the lower Glenelg River came from within a radius of only 40 miles from Nelson.

This current level of recreational use has resulted partly from the region's distance from the major centres of population at Melbourne and Adelaide and its small local population. Moreover, it is well off the direct route between the capital cities and its attractions

A quiet bend on the Glenelg River

have been little advertised. Because comparatively few people visit the region, very few facilities have been provided.

In contrast, it is believed that demand increases and improved transport will lead to substantial medium-term increases in the number of visitors, especially in the southern part of the study area, where the coastline, the lower Glenelg gorge, and Kentbruck Heath provide outstanding attractions. Improved facilities are a necessary pre-

requisite to such an upsurge, not only to allow enjoyment of the natural features, but to protect those features from the pressures of use.

Summary

Examination of social and economic factors and present trends indicates that the general level of recreation activity is likely to increase very greatly in the future. Decisions to reserve adequate land resources for recreation should be made now.

The most popular localities in the study area are the coast, the lower reaches of the Glenelg River, and natural areas around Portland. Most of the people using the area come from nearby districts, including South Australia.

However, the current levels of recreation activity are low because of the low regional population, long distances from the large populations of the capital cities, and a lack of facilities and publicity. Overseas experience strongly suggests that pressure can be applied to recreation resources very suddenly. Areas that are little used at present may experience very high, even destructive, pressures in the future.

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AGRICULTURE

The pastoral industries dominate land use in the south-western study area. The gross value of wool, livestock, and dairy production is of the order of $15 to $20 million per year. The townships are based upon service industries that transport, market, and process agricultural products and supply farm inputs. The tables in this chapter have been compiled from Commonwealth Bureau of Census and Statistics figures.

The present use of developed land

Table 10 shows the dominance of pasture, and therefore of the livestock industries, in local agricultural land use.

Wool, fat lamb,and beef production are the major animal industries of the area. Dairying is of minor importance, being restricted to small areas around Portland, Heywood, and Merino.

Figure 1 shows the trend in livestock numbers since 1965/66. Over this period sheep numbers dropped due to the drought of 1967/68 but regained their 1966/67 numbers within a year in Glenelg and within 2-3 years in Portland. The number of dairy cattle has declined over the period; it represented about 15% of total cattle numbers at March 1971. However, beef cattle numbers have increased very substantially, particularly since the 1967/68 drought.

Small areas carry cereal crops, vegetables, potatoes, orchards, and vineyards. The potato industry is concentrated in the Cashmore area and the orchards also lie to the north of Portland. These enterprises have local importance but do not make substantial contributions to State production. Apiculture is a minor industry, but one that largely depends upon the native flora of public lands. The recent high price levels for honey may encourage some expansion of the industry.

Since 1945 the average size of properties has declined, partly as a result of War Service Land Settlement. Well over 100 families were settled in the study area during this period, the majority on dairy farms within Glenelg Shire. However, the past 4 years have seen a decline in the number of rural holdings and an increase in the average size of each one.

Table 10

Agricultural Land Use as at March 31, 1971

	Portland*	Glenelg*	Total
Number of holdings	1,253	753	2,006
Total area occupied (acres)	555,606	592,869	1,148,475
Crop "	8,430	7,013	15,443
Fallow "	5,937	5,984	11,921
Native pasture "	71,406	99,483	170,889
Sown pasture "	432,871	427,294	860,165
Balance of occupied area "	36,962	53,095	90,057

* Shires of Portland and Glenelg. Portland figures exclude Portland town statistics and are not exactly comparable with earlier years.

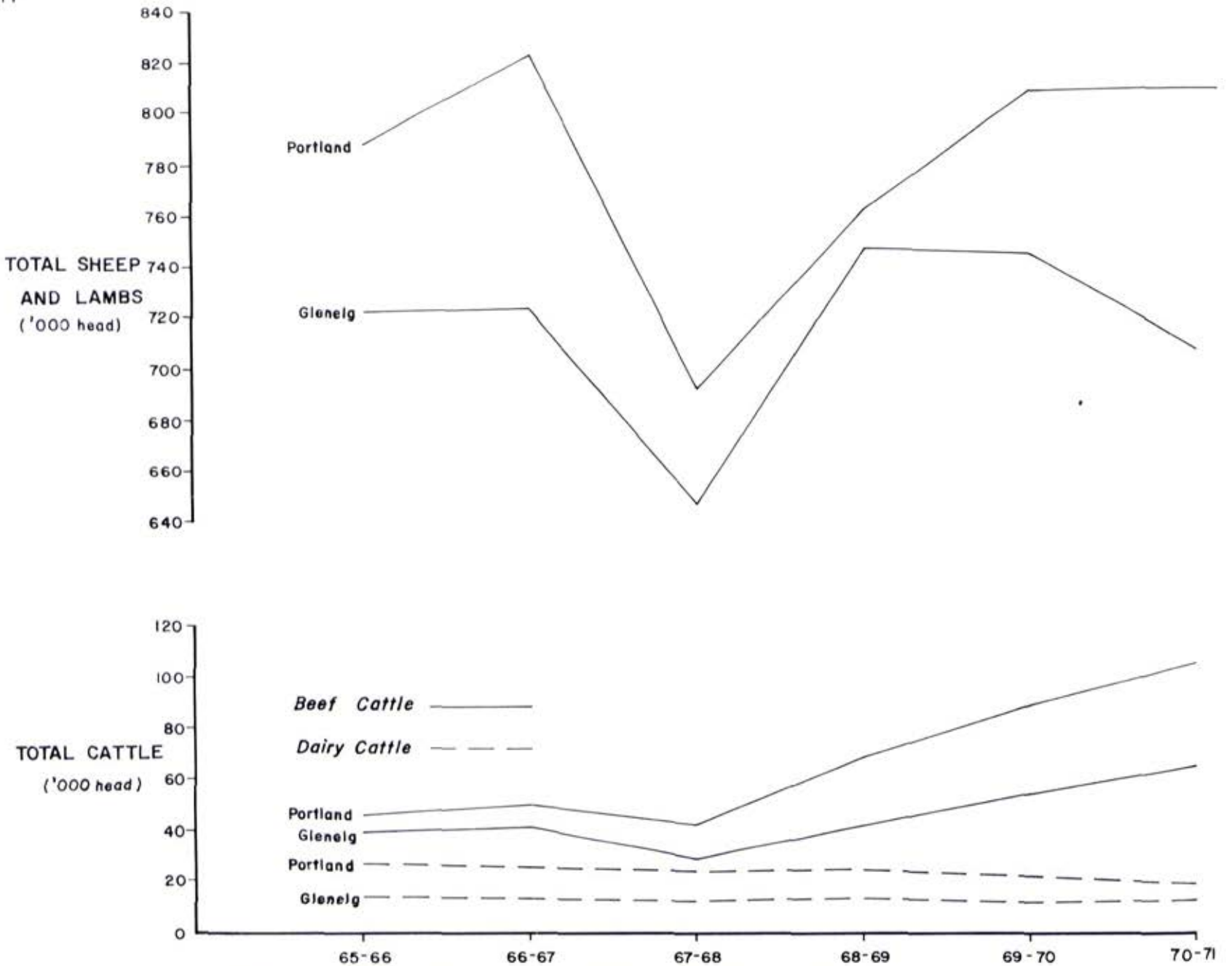

Figure 2. TOTAL CATTLE AND SHEEP NUMBERS, SHIRES OF GLENELG AND PORTLAND.

Table 11

Farm Size in the South-West Study Area

	Year	1967/68	1968/69	1969/70	1970/71
Number of holdings	Glenelg	799	788	769	753
	Portland	1,306	1,328	1,301	1,288*
Total area occupied (acres)	Glenelg	605,681	610,475	605,242	592,869
	Portland	536,334	539,408	550,917	557,418*
Average size of holdings (acres)	Glenelg	758	775	787	787
	Portland	411	406	423	433

* Figures for Portland town plus shire to enable comparison with earlier years

At the present time pastoral activities appear to have little direct impact upon the remaining public lands of the area. However, certain of these lands are subject to grazing licences, which usually supplement grazing on private property.

Development potential of alienated lands.

The relatively favourable economic conditions of the 15 years following 1950 encouraged timber clearing and pasture improvement on private lands. Some more recent examples of private and government-sponsored agricultural land development can be found in the Kentbruck area, also to the west of Dartmoor (Palpara) and around Dergholm. However, timbered country is not typical of the alienated lands of the region.

Table 12

Pasture Improvement and Stocking Rates

	Three-year average 1960/61 to 1962/63		Three-year average 1968/69 to 1970/71	
	Shire of Glenelg	Shire of Portland	Shire of Glenelg	Shire of Portland
Total area occupied (acres)	553,993	526,533	602,862	549,248
Percentage of occupied area under native or sown pasture	85	81	89	89
Percentage of occupied area under sown pasture	49	53	71	75
Percentage of total pasture recorded as sown pasture	63	65	80	84
Average stocking rate *	2.0	2.3	2.2	3.0

* A very crude index of stocking rate has been calculated by multiplying total cattle numbers by six and adding this to sheep and lamb numbers. This sum, divided by the total area of sown and native pasture, gives the index shown above. Actual stocking rates will vary widely between farms and localities within each Shire. Better systems of relating available forage to animal needs are commonly used. However, this crude index is considered to be adequate here, given the nature of the basic data and the prupose of the calculation.

Agricultural holdings in the study area occupy a total area of about 1.15 million acres. After allowing for those areas that would not be cleared on a "fully" developed farm, it appears that less than 50,000 acres of timbered land, with potential for pastures, remain on agricultural holdings. Clearly, any substantial increase in livestock production from alientated lands must come from land already under pasture.

Table 12 shows the large increase in pasture improvement in the area that has occurred since 1960. This development has enabled farmers to increase stock numbers, initially as sheep, but in recent years as beef cattle. It is estimated that about 350,000 tons of superphosphate has been applied to pastures since 1960. Evidently a few hundred thousand acres of pasture remain unsown or infrequently fertilized. The further development of this land towards its physical potential will ultimately depend upon farmer attitudes and upon the price levels achieved by beef, wool, and fat lambs relative to the costs of pasture and other farm inputs. Early in 1972, cleared alienated land was available for pruchase within the area. Price levels appear to be equivalent to the cost of clearing and developing similar land from virgin bush, but without allowing for possible taxation savings. (The Category 1 lands in the higher-rainfall zones of Portland Shire described on page 120, and in Table 13, on pages 122-3, may be an exception.)

In summary, the further development of private agricultural lands is possible but will depend upon future price levels for pastoral products and inputs. Ignoring taxation considerations, it appears likely that the further improvement of pastures on cleared or semi-cleared land would prove at least as profitable as the development of virgin lands.

Outlook For Agricultural Products

It is extremely difficult to assess market prospects for farm products. However, they are an important consideration in rural land use decisions. The major farm products of the south-west study area are meat, wool, and dairy products.

Meat production

In 1970/71, Australia produced record levels of all major meats. The large increase in beef cattle held on farms indicates that beef production will increase at an even greater rate over the next few years. The Commonwealth Bureau of Agricultural Economics (B.A.E.) suggests that these "increases are likely to be associated with increased sales to lower-priced export markets and with significant extra volumes going to the domestic market. This could lead to a clackening of retail prices of beef and at the same time increase competitive pressures on prices of other meats."

Cattle grazing on red gum plains

The 1971 mating statistics provide some evidence that producers intended to increase lamb production. However, as export prospects are limited ". . . this could lead to some downward pressure on lamb prices and could be accentuated by competitive pressures from other meats, particularly beef". It is clear that producers were already dissatisfied with 1971 lamb prices. It is not known whether the high lamb prices of winter 1972 will be repeated in future years. The export demand for mutton is substantial, but estimated price levels are such that mutton production is likely to remain a secondary object of other sheep activities.

In summary, meat production, especially beef, appears to have reasonable long-term prospects but production increases already planned may exert a downward pressure on Australian prices. The volume and price levels of international trade will largely depend upon policy decisions in the major importing countries or blocs.

Wool production

Australian wool production is expected to fall slightly from 1970/71 to 1972/73. Although the recent strong price rally will moderate this trend, no marked increases in output are likely in the medium term. The B.A.E. suggests that ". . . over a longer term wool prices are not likely to reach and maintain levels of only a few seasons ago. Increasingly the price of wool is being influenced by developments in the entire fibre market which are tending to constrain the limit to which prices might otherwise reach."

Although many Australian producers have few alternatives to wool production, farmers in the study area do have alternatives because of the comparatively reliable rainfall.

The marketing of wool is expected to undergo radical change over the next few years. This has the potential to effect changes in the economy of minor wool-selling centres such as Portland, but the direction and extent of these changes are uncertain. If objective measurement and sale by sample become prevalent, conceivably the quantity of wool handled and shipped through Portland could increase, despite a decline in, or cessation of, actual sales at Portland.

Sheep in yellow gum woodland

Dairy production

Australian dairy cow numbers have continued to decline and milk production fell in 1970/71 (although output was still the second-highest ever recorded). However, dairy cow numbers have been increasing slightly in Victoria. There is a trend towards a smaller number of efficient farms concentrated in the most favourable districts. Proposed quota schemes aim at adjusting future output levels to the quantities demanded at acceptable price levels.

In the short term, the outlook for dairy products remains very favourable and the current strong demand at high prices cannot be met. This will slow the longer-term decline in Australian cow and farm numbers. However, if the new members join the European Economic Community as planned, and the agricultural policy of that Community is not drastically changed, it is possible that Australian dairy exports will decline in price and volume after 1973, and that prices will recede from the present high levels.

Minor industries

The horticultural industries appear to face very poor market prospects. However, at least in the short term, the outlook for honey is excellent.

In short, of the major farm products suited to the south-west study area,

beef has the most favourable market prospects. However, widespread agreement on this fact-has led to increased supplies becoming available, and the extent of access to the American and Japanese markets could largely determine medium-term Australian beef prices. This is, of course, influenced by government policy decisions in those countries.

The market prospects for wool, lamb, and dairy products are not so favourable as to encourage the establishment of new producers largely dependent upon these enterprises. In the medium, term, unforeseen demand increases would raise prices and so encourage additional output through the intensification of existing farm operations.

The Capability Of Public Lands For Agriculture

Part IV of this report discusses the agricultural potential of specific public lands. Assessment of land's capability for agriculture requires the consideration of physical factors, such as rainfall and soil type, as well as economic factors, including the costs of development and of maintaining the productivity of the land. The report has not studied the profitability of agricultural development in detail at the individual farm level.

The classification of Table 14 has been used later in Part IV. It has a physical basis and is oriented towards the pastoral industries - the use of land for special crops, orchards, or vineyards has not been considered.

Land category 1

The public lands in this category are characterized by medium-fertility gradational soils of loam and clay loam surface texture. They occur in the Portland Land-Zone and can support productive perennial pastures but are at present covered by an open forest of messmate and brown stringybark, which is used for hardwood production. Average annual rainfall is greater than 30 in.

Pasture establishment here involves bulldozing, windrowing, heaping and burning, ploughing, root-raking, discing and harrowing, drilling seed, and applying fertilizer. Fencing, water supply, and building costs must also be incurred in development.

The costs of development will vary according to the size and density of the trees. An average estimate for the total cost of development of a farm unit on this land would be up to $180 per acre (not including livestock). When fully developed, these pastures would be capable of supporting about 4 to 5 stock-equivalents per acre, or one milking cow to 2 to 2¼ acres. One stock-equivalent (SE) is defined in terms of the amount of feed required to maintain a mature, dry sheep, at average

district production levels, for 1 year. Approximate values for other livestock classes include: 1 breeding ewe plus lamb = 1.5 SE, 1 cow with calf at foot = 10 SE, and 1 adult steer = 8 SE.

Special treatments needed for pasture establishment include small amounts of lime and the correction of molybdenum and copper deficiencies, plus the liberal use of superphosphate. Maintenance involves the annual superphosphate applications and periodic dressings of potash fertilizer, particularly where intensive utilization occurs.

Land category 2

This land supports vegetation consisting of open forest, gum woodland, or heathland. Its duplex soils have a surface horizon of sandy loam texture overlying clay subsoils at less than 24 in. Average annual rainfall varies from 27 in. on the most favourable soils to 36 in. on the poorer soils. Category 2 occurs in the Kanawinka Land-Zone where the sheets of sand are thin or absent, and in the Heywood Land-Zone.

Such lands can be made to support productive pasture. Development costs will vary according to the density of the forest and heath, but would not differ appreciably from those on category 1 land. Actual clearing costs could be lower, but the higher cost of fertilizer and the need to install adequate drainage on wet heath lands would offset this. The development of pastures on these soils requires application of large amounts of lime, adequate superphosphate and potash, plus the trace elements copper,zinc, and molybdenum.

However, when developed, they can be made to support at least three to four SE per acre, if they are adequately fertilized and managed correctly.

Maintenance costs are higher than for Category 1. In addition to the annual use of superphosphate, potash must be applied frequently and dressings of copper and molybdenum are needed every few years.

The wet heath and tree heaths represent a high percentage of the public land in the southern part of the study area.

Land category 3

Category 3 land consists of shallow sandy loams, which support an open forest with associated shrubs. It is limited to the Nelson Land-Zone, where average annual rainfall exceeds 30 in. Pastures based on annual species can be developed with the use of superphosphate plus the correction of copper and zinc deficiencies. The costs of farm development will vary according to the density of the forest, but full development would cost about $140 to $180 per acre. The potential carrying capacity of this category is about 3 SE per acre.

Table 13

AGRICULTURAL LAND CLASSES

Category	Soils	Rainfall
1	Red to brown weakly bleached gradational soils of clay loam over clay textures, and some brownish gleyed soils of clay texture - Portland and Dundas (southern part) Land-Zones	greater than 30 in.
2	Duplex soils of sand to sandy loam over clay within 24 in. of the surface - areas of thin sand sheets in the Kanawinka Land-Zone, and Heywood Land-Zone	greater than 27 in.
3	Red to black soils on limestone, and coloured, loamy leached sands with an impeding layer within 48 in. of the surface - Nelson Land-Zone	greater than 30 in.
4	Grey to white leached sands, with an impeding layer within 48 in. of the surface; duplex soils of acid sands over clay.	variable less than 27 in.
5	Grey to white leached sands, with no impeding layer within 48 in. of the surface - Kanawinka Land-Zone	variable

Table 13 continued

Vegetation	Pasture carrying capacity* (Stock-equivalents per acre)
Open-forest II of messmate, peppermint, and gums, and open-forest I of swamp gum	4-5
Variable - wet heaths and gum woodlands in Kanawinka Land-Zone, and open-forests I and II of messmate and gums in Heywood Land-Zone	3-4
Open-forests I and II of manna gum and manna gum - brown stringybark	3
Open-forest I of brown stringybark over heath	1-2
Open-forest I of brown stringybark over bracken or low heath	1

* Estimated carrying capacity in the absence of marked changes in technology or economic factors.

Land category 4

Occurring throughout the study area, this category represents a major part of the public lands. The soils - acid sands to sandy loams of low fertility with an impeding layer within 48 in of the surface - support an open stringybark forest and associated heath understorey. Areas of duplex soils receiving less than 27 in. of rainfall per annum fall into this category.

For pasture development, specialized sowing techniques are essential. They involve the use of lime, superphosphate, potash, and trace elements. The costs of development are high and would vary from $140 to $180 per acre. And even when fully developed such land can support only poor pastures composed basically of inferior pasture species. The potential carrying capacity would be between 1 and 2 SE per acre.

Pasture maintenance is costly and involves, in addition to superphosphate, repeated applications of potash and trace elements.

Land category 5

This type of land supports a stringybark forest and associated heath. The soils are deep, acid sands and are capable of supporting only very poor pastures. Average annual rainfall varies through the whole range received in the study area.

Despite high development costs, similar to those for category 4, the land has a lower productive potential. It is doubtful if such land is suitable for agriculture.

The Present Situation

The most recent example of the development of public land for agriculture is the Palpara project. The Rural Finance and Settlement Commission began to clear 7,000 acres at Palpara, west of Dartmoor, in 1969 and pasture sowing is expected to be completed in 1972. Most of the land develoepd would fall within category 2. The project has been a technical success, but the broad economic and social aspects of the development are uncertain.

In summary, a large proportion of the remaining public land can support only poor pasture and the costs of developing and maintaining those pastures would be high. The exceptions to this generalization include substantial areas of category 1 land within the Shire of Portland in the Cobboboonee, Annya, and adjacent blocks.

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SOFTWOOD TIMBER

Pine plantations are a notable feature of the southern and western parts of the study area, where sandy soils and high rainfall provide good growing conditions. The plantations, which consist almost entirely of radiata pine (*Pinus radiata*), cover about 75,000 acres of private and public land and over the past few years have been increasing at the rate of 2,500 acres per year.

The three major owners of plantations in the study area are the Forests Commission, Southern Australian Perpetual Forests Ltd. (SAPFOR Ltd.), and Softwood Holdings Ltd. Table 14 shows the acreages these organizations hold on both public and freehold land. A few hundred acres in school endowment plantations and farm woodlots are scattered through the area.

The total annual output from the plantations is currently about 75 million super feet, but this will increase rapidly as large areas of young stands mature. Sawlogs are converted at mills in Dartmoor, Nelson, Tarpeena and Rennick; small round timbers are treated with preservative at Dartmoor and Colac, while particle-board manufactured at Mount Gambier utilizes pulpwood and some mill waste.

The major markets for finished products from the region are Melbourne and Adelaide.

History

The first softwoods in the region were planted in the 1880s at Mount Burr, but it was not until 1907 that regular plantings began, all in South Australia. Private companies began planting significant areas in both Victoria and South Australia in the late 1920s.

In 1947 the Victorian Forests Commission commenced planting at Rennick and by 1960 had established 3,100 acres.

At about this time the State planting plans were revised in accordance with additional available government finance. They set annual planting rates of 500 acres for the Rennick plantation and 1,000 acres for a new plantation to be established within 40 miles of Portland. These rates have been maintained, and in December 1971 the Rennick plantation contained 10,432 acres and the Portland (Kentbruck-Casterton) plantation 12,670 acres.

Since the mid 1950s, the acreage of

plantations established by SAPFOR Ltd. has increased rapidly. The majority of the company's plantations have been established on leased public land made available under the provisions of the Land (Plantation Areas) Act (1966). The company has the right to purchase land leased before 1966. It has purchased a 60-acre site near Casterton and intends to establish a milling complex there when adequate log supplies become available from plantations within economic carting distance.

The expansion of the Softwood Holdings Ltd plantations has been based on purchased marginal farm land in areas close to their mills at Dartmoor and Nelson, and two small areas of leased Crown land.

Social benefits

Softwood plantations and associated industries contribute to the welfare of the nation by providing employment in rural areas and provincial towns.

In the south-east of South Australia, forestry supports about one family per 40 acres of plantations, and this is expected to rise to one family per 25 acres when the potential of the area has been fully developed. Similar figures can be expected for the plantations in the study area when a plantation resource capable of supplying a complex of wood-using industries reaches full production.

Industry requirements

In general, the industry requires 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, roads, and maintenance costs. The flat terrain of the south-west is ideal for mechanical harvesting equipment. As log transport costs make up a high proportion of the cost of the raw materials, the plantations must be located close to milling centres.

Modern log-handling methods, near Nelson

Table 14

PINE PLANTATION ACREAGES

(rounded figures as at December 1971)

	Forest Commission	SAPFOR Ltd	Softwood Holdings Ltd Group	Other Private	Totals
Public land	23,000	14,500	3,000		40,500
Freehold land		11,500	18,500	5,000	35,000
TOTALS	23,000	26,000	21,500	5,000	75,500

The most efficient utilization of raw materials is achieved by a complex of integrated industries, which can handle small-size material from thinnings as well as logs and in which one industry can utilize the by-products of another. However, modern wood-processing plants such as sawmills and particle-board plants are capital-intensive installations, and an assured supply of raw material is a prerequisite to their construction.

In general, economies of scale are realized in plantations larger than 10,000 acres, and a plantation resource of at least 40,000 acres is necessary to support an integrated complex of industries.

Outlook

It is difficult to make even short-term forecasts of demand for a commodity, and longer periods increase this difficulty enormously. However, for forest crops current planting rates must be based on forecasts of the amount and nature of consumptions in 30-40 years' time. In Australia, current planning is based on forecasts of demand for the year 2000.

The demand for softwoods

Australian native softwood resources are restricted to some rainforest species in the tropics and Tasmania, and the slow-growing *Callitris* forests

of the dry inland. These forests make up only 4.8 million acres of a total commercial forest area of 87 million acres.

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 characteristics. Australian production of softwoods has remained at a low level, and consequently large volumes have been imported.

After the wool boom in the early 1950s Australia entered a phase in which balance of payments difficulties were a prominent economic problem. Forest administrators began to express concern at the high volume of softwood imports and the future implications of a dependence upon imports. Jacobs stated this concern, and a plan for reducing such dependence, in the following way:

* Australia's import bill for timber and timber products is about $200 million *per annum*.

* This import bill is so high that it acts as a constraint on the development of the nation.

* Population and *per capita* consumption will increase, and so shortfall in timber supply will be greater in the future. As its basis for planning, the Commonwealth Government has used 1,100 million cubic ft of forest products as an estimate of Australian requirements by the year 2000 A.D.

* Australia has large areas of land suitable for the growth of conifer forests, which could produce substitutes for most of our present imports.

* In future it may not be possible to find adequate supplies of wood on world markets, as countries that export at present will be forced to direct their resources to satisfying domestic markets.

* The reliability of imports may be threatened by wars and internal economic controls.

Jacobs suggested that half of Australia's requirements in 2000 A.D. could be grown on 3 million acres of coniferous plantations and the remaining half on 25 million acres of native forest. He also pointed out that any programme to implement such a plan should be reviewed periodically in the light of revised supply and demand estimates.

Parkes and others have criticized these arguments on several grounds, which include the following opinions:

* Undue emphasis has been placed on balance of payments difficulties, as

Australia has recently accumulated large reserves of foreign exchange.

* Even if Australia faced an unfavourable trade balance, the substitution of locally grown timber for imported timber may not be the best means of improving the balance. If Australia is comparatively more efficient in other industries, it would be to the general advantage for new investment to be concentrated in those industries. Australia would then rely upon softwood imports from existing sources, including New Zealand, and perhaps encourage the development of the timber industries of Papua-New Guinea, Indonesia, and Malaysia. Thus, each country would produce and exchange the goods in which it has a comparative production advantage.

* Australia's imports of timber products are not high compared with those of other important trading nations such as the United Kingdom, West Germany, and South Africa.

* Some recent predictions of consumption and yield suggest that the current planting programmes will produce a surplus of timber within Australia after the year 2000.

However, the Commonwealth Government has accepted the need for greatly increased softwood plantings, subject to review every 5 years, and the arrangements for this are outlined below.

Farmland newly planted to pines

Commonwealth Act

In 1967, the Federal Government passed the Commonwealth-States Softwood Forestry Agreements Act to ratify an agreement between the Commonwealth and the 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 is 3,000,000 acres of plantations by the year 2000. The target for the State Forest Services for the first 5-year period 1967-1971 was 256,800 acres.

Victoria planted 50,000 acres during this period. The State financed the first 6,000 acres of planting in each year and the Commonwealth the balance with loan funds that are interest-free for the first 10 years.

The Victorian Forests Commission expects to plant 11,580 acres per annum for the current 5-year period, which ends in 1976. Private companies will plant about 6,500 acres per annum, bringing the total for the State to 18,000 acres per annum. Private companies are not assisted by the Commonwealth.

Plans for the study area

Within the south-western study area, the Forests Commission's long-range plans are to expand the Rennick plantation to a total of 20,000 acres and the Portland plantation project to 40,000 acres, including the small plantations south of Casterton. It is proposed to establish the plantations on selected areas of public land and purchased farmland. The Commission has purchased 2,866 acres of private land in this area over recent years for inclusion in the planting programme.

SAPFOR Ltd plan to establish an extra 34,000 acres of plantation by the year 2000 A.D., provided suitable land and finance from investors is available. Not all of this land would necessarily be in Victoria, but the Company does propose to establish further plantations within economic cartage distance of Casterton. At present the Company's total holdings in the Penola-Dartmoor region is about 50,000 acres.

Softwood Holdings Ltd plan to continue planting 600 acres net per year in Victoria. In recent years about 20% of this annual establishment has been on second-rotation sites. With their pre-

A 5-year-old plantation at Rennick

sent holding of land this will increase to 80-90% by the early 1980s.

Projected total log output from plantations in the study area in the year 2000, if these plans are carried out, is 400 million super feet (t.v.) per annum, of which about 290 million super feet will be sawlogs.

Capability

Requirements of radiata pine

The site requirements for commercial plantations of radiata pine are:

* a minimum annual rainfall of 30 ins.
* an acid soil of at least moderate fertility.
* an optimum of 30 in. topsoil over any root- or water-impeding layer, and a minimum of 18 in.
* good soil drainage.

Rainfall

The map facing page 28 shows which parts of the study area receive 30 in. or more rainfall per annum. Commercial plantations of radiata pine can be grown under rainfalls less than 30 in. provided the soil contains a layer at a depth between 18 and 48 in. that impedes the drainage of water out of the soil, and groundwater is within

Stacked logs and pulp from a delayed first thinning

reach of pine roots. These conditions are found on some of the leached sands in the blocks on the Follett Plains.

Soil fertility

It is not possible to quote soil nutrient content figures that set adequate levels for radiata pine. However, experience has shown that the yellow or creamy leached sands are suitable provided they are deep enough. The white and grey sands are usually too impoverished to support economic stands of radiata pine without treatment. SAPFOR Ltd apply superphosphate to their plantations on

infertile sands at the time of planting, and claim that this increases productivity at least 250%. Additional increases have resulted from experiments using nitrogen and trace elements.

All the sandy soils are deficient in zinc, and this element is applied as a matter of course at age 24 years. Chronic zinc deficiency occurs on the highly alkaline black soils on limestone, and so these soils are unsuitable for radiata pine.

A major group of soils that the Forests Commission has investigated for pine-growing comprises the weakly bleached gradational soils of the Portland Land-Zone in the Cobboboonee block. These lack phosphorus, and this deficiency has been overcome in trials by adding suitable fertilizer.

Soil depth

Most of the sandy soils of the Kanawinka and Nelson Land-Zones are sufficiently deep - many are too deep. But the red and black soils on limestone that form part of the Nelson Land-Zone are often too shallow.

The weakly bleached gradational soils of the Cobboboonee block have a heavy clay horizon at 10-15 in. depth. Trials on these soils have shown that ripping to a depth of 3 ft with a bulldozer-drawn tyne, and planting trees near the rip lines, increases tree growth.

Soil drainage

Radiata pine can tolerate brief waterlogging, but cannot tolerate conditions where the roots lie in saturated soil for 3-4 months each winter. In the study area, heaths and low swamp gum indicate conditions too wet for radiata pine. This problem can be overcome by mounding - that is, throwing up a mound 20-30 in. high with a plough and planting the trees on this - but stands established in this way are liable to wind-throw later in the rotation.

Drainage is related to soil depth and the presence of shallow impeding layers in the soil - the better performance of plants on ripped ground in trials in the Cobboboonee block is partly the result of better soil drainage in winter.

Salting

In the Strathdownie and Tooloy blocks in 1968/69, deaths due to high foliar chloride levels occurred in plantations established on thin sand sheets over poorly drained clayey deposits. It is thought that the pine roots had tapped saline lagoon deposits laid down during the retreat of the sea from this area during the Pleistocene.

A salt hazard exists where shallow sands occur over wet clays on the Follett Plains. Such sites are often associated with red gum woodlands.

Table 15

SITE QUALITY FOR RADIATA PINE

Site Quality	Site Index height (ft) at age 20	Volume super feet at age 30	Mean Annual Increment super feet to 30 years
I	102	163,920	5,464
II	96	146,040	4,868
III	90	127,920	4,264
IV	85	110,760	3,692
V	79	91,800	3,060
VI	71	65,280	2,176
VII	61	40,680	1,356

Site quality

Although radiata pine grows quite rapidly in this region by world standards, wide variations in growth rate occur due to differing site factors. Plantations are assessed and placed into site-quality classes (SQ) at about 10 years, to form the basis for calculating growth rates and the quantities of the various classes of log material that will become available for industry. The sole criterion of site quality is the total volume of timber produced.

Seven qualities have been defined. Five cover healthy stands; SQVI means marginally healthy, and SQVII ranges from marginal to failed. Maritime pine has often been planted on sites judged to be SQVII for radiata pine.

The 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 90 would fall into class SQIII. Table 15 sets out the productivities of the different classes.

It is not possible to classify a site accurately until a stand of trees has actually grown on it. However, the form and composition of native vegetation, and soil, climatic, and topographic factors are useful indicators of suitability for radiata pine.

Table 16 divides the land in the study area into categories based on suitability for radiata pine. These form the basis for the description of pine potential in Part IV.

Second-rotation degrade

During the late 1950s and early 1960s it became apparent to foresters in the south-east of South Australia that the second-rotation stands were producing less than the first. Detailed measurements revealed that a decline in productivity of the order of 1½ SQ units was occurring over 85% of second-rotation areas. This implies 26-33% less production over a rotation - and such losses pose a serious threat to the economic viability of some plantations and to the level of future supply of raw material to industry.

The Nelson and Kanawinka Land Zones have soils similar to those on which degrade has been recorded in south-eastern South Australia. All existing plantations in south-western Victoria have been established on these soils.

The maintenance of productivity, and the

Table 16

Category	Native vegetation
A	Manna gum, and/or brown stringy bark with tall silver banksia, blackwood, or black wattle over bracken, grasses, and herbs
B	Messmate, peppermint, swamp gum, and manna gum>60 ft high over blackwood, bracken, and grasses, or heath
C	Brown stringybark with some manna gum over bracken or low heath
D	Brown stringybark over bracken or tall heaths
	Gum woodlands*
	Heaths and swamps

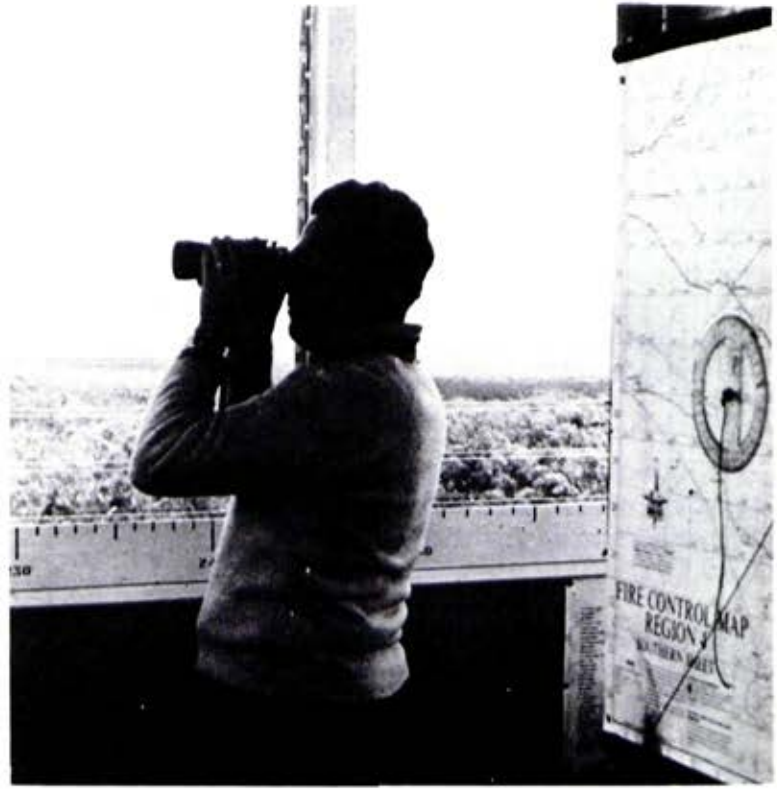
* The manna gum woodlands in the Tooloy block fall between categories A and B.

RADIATA PINE SUITABILITY CLASSES

Soils	Rainfall (in.)	Pine potential
Orange, yellow, or creamy leached sands (loamy sands) with an impeding layer 24-60 in. from the surface, and red soils on limestone more than 15 in. deep	>30	Proved potential of SQII-V; zinc application necessary (covers most plantations in the Mount Gambier-Rennick-Dartmoor-Kentbruck area) (Nelson Land-Zone)
Red, brown, and grey weakly bleached gradational soils (loams and gravelly loams over heavy clay at 10-15 in.)	>30	Potential not yet fully proved but trials with ripping and phosphate fertilizers indicate SQII-V (Portland Land-Zone)
Grey to white leached sands, with an impeding layer within 48 in. of surface	>26	Low potential but SQIV-VI possible with careful site preparation and addition of fertilizers (Kanawinka Land-Zone)
Grey to white leached sands with no impeding layer within 48 in. of the surface		Not suitable for pines due to low fertility, and summer drought or winter waterlogging: a salt hazard exists on some gum woodland sites
Clayey duplex soils		
Various soils subject to waterlogging		

NOTE: The categories are generalized and describe broad land types, each containing considerable variation. They are based on evidence from existing plantations and trial plots, and will apply to private land distant from existing plantations, provided variations in rainfall are taken into account.

This Rennick plantation, after second thinning at 25 years (below), illustrates the importance of fire protection (right)



upgrading of second-rotation sites, has become a major research project, involving the State forest service, the Forest Research Institute, CSIRO, and universities. The research effort is divided into five broad fields - nutrient supply, water supply, root inhibition, planting-stock vigour, and establishment practice. No single factor appears to be responsible.

At present the most promising line of attack on the problem appears to be

improved cultural practices in establishing the second rotation. The pattern of growth of a stand throughout a rotation may be determined by growth in the first 5 years after planting. Experimental techniques used to obtain maximum growth during this period are: mulching rather than burning of logging slash; cultivation of the site; correction of any nutrient deficiencies; use of vigorous planting stock; and elimination of competition from weeds.

Basic research into the other aspects of the problem is continuing, and methods of containing the decline in productivity will probably be available by the time the oldest Victorian plantations in the south-west are due to be clear-felled and replanted.

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Loading 8-ft logs from a 23-year-old plantation

HARDWOOD TIMBER

Prior to European settlement the whole of the study area was clothed in forest or woodland interspersed with open grassy areas, swamps, and tracts of low or stunted vegetation. Since then, the forest area has been reduced considerably by clearing for settlement and the widespread use of fire has modified the vegetation in some areas and seriously damaged regrowth.

Historical development

Although alienation of land from the Crown began in very early times, particularly in the Portland area, much of the privately owned land remained forested until recent times. Small areas still carry dense forests.

Historical accounts of Portland, Heywood and adjacent areas show that sawmilling has long held a major place in the industrial life of the area. The early settlers' requirements for sawn timber, fencing, and firewood were met from the forest at large, either from the areas then passing to private hands or from unoccupied Crown lands.

Sawmilling in the Heywood area was recorded as early as 1856 at Milltown. Demands for sawn timber increased following closer land settlement in the 1870s, and when the railway to Portland from Hamilton was opened. Many of the early mills were small units that moved from location to location as suitable log supplies were cut out.

Since 1924, annual production of sawlogs from public land has averaged about 7 million super feet. The housing booms of the 1920s and 1950s created periods of high demand. (An average-sized brick veneer house with timber frame and floors requires about 7,000 super feet of sawn timber; an all-timber house could require twice this volume.)

Limited volumes of hardwood logs are obtained from private property, as a salvage operation before clearing for agriculture.

For most of the past 50 years, timber-harvesting on public land has been controlled by Forests Commission staff, who selectively mark individual trees for removal. Saplings and immature trees have been reserved and given silvicultural treatments to stimulate their growth rate.

Messmate in Cobboboonee block - a valuable source of timber

During the depression years, felling of useless trees and thinning of regrowth - carried out over large areas, particularly in the forests surrounding Heywood - have given rise to much of the better-quality forests of today in this area. Similar stand-improvement work has been carried out since then as funds permitted, and in 1967 more than 3,000 acres were treated as part of the drought relief employment scheme. At present the hardwood industry employs about 120 men.

Timber species

Messmate and brown stringybark, the two most important timber species in the area, have pale-coloured, strong, and moderately durable wood. It is used extensively as a general-purpose timber for housing and light construction, fencing, poles, and many minor purposes. Messmate's relatively fast growth rate and large log sizes make it the more important of the two.

Peppermint, manna gum, and swamp gum are also used to a limited extent to provide timber of inferior quality.

Red gum and yellow gum, which have somewhat restricted occurrence on public land, produce tough, hard, durable wood that is used for heavy construction works and for sleepers and fencing.

Present stands

The most important stands of native timber occur in the Cobboboonee, Annya, Narrawong, Homerton, and Hotspur blocks.

In these blocks, extensive stands of messmate, often exceeding 80 ft, occur with gum and peppermint, and some brown stringybark. These have been selectively logged since early settlement and, despite conscious efforts to improve stand quality, in many places more than half the basal area still comprises defective trees unsuitable for sawlogs.

Table 17

POTENTIAL FOR HARDWOOD TIMBER PRODUCTION

Category	Tree species	Mature stand height (ft)	Rainfall (in.)	Potential
A	Messmate, some peppermint	>80	>30	best sites, sawlog increment of the order of 600 super feet per acre per annum; current increment about 200 super feet per acre per annum
B	Messmate, with peppermint, gum, and occasional brown stringybark	60-80	>30	sawlog increment of the order of 450 super feet per acre per annum; current increment about 150 super feet per acre per annum
C	Brown stringybark	60-80	>26	sawlog increment of the order of 300 super feet or less per acre per annum; current increment less than 150 super feet per acre per annum
D	Peppermint, with scent bark, manna gum, swamp gum	60-80	>30	inferior timber species producing some logs, poles, and posts
E	Red gum, yellow gum	50	<28	slow growth rates of durable timbers, sleepers, posts, poles
F	Brown stringybark, with occasional peppermint, swamp gum, manna gum	30-60	<30	few logs, poles, posts, firewood

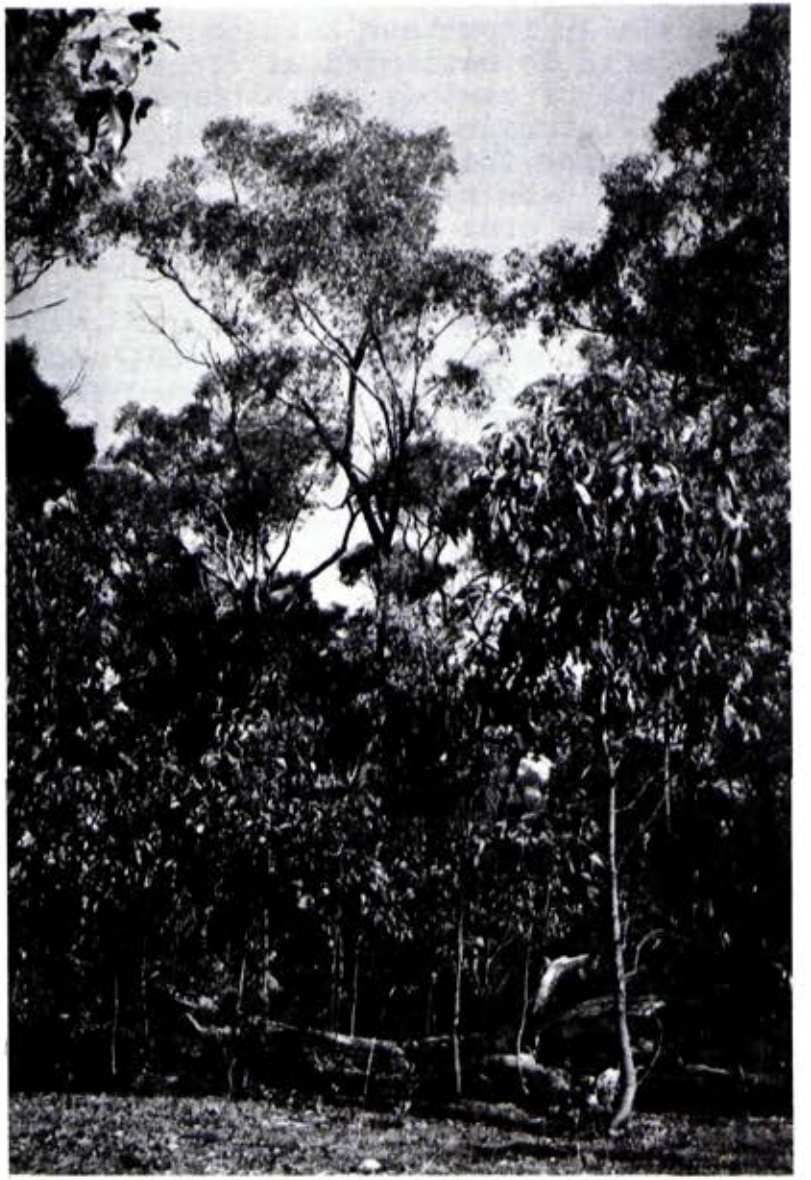
The messmate stands in the Annya, Cobboboonee, and Narrawong blocks have received most silvicultural treatment. Less productive stands occur in the Hotspur and Homerton blocks.

Extensive timber stands of brown stringybark occur in the Hotspur and Lower Glenelg blocks, and smaller ones in the Cobboboonee, Narrawong, Annya, Kentbruck Heath, and Weecurra blocks. These stands have also been selectively logged since early settlement. Because of their lower potential productivity, less effort has been spent on silvicultural works, and as a result they are generally in a poor condition.

Productive timber stands cover a total of about 100,000 acres. They seldom occur in consolidated areas, but rather as a mosaic with heaths, swamps, and stunted forest. Stands growing on much of the public land in the drier northern half of the study area rarely exceed 60 ft in height. They comprise mainly brown stringybark, and are not suitable for commercial timber production. Small areas of red gum and yellow gum provide exceptions, but unfortunately these valuable timber trees grow on soils that are particularly suitable for agriculture, and progressive alienation has left only pockets of them, often of only marginal site quality, on public land.

Current yields

The present yield capacity of the



Messmate regeneration after the removal of a cull tree

commercially important hardwood stands in the area is estimated as 8.5 million super feet of sawlogs per annum (out of a total Victorian yield of about 425 million super feet). This level of output could be maintained indefinitely, provided the area is protected from fire and the present level of silvicultural activity is maintained.

Poles, fencing material, firewood, and some railway sleepers are obtained from the forest, but their total volume is relatively very small, although important in meeting local demand.

Outlook

The present output of hardwood timber is consumed almost entirely within the region bounded by Warrnambool, Hamilton, and Mount Gambier, and this situation is unlikely to change.

Local demand for hardwood timber will probably remain fairly constant for, although the population will probably increase slowly, *per capita* consumption of sawlogs is expected to drop slowly from the current 140 super feet per annum to about 120 super feet in the year 2000. Softwood timber is also likely to replace hardwood in some of its traditional roles.

Capability

Table 17 classifies the hardwood timber resources of the study area, and this generalized classification is used in Part IV.

Large volumes of inferior-quality trees take up valuable growing space in the forest. Given a ready market to allow their economic removal (and there is some prospect of such a market), or a greater expenditure on non-commercial silvilcultural operations, the sawlog yield from existing stands could be increased two- or threefold.

The forests have particular value, as they are the most westerly source of hardwood timber in south-eastern Australia and are separated by about 80 miles from the closest other source to the east.

MINERALS

The area has no known economic deposits of metallic minerals, although very small, uneconomic deposits of silver-lead suphide and gold were worked briefly late last century. Minor occurrences of nickel and barium mineralization have been reported, all in, or adjacent to, the Dundas Tablelands physiographic unit, and it may be expected that future exploration for metallic minerals will be concentrated there.

The only "minerals" of importance in the study area are the common non-metallic minerals and rocks covered by the definition of "stone" in the Extractive Industries Act, 1966: sandstone, freestone, building stone, basalt, granite, limestone, quartz, slate, gravel, clay, sand, earth, soil, and other similar materials. (Metallic minerals are included in the interpretation of "mineral" given in the Mines Act, 1958, and are expressly excluded from the definition of "stone".)

These extractive industries materials are quarried and transported in large quantities throughout the State. They are used as aggregate for concrete, for road-making, building, filling, harbour, airfield, and other major construction works and in the manufacture of cement, lime, bricks, and tiles. Materials of this type have little value per unit volume, and transport costs of about 10 cents per ton per mile represent a significant part of the final cost to the purchaser. For this reason, the cost of quarry materials roughly doubles for each 25 miles of transport and it is clearly not economically desirable to transport these materials long distances if they, or suitable substitutes, are available locally.

Mineral Occurrences

The following notes, while not exhaustive, are believed to include most deposits that have been exploited economically.

Basalt

Crushed basalt is required for road-making and concrete aggregate, and large blocks have been used for harbour and foreshore works.

Although large areas of late Cainozoic basalts occur in the study area, most of these rocks have undergone deep weather-

ing and are not suitable for aggregate or other uses. However, near the coast south-west of Portland they have locally been protected from weathering and fresh basalt is obtainable.

The large basalt blocks used to construct the Portland Harbour breakwater were taken from a deep quarry on Cape Sir William Grant within the boundaries of the town. This quarry, operated by the Portland Harbour Trust Commissioners, produced 76,548 UK tons during the year 1969/70.

Small quarries have been worked from time to time in basalts near Bolwarra, in the Annya - Curracurt area, between Drumborg and Lyons, at Glenaulin north-west of Lower Crawford, and Jones Ridge near Moleside. However apart from the one at Cape Grant, few quarries are at present mining public land in the study area. Although basalt underlies large areas of public land in the Cobboboonee, Narrawong, and Annya blocks, exhaustive and costly search involving a good deal of drilling would be necessary to locate sites suitable for quarrying. This is chiefly because of the advanced state of weathering of most of the rock.

Very young basalts of the "stony rises" type occurring adjacent to Darlot Creek, between Tyrendarra and Lake Condah, have provided limited amounts of building stone, but do not appear to have been worked extensively for aggregate.

Basalts of Mesozoic age occur on private lands in and around the Dundas Tablelands. One of these deposits being worked at Moree in the extreme north-east of the study area produced 11,500 UK tons during 1969-70. Other small quarries at "Roseneath", east of Red Cap Creek, and at two localities near Dergholm have produced little stone, and that generally of poor quality.

Scoria

Scoria is worked at quarries located on private land at Mount Rouse (near Penshurst), Mount Eccles (near Macarthur), and Mount Napier, all to the east of the study area. They are all situated on prominent volcanic hills of interest to naturalists and tourists, and their workable reserves of scoria are limited.

A complex of scoria cones at Mount Eckersley (near Heywood) has been used as a local source, but this occurrence and the much smaller single scoria cones at Mounts Vandyke and Deception, west of Heywood, are generally more deeply weathered than those further to the east. Part of Mount Eckersley merits further investigation as a possible future source.

Serpentinite

A large quarry that formerly worked tough serpentinite (or diabase) on private land at "The Hummocks" near

Wando Vale now operates only intermittently. Production of the material has virtually ceased, primarily because the Country Roads Board has introduced more exacting specifications for road-making materials.

Granite

Granitic rocks outcrop at a number of places in valleys dissected in the Dundas Tablelands and Dergholm Platform. A coarse-grained red and green to greenish-pink granite occurring west and north-west of Dergholm is the most sought-after. The best outcrops are at Bailey's Rocks on Rocky Creek near its junction with Salt Creek, about 9 miles north-west of Dergholm. The stone at this locality is an attractive pinkish green colour, but the site is a Crown Reserve and is protected from quarrying. Similar stone, although containing less of the desirable green mineral, is now worked at a quarry about one-third of a mile to the north. The rock is used mainly as an ornamental veneer for facing buildings.

Spalls and slightly weathered rock may be used for making reconstituted stone.

The granite in this area has widely spaced joints and can supply large blocks, but many of the outcrops are deeply weathered and sites suitable for quarries are limited. Similar granite ranging from red to green in colour was formerly worked at a quarry near Boiler Swamp, about 4½ miles south-west of Dergholm.

Granitic sand for road-making is excavated from shallow borrow pits located on private land near the head of Salt Creek.

A pink, finer-grained granitic rock at Wando Vale (the "St.Elmo" granite) provided building stone prior to the 1939-45 war. Normal grey granites occur at other localities north of Dergholm, but have not been exploited to date.

Ironstone gravels

These gravels occur in an extensive system of ancient soils that were formed by the process of lateritization during the latter part of the Tertiary period. These soils now cap remnants of the original surfaces of the Dundas Tablelands and Merino Dissected Tablelands and have well-developed ironstone horizons. On the public lands in these areas, an overburden of wind-blown sand (Malanganee Sand) generally covers the original surface. Most flat surfaces older than Pleistocene now bear a layer of gravelly ironstone (buckshot gravel) at a depth of 6-20 in.

The ironstone gravels are used extensively in making unsealed shire and Forests Commission roads. The gravel generally ranges from ½ to 1½ in. in size and, mixed with some clay or loam, compacts to make a solid surface.

Numerous shallow borrow pits on public lands in the Cobboboonee, Homerton, Hotspur, Weecurra, Narrawong, and Annya blocks have yielded this material which has also been worked extensively from private lands around Merino and Casterton.

Material excavated from borrow pits less than 6 ft deep is not included in stone production figures for Victoria. The area required to produce a ton of road-making material from pits of this type is much greater than that assumed below for deeper quarries.

Mid-Tertiary limestone

Limestones are widespread in the Glenelg Group (see the geological map at the back of this report). The material is mostly marly and chalky limestone, but bryozoal limestones similar to the Mount Gambier Limestone occur in a few areas. In the past, hewn blocks were removed from an outcrop of limestone on public land where the Kentbruck Road crosses the Moleside Creek. Massive bryozoal limestone also occurs at "Snizort", west of Hotspur.

Extensive deposits of Tertiary limestone containing 80 to 95% calcium carbonate are common north-east of Portland. Good-quality limestone suitable for cement-making or agricultural lime also occurs in low hills west of Heywood. The Heywood Lime Works produced 1,918 UK tons in 1969/70. Other limestone occurrences are scattered through the study area, mostly on private lands, at Glenaulin, Wataepoolan, Sandford, Bahgallah, and Corndale, west of Red Cap Creek, and at Dorodong. A small quarry about 1½ miles north of Nelson formerly worked these limestones, but is now used as a rubbish tip. There is no quarrying of mid-Tertiary limestone on public land at present.

Sawn limestone blocks from Mount Gambier are used extensively as a building stone throughout the area.

Whalers Bluff Formation limestone

In common with the dune limestones, these rocks consist principally of carbonate sand (mostly shell grit), which is cemented to varying degrees by calcium carbonate. These limestones are now used extensively as base course material for road-making, to take advantage of the natural cementing properties of the carbonate grains.

Quarries have generally been established where zones of moderately cemented limestone are associated with uncemented or weakly cemented sands, enabling earth-moving equipment to excavate the formation. They are located in the Glenelg valley near Myaring Bridge (Goff's, Ponderosa, and Sullivan's Pits) and at Dartmoor. Large quantities of limestone from Goff's Pit are being used to rebuild the Glenelg Highway near Strathdownie. Early experimental work on this

cheap and abundant material was done on the Princes Highway near Dartmoor. It is quarried in conjunction with the overlying dune limestones nearby. Existing quarries are mostly located on private land.

Dune limestone (Bridgewater Formation)

These limestone resemble the sandy limestones and carbonate sands of the Whalers Bluff Formation, but as a result of wind sorting are more uniform in grain size.

They occur mainly in dune limestone ridges, especially in the Nelson-Kentbruck-Mount Richmond area, at Cape Nelson, the Mumbannar - Dartmoor area, and at Ardno-Puralka and Strathdownie. Isolated pockets occur on the Follett Plains as far north as Tullich and Dorodong.

As with the Whalers Bluff Limestones, the composition and hardness of the rock vary from place to place with variation in the amount of carbonate cement, which commonly ranges from 70 to 98%.

This material was used as a bulding stone in the early days of settlement. Large quantities of dune limestone are now quarried on public land and used for road-making. Local shires and the Country Roads Board use it as a base course in the construction of sealed roads, and the Forests Commission use it for making plantation roads in the Lower Glenelg area. Quarries either once or currently worked in this formation are located at Strathdownie, Dartmoor, Marp, Mumbannar, Battery Hill (Lake Mundi), Ardno, Puralka, Moleside, and Kentbruck.

Fresh-water limestones

These occur in the floors of some swamps and as deposits adjacent to springs in the Glenelg valley. They have been used to a limited extent for making tracks and as a source of agricultural lime, for example in the Tullich area.

Calcareous sands

Very large quantities of unconsolidated calcareous sands occur in extensive mobile dunes fringing Discovery Bay and

The calcareous sands of Discovery Bay

Bridgewater Bay. They contain 60-95% calcium carbonate, mostly of organic origin with silica as the main impurity. Almost all the sands are on public land. They are a potential source of high-grade lime for agricultural purposes, glass-making, or other uses, but are not utilized at present, although some material is reported to have been worked in the past at Lake Bong Bong.

This material is potentially a very useful and cheap source of calcium carbonate.

Quartz sands

Siliceous sands of the Malanganee Formation form sand sheets and dunes covering thousands of acres of public land in south-western Victoria. In places near the foot of the Kanawinka escarpment they attain thicknesses of up to 100 ft and very large reserves are present. No detailed information on their size distribution is available, but both medium- and fine-grained sands occur.

Sands are extracted from public land in the Narrawong block for use in making concrete, and for filling.

Bowen has pointed out that the big cities' consumption of sand is very large and growing rapidly. It is unlikely that their requirements up to and beyond the year 2000 could be met from deposits located near them. Deposits of various types of sand are not as abundant as is commonly thought and, although remote, the deposits in this area may eventually be required for exploitation.

Diatomite

This material is used chiefly for industrial filtration and insulation. Small deposits were worked at Bolwarra and Gorae early this century, producing 250 UK tons during the period 1913-1943. No other deposits are presently known, but further exploration for this material would be justified if demand continues at its present level.

Peat

Peat occurs intermittently throughout the wetlands of the region, but generally in small and poor-quality deposits. One deposit at Bolwarra ignited by spontaneous combustion and continued to burn for a number of years. Other small peat swamps occur west of Casterton. Peat may be used for agricultural and horticultural purposes as a soil conditioner.

Brick clays

No brickworks currently operate in the area, but buildings at Casterton, Coleraine, and Merino were built of bricks made from local clay shales of the Otway Group. Thus, a brick industry could probably be developed in the region if

sufficient need arose. The nearest brickworks are located at Glenthompson, Colac, and Stawell.

Coal

Some deposits of black coal have been observed in outcrops at Merino and Mocamboro (Dwyers Creek), but the seams were thin and despite considerable exploration by drilling between 1885 and 1938 none of the deposits could be worked economically. Isolated thin seams of brown coal have been reported from bores, but no commercial deposits are known.

Oil and gas

There are no present indications of oil or gas, but substantial areas remain to be investigated in detail and few local wells go deep. The area has a number of promising features for petroleum occurrence, and exploration should continue.

South Australia

The minerals and mineral deficiencies of the adjoining parts of South Australia are generally similar to those of the study area and in the long term, as the entire region develops, demand for aggregate materials will probably increase.

Important quarries in the borderland regions of South Australia are located at the following places:

Basalt - Mount Schank and Mount McIntyre

Limestone - (crushed and broken) - Mainly produced from Tertiary limestone in numerous local quarries in the areas south and west of Mount Gambier and Naracoorte

Limestone - (building stone) - Mount Gambier

Dolomite - Tantanoola

Sand - Compton

Consumption of All Quarry Products

The total recorded production from the area in 1969-70 was 231,000 UK tons. When adjusted to include part of the scoria and trachyte produced outside the area but used for road-making within it, and to exclude part of the basalt (from Moree) consumed outside the area, the total estimated consumption for that year rises to approximately 231,700 UK tons. As the population of the area in 1969-70 was about 19,700, this corresponds to a *per capita* consumption of 11.7 UK tons, compared with a *per capita* consumption for "all Victoria" (calculated from Bowen) of 9.4 UK tons. The Mount Gambier building stone used in the area and materials won from pits less than 6 ft deep have not been included.

Assuming that the average quarry is 30 ft deep and, on average, 1 cubic yard

of stone weighs 1.5 UK tons (i.e. 72,600 UK tons per acre), then 3.2 acres of land would be required to produce 231,700 UK tons of mineral materials.

Predicted future consumption

Predictions of population changes and growth in stone consumption are extremely difficult to make for this area. However Table 18 presents estimates of future consumption and the land area likely to be required to meet it. These indicate that consumption will probably reach 305,400 UK tons in 1980 and 530,700 UK tons in the year 2000, assuming a fixed population.

The estimates given in Table 18 are based upon the following assumptions:

* The medium projection assumes that no major new development will take place in the area and that, as in recent years, total population of the area will remain roughly constant. Further, *per capita* consumption of all quarry products will grow at the projected Victorian rate of 2.8% per annum.

* The high projection (possibly maximum) assumes that population will grow at the "all Victorian" growth rate and also that consumption of all quarry products will continue to grow at the Victorian rate of 5%.

* No attempt has been made to calculate a low projection of requirements, but an assumption that population and annual consumption will not change would probably produce a fair estimate.

Summary and Outlook

Taken as a whole, the area is well endowed with limestone, suitable for manufacturing agricultural lime, cement, and glass. Sand is also fairly abundant but is not well distributed in relation to Portland, the present main market. Brick clays could probably be located and developed in the Casterton-Merino area if required.

Coal and other fuels are lacking, although oil and natural gas may be found in the future. The area is poorly endowed with first-grade aggregate materials, and no economic deposits of metallic minerals are known.

The estimated total consumption of quarry products in the area during the year 1969/70 was about 231,700 UK tons. Assuming an average quarry depth of 30 ft this represents a consumption of 3.2 acres of land per annum. The future consumption of stone depends almost entirely on the growth of population and industry in the region. Population growth and industrial development at Portland would create a demand for large quantities of the basic construction materials, particularly basalt, limestone, and sand. Annual total consumption of quarry materials is

Table 18

CONSUMPTION, PROJECTED CONSUMPTION, AND PROJECTED LAND REQUIREMENTS FOR ALL QUARRY PRODUCTS

	1969/70	1980		2000	
		Medium projection[3]	High projection[4]	Medium projection[3]	High projection[4]
Consumption & projected consumption (UK tons)	231,700	305,400	377,500	530,700	1,002,000
Projected cumulative consumption (UK tons) from 1970	-	2,630,000	2,914,000	10,680,000	15,400,000
Area required to meet annual consumption[1] (acres)	3.2	4.2	5.2	7.4	13.8
Cumulative area (acres) from 1970[2]	-	36	40	150	210

Footnote 1 Assuming an average quarry depth of 30 ft

2 Assuming reserves of suitable material are available in the area

3 Medium projection - assuming a fixed population but a growth in the *per capita* consumption of 2.8% per annum

4 High projection - assuming a 5% per annum growth rate in consumption (i.e., population and consumption growing at the rate of all Victoria)

estimated to rise to between 530,000 and 1 million UK tons by the year 2000.

A major consideration in siting quarries to extract these materials is the cartage distance to the point of use, so quarry sites should be located within a reasonable distance of the main centres of population and development.

A strong demand is expected to arise in future that the land underlain by strtegic reserves of these materials be used to provide stone.

Pressure on local extractive material resources will also come from South Australia. The developing region extending from Port MacDonnell through Mount Gambier to Penola and Naracoorte has only limited reserves of first-quality aggregate material. Additional supplies of stone suitable for road-making and harbour works will be increasingly sought from south western Victoria.

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APICULTURE

Apiculture is a small but important primary industry producing honey and beeswax.

The industry

Honey mainly provides a food for humans and stock, but is also used in the preparation of mead, vinegar, some types of tobacco, and some pharmaceutical and cosmetic products. A wide variety of industries use beeswax, the most important being polish and cosmetic manufacturers.

Apiculture contributes to the welfare of some other primary industries, as many fruit, vegetable, and seed crops of commercial importance depend almost completely upon the honey-bee for pollination. Such crops include apples, plums, pears, pumpkins, clovers, cabbages, rape, and sunflower.

Level of production

Victorian production of honey over the last 5 years has averaged 7.3 million lb per year. This represents just over 18% of the total Australian production of 39.9 million lb. A large proportion of Australian honey is exported to the United Kingdom and in 1970/71 Victoria produced 9.8 million lb, of which 6.5 million lb (66%) was exported.

Beeswax is also exported, Japan and the United Kingdom being the main buyers. Of the 120,000 lb produced in Victoria in 1970/71, 101,000 lb (83%) was exported. This represents about one-third of Australian exports.

The level of production can fluctuate considerably according to climatic conditions. For example, as a result of the 1967 drought, Victoria produced only 3.6 million lb in 1968/69 compared with the 1970/71 figure of 9.8 million lb.

Value

In 1970/71, 1,278 apiarists were registered in Victoria. Many of these, however, have few hives and make an insignificant contribution to the industry. About 300 apiarists produce 90% of the State's honey and beeswax.

During the past 5 years, the net value of production (the value placed on recorded production at the wholesale price realized in Melbourne, less costs of materials used in the production process and less costs of marketing) has averaged about $750,000 per year.

Industry Requirements

Australia has a number of indigenous bee species. The honey bee used in apiculture, however, is the European species *Apis mellifera*.

The honey bee

Within the species, several distinct races differ not only in appearance, but also in characteristics such as temperament, hardiness to cold and wet conditions, and timing of the breeding cycle. The honey bee is a social insect and lives in colonies or hives of up to 100,000 individuals.

Efficient production of honey requires that colonies of bees be kept healthy and at top strength, and that they be relocated periodically so that they can readily harvest a continuous series of nectar flows.

Maintaining the colony

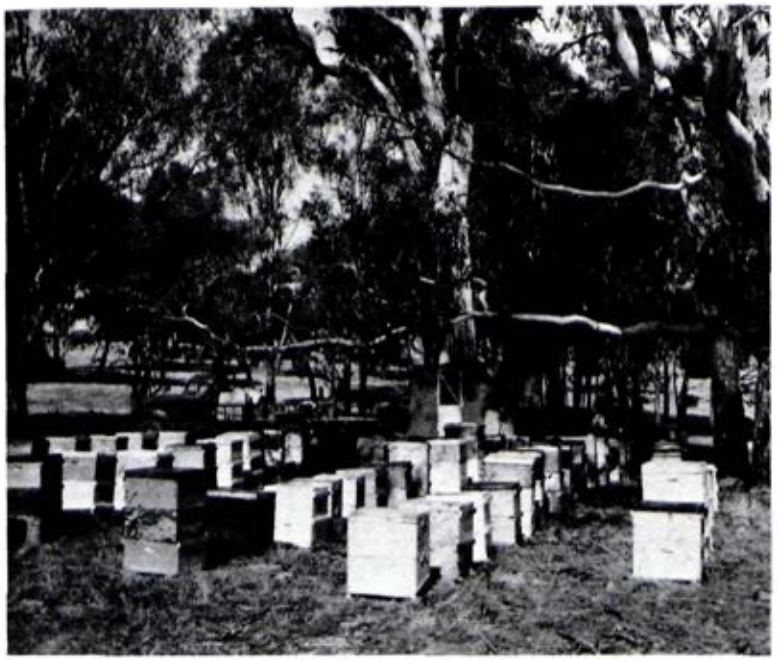
Bees collect nectar, water, pollen, and propolis from the field. Through a process of fermentation and evaporation, they convert the nectar into honey, which - being high in carbo-hydrates - is the major energy-producing food for the hive. They use water for drinking, for diluting honey to make food for the bee larvae, and for cooling the hive. Pollen is the bee's sole source of protein. Propolis, a resinous exudation from certain plants, is used as a general-purpose cement or putty about the hive.

In their natural state, bees collect and store sufficient nectar and pollen over the summer months to provide themselves with food for winter and for rearing young bees in spring. When they are managed for honey production, the aim is to rob them of as much honey as possible without endangering the colony's survival. Adequate stores of pollen and honey must be available to the bees if they are to survive the winter and produce a full strength of young bees ready to commence harvesting the first nectar flows in the following season.

Importance of eucalypts

The principal supply of nectar in Victoria comes from eucalypts and a few other native trees and shrubs. The ground flora, although important in other countries, has relatively little importance in most parts of Victoria.

The value of a particular eucalypt species to the apiarist depends on its flowering period and its yield of nectar and of pollen. Flowering periods vary, not only between species, but also within species from district to district due to local climatic effects. Flowering intensity varies from year to year, poor flowering being caused by low levels of food reserves within the tree, by adverse weather, or by insect attack or fire resulting in defoliation. As a



Bees must follow nectar and pollen supplies

general rule, however, the majority of important eucalypts flower heavily every second or third year.

Some species are valued for their yield of either nectar or pollen, others for their yields of both.

Migratory bee-keeping

Because of its dependence upon flowering eucalypts, bee-keeping must be migratory or nomadic. For maximum production of honey, hives are moved from district to district to coincide with peak nectar flows of various eucalypts over the summer months. Hives must be placed close, not only to the nectar source, but also to a reliable water source. One apiary of 450 hives consumed more than 1,000 gallons of water during a 10-day heat-wave. An adequate source of pollen must be available, especially in autumn when bees are storing food for winter.

The best localities for over-wintering hives are warm coastal districts or the so-called desert areas of western Victoria and south-eastern South Australia.

Bee-keeping in the South-West

Value as breeding area

The southern portion of the study area frequently provides some of the best breeding conditions available to Victorian apiarists. The trees of the area produce both pollen and nectar and provide good conditions for building up hive strength. Their flowering period is such that they can be worked in sequence with trees in other districts.

A typical pattern would be for apiarists to over-winter bees in north-western Victoria before moving to yellow gum areas of the northern districts. Yellow gum, although yielding good crops of honey, produces no pollen. So by about December hives must be shifted to

Table 19

IMPORTANT HONEY- AND POLLEN-PRODUCING
PLANTS OF SOUTH-WESTERN VICTORIA

Species	Flowering period	Honey yield	Pollen yield
Messmate	Dec-Jan	Good	Good
Brown stringybark	Feb-Apr	Good	Good
Manna gum	Mar-May	Light	Heavy
Yellow gum	Sep-Dec	Very good	Poor
Pink gum	Sep-Dec	Good	Poor
Sweet bursaria	Jan-Feb	Fair	Good
Silver banksia	Feb-Mar	Fair	Good
Coast beard-heath	Jun-Sep	Good	Good
Swamp gum	usually over winter	Fair	Good
Red gum	Dec-Jan	Good	Good

the study area, where messmate provides both pollen and a crop of honey. The revitalized hives are then moved to yellow box and red ironbark areas, where they can produce twice as much honey as local bees. Lack of pollen again forces a shift in autumn to brown stringybark and manna gum areas of the south-west, where hives can gather a further honey crop and build up food reserves for winter.

Important plants

Table 19 shows the plant species found in the study area and valued by apiarists, listing them in order of importance, and indicating flowering period and honey and nectar yields.

Bee sites

Apiarists located on public land must have a licence and must pay a small rental for the site. Demand for such sites varies from year to year depending on conditions. During the past 10 years the number in the study area has ranged from 20 to 160. It is estimated that at least equal numbers of sites are located on private property.

The blocks most heavily used by apiarists are Cobboboonee, Annya, Narrawong, Lower Glenelg, Hotspur, Weecurra, and Youpayang.

Land use considerations

Land clearing in the past has considerably reduced the value of the study area for bee-keeping. Red gum, yellow gum, and pink gum are very important to apiarists if they occur in sufficiently extensive areas to be utilized. These species did formerly occur in large areas, red gum over much of the Dundas and Casterton Land-Zones, and yellow gum and pink gum in the northern parts of the Kanawinka Land-Zone. However, as they grow on relatively fertile soils, suitable for agriculture, they have been largely cleared, red gum very early in European settlement and yellow gum and pink gum in more recent settlement schemes such as at Dorodong. Only small pockets remain on public land.

Coast beard-heath, another valuable plant to the apiarist, is currently suffering a significant reduction in its distribution through the establishment of pine plantations in the Nelson Land-Zone.

Large areas of public land are becoming increasingly important to apiarists as private property is progressively cleared and as insecticides, especially those applied by aerial spraying, become more widely used in agriculture.

Bee-keeping is compatible with any form of land use that retains a cover of suitable flowering plants. Nectar and pollen crops can be repeatedly harvested from such areas without any detriment to other values.

LAND USE RELATIONS

The preceding chapters of this report have described the natural resources of the study area and discussed the potential uses of public land. This chapter examines the relations between these various uses.

Uses are said to be competitive when an increase in one leads to a decrease in another based on the same set of resources; they are supplementary when the increase in one does not lead to any change in another, and complementary when an increase in one benefits another. Often a given set of uses can be complementary, supplementary, or competitive depending on the level of each. The most flexible uses are often those that are complementary or supplementary with many other uses over a wide range of levels.

Agriculture

The pattern of agriculture that prevails in the study area is, by Victorian standards, a relatively extensive grazing system. At this level supplementary uses include apiculture, water production, and recreation activites such as driving for pleasure and picnicking.

Agriculture also favours some aspects of nature conservation, as some animal species have benefited from the expansion of grassland habitat brought about by clearing. Species such as the stubble quail, brown hawk, white-backed magpie, and grey kangaroo profited at the expense of others inhabiting the original vegetation.

Even at its present level, agriculture is competitive with softwood and hardwood timber production, many aspects of nature conservation, and with recreation activities requiring timbered country or solitude. Increased levels of production will make agriculture increasingly competitive with most other forms of land use, including water production.

Softwood timber production

Softwood timber production in plantations is an inflexible land use. It is competitive with hardwood timber production, agriculture, nature conservation, and some types of recreation activity. It may also be competitive with water production, as pine plantations may lower the regional water table.

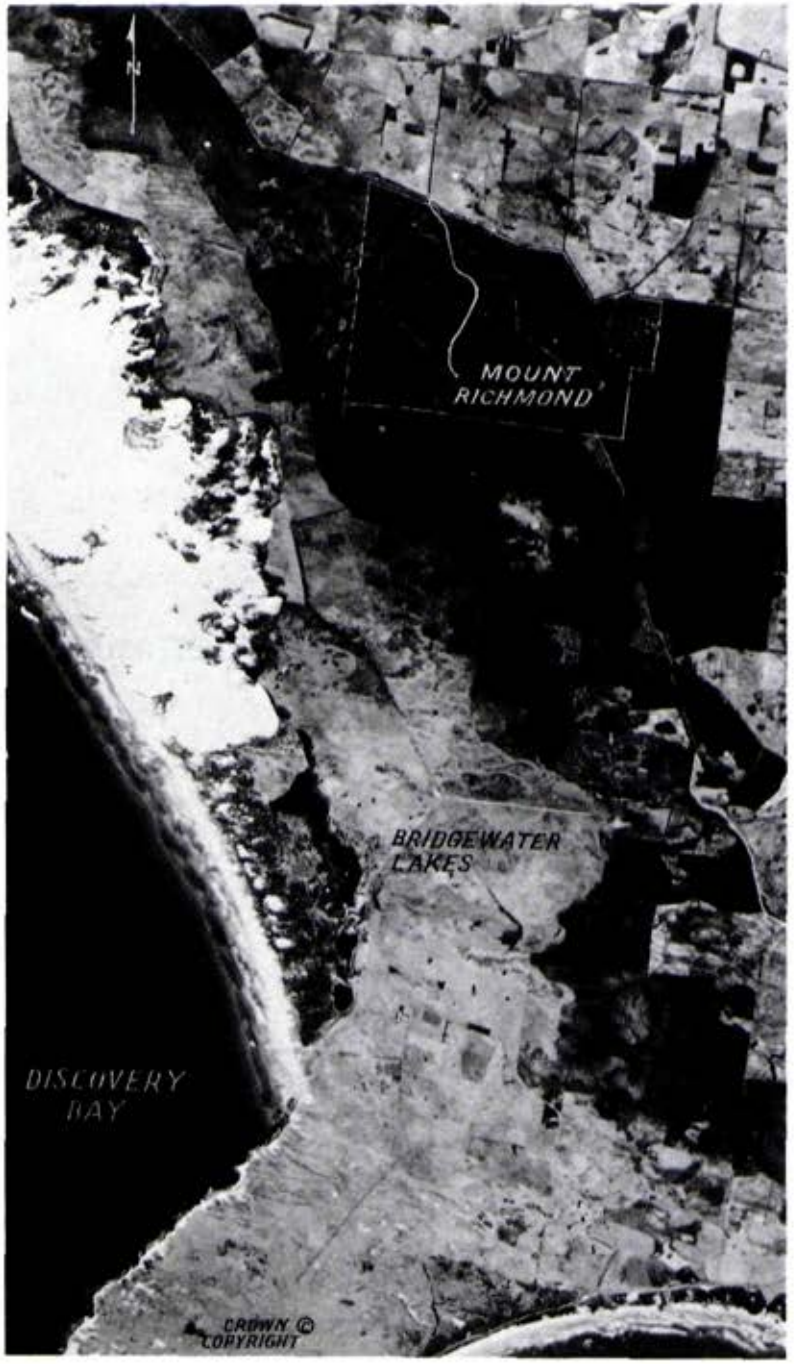
Hardwood timber production

Hardwood timber production is the major land use on the more fertile blocks of public land in the study area. Its present low level of production allows many complementary and supplementary uses, including grazing, apiculture, all but the strictest aspects of nature conservation, most forms of outdoor recreation, and water catchment protection. Even at high levels of production it is still only slightly competitive with most other uses. For example most native plants and animals will still be preserved (perhaps with altered abundance) and there will still be opportunities for many forms of outdoor recreation.

It is competitive with intensive agriculture and softwood timber production.

Mineral extraction

Although quarrying and extractive industries operating in the area at present have little impact on the environment, they are competitive with all other uses in their particular locality. However, in the long term they may be complementary with some recreation activities, as old mines and quarries have definite historic appeal. Moreover, they may also be complementary with the study of some aspects of natural history, since they provide excellent



A diverse area with many land uses

opportunities for studying geology, palaeontology, and plant succession.

Nature preservation

Areas set aside for strict nature preservation and for scientific purposes are competitive with all other uses. Even in parts of such areas set aside for recreation and education, only a restricted few activities related to enjoying and understanding natural environments are compatible, and these usually at a low level of use.

PART IV BLOCK DESCRIPTIONS

DISCOVERY BAY

A. General

(1) Location

Two parcels of public land - 20,100 acres fringing Discovery Bay and 3,600 acres on Bridgewater Bay - total area 23,700 acres. Parishes of Glenelg, Warrain, Kentbruck, Mouzie, Tarragal, and Trewalla - County Normanby.

(2) Present tenure

Game Reserve - 5,800 acres (Long Swamp)
Reserved Crown land - 3,500 acres
Unoccupied Crown land - 15,400 acres.

(3) General description

Precariously stable and mobile dunes of calcareous sand in a strip 1-2 miles wide back the shore. Lakes and swamps lie immediately behind, and are locally included in, the dunes. The block is in the Nelson Land-Zone.

(4) Present use

The dunes provide scenery and are used for dune-buggy riding and some hiking. Access is poor. Water-skiing is popular at Bridgewater Lakes, and fishing at Lake Bong Bong (also known as Lake Moniboeng). Long Swamp provides suitable breeding habitat for some species of duck, but is not intensively managed.

B. Nature of the Land

(1) Climate

Average annual rainfall varies from 30 to 34 in. Temperatures are mild. The area is subjected to strong, salt-laden onshore winds.

(2) Geology and physiography

The seaward side of the block consists of a long sandy surf beach interrupted locally by cliffed and rocky shores of Pleistocene dune limestone.

Behind the beach, unconsolidated dunes of fine calcareous sand overlie a series of dune limestone ridges. These unconsolidated dunes are typically high and steep, some exceeding 200 ft in height. In some places the dunes are mobile, and are tending to move inland under the influence of onshore winds.

In protected locations on the landward side, the vegetation holds the dunes in

place. Behind them and parallel to the coast, a long line of poorly drained country occupies a swale in the dune limestone. A tract of lakes was probably once continuous from the mouth of the Glenelg River to the Bridgewater Lakes, but it has since been divided and reduced by swamp encroachment and dune advance. Water levels vary in relation to rainfall and run-off, and are directly linked with the regional water table. Lake surfaces are typically up to 10 ft above mean sea level in Discovery Bay.

(3) Soils

Undifferentiated calcareous sands cover most of the block. Brownish gradational soils occur in limited areas where dunes have been stable over long periods and organic matter has accumulated in the surface horizons. Peats have developed in the swampy areas.

(4) Vegetation

In this block vegetation is absent from almost half of the area; bare shifting sand covers more than 10,000 acres of public land. Vegetation on the remaining areas is very varied and has been shown as a complex on the vegetation map.

Aspect, exposure to wind and salt spray, and degree of soil drainage all affect composition and luxuriance of plant communities in this topographically varied area. Fire has certainly modified

Lagoon and dunes near Nelson

the vegetation, even when it has not resulted in dune erosion.

The foredune immediately behind the sandy beach is largely covered with the introduced marram grass *(Ammophila arenaria)*. Native hairy spinifex *(Spinifex hirsutus)* also occurs in some areas.

Scattered patches of dry scrub of varying density persist on much of the area as relics of the former vegetation and stable dune topography, which has now been disrupted. The dry scrub occurs most extensively on the landward side of the dunes.

Coast wattle, coast beard-heath, twiggy daisy bush *(Olearia axillaris)*, and

occasional drooping sheoaks are usually dominant. Other common shrubs are seaberry saltbush *(Rhagodia baccata)*, sea box *(Alyxia buxifolia)*, white correa *(Correa alba)*, and coast ballart *(Exocarpus syrticola)*, while New Zealand spinach *(Tetragonia implexicoma)*, climbing lignum *(Muehlenbeckia adpressa)*, coast swainson pea *(Swainsona lessertiifolia)*, bidgee-widgee *(Acaena anserinifolia)*, small-leaved clematis *(Clematis microphylla)*, and austral trefoil *(Lotus australis)* form the ground cover.

The vegetation of the fresh-water swamps is very complex. Common reed and bulrushes are prominent among the plants spreading into open water. Many sedges and rushes make up the low swampy vegetation, including species of the genera *Cyperus*, *Scirpus*, *Eleocharis*, *Schoenus*, *Cladium*, *Baumea*, *Gahnia*, *Lepidosperma*, *Carex*, *Leptocarpus*, and *Juncus*.

Dense wet scrub forms impenetrable thickets around many of the swamps. It is dominated by scented paperbark and woolly tea-tree. Moonah occurs on drier sites around some of the swamps. A small area of salt marsh borders the Glenelg River estuary south of Nelson.

(5) Fauna

The wildlife of the area, while not abundant, is quite varied because of the diversity of habitats. The birds and mammals most likely to be observed in the ocean, coastline, wetland, and dune complex habitats can readily be ascertained from Appendix II.

The ocean beaches are generally not good areas for birds, although gulls, terns, dotterels, and, during the summer months, small numbers of waders do frequent them. The small area of salt marsh provides better habitat for waders. No nesting colonies of sea birds are known in the block.

The lakes and swamps provide good habitat for many waterfowl. Cormorants and several species of heron-like birds, including white-faced heron and brown bittern, frequent these areas. Summer refuge is provided for many duck species, and in most years conditions are suitable for the breeding of chestnut teal and blue-winged shoveller. Crakes, little grassbirds, and, in the summer months, reed warblers and some waders (including the Japanese snipe) can be found in various parts of the swampy areas.

The dense undergrowth found around the swamps provides ideal habitat for bush rats, potoroos, dusky phascogales, and the rare swamp phascogale.

Many small birds such as grey fantails, superb blue wrens, white-browed scrub wrens, brown thornbills, and silvereyes inhabit the dune vegetation. Up to ten species of honeyeater can also be observed in these areas. Mammals frequenting this type of vegetation

include the echidna, short-nosed bandicoot, rednecked wallaby, and the rarely seen white-footed dunnart.

The olive whistler and ground thrush, species usually found in wet sclerophyll forest, frequent the dense stands of tea-tree. The swamp harrier, brown hawk, and kestrel are the only hawks, and the feathertail glider and eastern pigmy possum are the only arboreal mammals commonly found.

C. Capabilities

(1) Flora

This is the largest area of natural coastal dune and swamp vegetation in western Victoria and has a moderate to high potential for flora conservation.

(2) Fauna

This block provides valuable habitat for the following uncommon species: rufous bristle bird, beautiful firetail, southern emu wren, ground parrot, orange-bellied parrot, king quail, and swamp phascogale.

The olive whistler, potoroo, and rednecked wallaby are species at the very western limit of their range. Five uncommon migratory waders are recorded in the area. It is an important refuge and breeding area for several species of duck. The block has high potential for fauna conservation.

(3) Other features

The following areas are of scientific interest: the mouth of the Glenelg River and the estuarine lagoon; Aboriginal middens, especially at Nobles Rocks; Long Swamp - Lake Bong Bong; Johnstone's Creek - Swan Lake.

(4) Recreation

The present level of recreational activity in this block is low compared with

A new road to the mouth of the Glenelg

areas closer to Melbourne; however, this and the adjoining Lower Glenelg block have higher levels of use than any of the other blocks in the study area.

Recreational use is directly related to access. The heaviest use occurs at the Bridgewater Lakes close to Portland, and at the mouth of the Glenelg River. In both these areas boating, fishing, water-skiing, swimming, and sunbathing are popular. A track from Black Swamp provides access for surf fishermen to the beach near Noble Rocks and the near-by outflow from Long Swamp. Lake Bong Bong is readily accessible and is used for fishing and duck shooting. Swan Lake has road access and is used by fishermen and picnickers. Dune buggies gain entry to extensive areas of bare sand at these points, and through pine plantations near Kentbruck.

The bare and shifting dunes provide spectacular scenery, whether viewed from a distance or close at hand, and will be a source of attraction for tourists.

The vast area of the dunes and the present lack of access to them and the adjoining ocean beaches offer some of the last opportunities in Victoria for remote coastal solitude.

(5) Agriculture

The sand dunes are unsuitable for agriculture due to their high alkalinity, their lack of organic matter or clay, and consequent low moisture-holding capacity, and the prevalence of strong salt-laden winds and sand-blast. The swampy areas could support pastures if drained and fertilized, but costs would be very high.

(6) Softwood

The dunes are unsuitable for radiata pine for the same reasons given above. Afforestation with maritime pine may be possible, but as the dunes would have to be stabilized, costs would be high.

(7) Hardwood

No trees suitable for commercial timber production occur naturally in the dune complex, nor are there any exotic trees that could be planted for this purpose.

(8) Honey

Coast beard-heath, one of the dominants in the dune vegetation, provides an excellent winter supply of pollen and nectar. Present access to the area, however, is difficult. Large areas formerly supporting this species in the adjoining Lower Glenelg block have been cleared in recent years for pine plantations.

(9) Minerals

The dunes are a very cheap and extensive source of lime for agricultural and industrial use. While extraction from a

few small pits will meet the demands of the district, in future the area may be subjected to heavy demands from distant population centres.

(10) Water

Some supplies of hard groundwater are available from the underlying Bridgewater Formation. A small perennial stream flows from Long Swamp into the estuary of the Glenelg River and another flows into the sea. The dune limestone behind the sand dunes contains many fresh-water springs.

D. Hazards and Conflicts

Much of the dune system in the block is shifting, but it is stable along almost all of its landward edge. The sand generally moves north-eastwards, in response to the prevailing south-westerly winds.

However, the sand is actively moving inland at about 6 places, where stabilizing vegetation on the landward edge of the dunes is absent and blow outs have developed. The largest and most serious of these blow outs appears to lie behind Long Swamp; two others are near the northern end of the Bridgewater Lakes.

Few measurements have been made of the rate of advance of the moving dunes, but surveys made in May 1969 and repeated in December 1971 near the Bridgewater Lakes showed that a dune face up to 136 ft high advanced up to 17 ft in 2½ years. This represents movement of about 950 cubic ft of sand per foot of dune crest per year, or an annual advance of about 8 ft on a dune 100 ft high. Perusal of the original parish surveys in the area, dating back more than 100 years, shows a variety of rates of advance from less than 1 ft per year to almost 53 ft per year.

In the Long Swamp sector, the advance of the dunes since 1949 can be gauged from old aerial photo maps. If this rate of dune movement is maintained, blow outs may run right across Long Swamp within the next 20 years.

The scenic attractiveness of the area depends on the steep topography of the large, unvegetated dunes. Complete stabilization of the entire dune system would be extremely difficult, and is unnecessary as the dunes are moving inland only in the few places where blow outs have developed.

Local farmers have planted marram grass on the landward edges of dunes for many years, and these plantings have helped the native vegetation to recolonize previously unstable areas. In recent years marram grass plantings by the Soil Conservation Authority on blow outs near the Bridgewater Lakes appear to have been successful. Maintenance of the dune vegetation requires the exclusion of cattle and sheep, as well as rabbit control and fire prevention.

Conflicts may possibly arise between the following uses of the land:

Cape Bridgewater beyond Discovery Bay dunes

(a) Active management to provide better habitat for waterfowl could conflict with preservation of the natural swamp environment.

(b) Dune buggies would conflict with solitude and with attempts to stabilize and revegetate the dunes.

(c) Provision of better access for swimming, boating, and fishing could conflict with solitude, and in localized places with attempts to stabilize and revegetate the dunes.

E. Significance

The public land in this block has significant capabilities for conservation of flora and fauna, scientific study, various forms of recreational activity, and the supply of minerals.

Reference

Bird, E. C. F., Womersley, I. and Fraser D. The geomorphology and plant ecology of the Discovery Bay dunes, with special reference to fresh-water lakes. *Report to the Land Conservation Council*, 1972.

LOWER GLENELG

A. General

(1) Location

South and west of Dartmoor and adjacent to the South Australian border. The block contains 94,000 acres of public land in one parcel, and 5,300 acres in 16 small parcels - total area 99,300 acres. Parishes of Drik Drik, Balrook, Kentbruck, Warrain, and Glenelg - County Normanby - and Ardno, Malanganee, Palpara, Mumbannar, Dartmoor, Wanwin and Kinkella - County Follett.

(2) Present tenure

National Park - 11,000 acres (Lower Glenelg)
Forest Park - 3,000 acres (Bulley Ranges) Reserved forest - 40,800 acres
Rural Finance and Settlement Commission - 7,000 acres (Palpara)
Unoccupied Crown land - 22,500 acres
Permissive occupancy - 9,700 (Forests Commission)

(3) General description

The area forms part of an extensive coastal plain with indurated (case-hardened) calcareous dunes at intervals throughout, either exposed at the surface or covered by low dunes or sheets of wind-blown sand deposited during the late Pleistocene to Holocene In some places weathering of the indurated dunes has produced sink holes and swales. Low open forests and woodlands of brown stringybark and manna gum form the characteristic vegetation. Most of the public land is in the Nelson land-zone.

The alienated land south of Mumbannar is a flat plain on sandy and peaty lagoon deposits, and originally supported dense wet heaths. This land is in the Kana-winka Land-Zone.

(4) Present use

A total of 25,000 acres of public land has been planted with softwood, and 7,000 acres have recently been cleared for agricultural development. The remainder of the area is used for conservation of flora and fauna, and recreation. Low-intensity hardwood logg-ing has been carried out in the area.

B. Nature of the Land

(1) Climate

Average annual rainfall varies from 30 to 34 in. with a marked winter incidence. Summers are warm and winters cold, but temperatures are generally less extreme than in some other parts of the study area further inland.

(2) Geology and physiography

Marine limestones of Miocene age form the basement of the coastal plains throughout this block. In the eastern part of the area these are overlain by a horizontal layer of Whalers Bluff Formation limestone. Both these formations are overlain by Pleistocene limestone dunes, sheets and low dunes of siliceous sand, and, north of the Glenelg, swampy lagoon deposits.

The Pleistocene dunes were largely carbonate sands of organic origin exposed on the sea floor during the low sea levels of the Pleistocene. The dunes of calcareous sand have been modified by the dissolving, downward movement and redeposition of calcium carbonate. This resulted in strong cementation of the sub-surface of the dune and a residual upper horizon of siliceous sand. This sand was then blown off the crests of the dunes into the swales between them, and spread over the inland areas in the lee of the dunes.

The sands closest to the exposed areas of indurated calcareous dunes are generally of brighter colour and have rolling topography, while those further away are paler and have more gentle topography.

The Glenelg River is the only major stream in the area. Its lower reaches, which traverse the block, can be divided into three sections. South from Dartmoor to Moleside Creek the river meanders extensively, entrenched in a deep gorge with vertical or sub-vertical walls 90-125 ft high.

At Moleside Creek the river changes direction to the north-west. The stream meanders less but is still deeply entrenched between limestone cliffs 50-70 ft high, rising to 100 ft near the South Australian border. At Donovan's Landing the stream again changes direction, to the south-east, and passes through low sub-vertical cliffs to the sea. The river is tidal almost to Drik Drik.

(3) Soils

Soils in this block are closely linked with parent material. Where the crests of the limestone dunes are exposed, red to black soils on limestone occur. Of the leached sands on the sand sheets and dunes, the younger, more fertile ones have bright orange, red, or yellow colouring, while the older impoverished soils are grey to white, often with

heavy ironstone or coffee rock layers at depth. On the low heath plains the soils are duplex (sand over clay) with some areas of deep leached sands.

(4) Vegetation

The red soils on limestone carry manna gum forest over bracken and grasses, except in some places south of the river where they are shallow and dry; and here they carry scrubs of coast wattle and coast beard-heath in the Bulley Ranges, and messmate - brown stringybark north of Nelson. On the large areas of leached sands, brown stringybark forest, with manna gum on more fertile sites, is the characteristic vegetation type. The forests are taller (Open forest II) on fertile sheltered sites, and lower (Open-forest I) on the strongly leached sands or in positions exposed to onshore winds. On fertile sites the understorey consists of sparse tall silver banksia, black wattle, and blackwood over bracken and grasses. On poorer sites low heathy plants, and bracken on well-drained soils, dominate the understorey.

Wet heaths and wet scrubs occur along the northern boundary of the main area of public land, and on many of the small isolated areas. The wet heaths are dominated by species of the genera *Casuarina, Banksia, Leptospermum, Hypolaena, Xanthorrhoea,*and *Pultenaea.* The wet scrubs consist of stunted brown stringybark and peppermint over wet heath.

Small swamps are scattered through the area, and several large peat-filled swamps occur south-east of Wanwin. These are usually surrounded by woolly tea-tree and swamp gum.

A thin line of red gums and extensive areas of common reed (*Phragmites communis)* fringe the Glenelg River.

(5) Fauna

The diverse vegetation of this block provides habitat for a wide range of animals.

The many swamps and the Glenelg River itself are frequented by many species of waterfowl including crakes, grebes, cormorants, snipe, heron-like birds, and ducks. The forested areas provide good habitat for crimson rosellas, grey fantails, brown and striated thornbills, grey thrush, white-throated tree creeper, and grey currawongs. More oepn areas have emus and yellow-rumped and buff-rumped thornbills. Dry scrub areas near the coast shelter the rufous bristle bird and the beautiful firetail.

The common hawks of the area are brown hawk, nankeen kestrel, whistling eagle, wedge-tailed eagle, swamp harrier, gos-hawk, and peregrine falcon. At least 17 species of honeyeater can be found here.

Large numbers of emus and yellow-tailed black cockatoo feed in the pine plan-tations.

Red-necked wallaby and grey kangaroo are the most readily observed mammals of the area. Other common species include echidna, ring-tailed and brush-tailed possums, short-nosed bandicoot, yellow footed phascogale, and tuan. The bush rat and dusky phascogale occur where there is a dense moist ground cover.

The brush-tailed possum

The large-footed myotis and the bent-winged bat commonly roost in limestone caves throughout the area.

C. Capabilities

(1) Flora

More than 30 plant species have their western limit within the block. They are species typical of the cooler and moister parts of south-eastern Australia and include slender wallaby grass (*Danthonia penicillata*), bent grass (*Agrostis venusta*), hairy rice grass (*Tetrarrhena distichophylla*), wattle mat rush (*Lomandra filiformis*), sickle green hood (*Pterostylis falcata*), rosemary grevillea (*Grevillea rosmarinifolia*), clematis (*Clematis aristata*), forest stellaria (*Stellaria flaccida*), forest mint (*Mentha laxiflora*), tantoon tea-tree (*Leptospermum obovatum*), mitchell wattle (*Acacia mitchelli*), and bog gum (*Eucalyptus kitsoniana*).

The block contains good examples of dry scrub on dune limestone, and both tall and low forests of brown stringybark, manna gum (now largely cleared), and mixtures of these two.

Red gum is thinly scattered along the length of the Glenelg River gorge. Snow gum is found occasionally in areas

Alluvial terrace on a meander of the Glenelg River, carrying common reed (left) and a structural ledge following bedding planes in Miocene limestone (right).

north of the river, although areas where it formerly occurred have largely been cleared. The block has a high potential for flora conservation.

(2) Fauna

Probably the most significant feature of the area for fauna is the corridor of native vegetation that runs along the Glenelg River (the only sizable stream in the study area) from Nelson towards the Kent
blocks. These are undoubtedly important to the many nomadic and migratory birds that occur in the area. Both the black-faced and grey kangaroo occur in the block, but it is not known definitely whether the distribution of these species overlaps.

Two rare bird species, the rufous bristle bird and the beautiful firetail, occur in the southern parts adjoining the Discovery Bay block. So the area has high potential for fauna conservation.

(3) Other features

The limestone caves of the area are of considerable interest. Primary cave development appears to have resulted from the enlargement of joints. In a few cases these enlarged joints have also been subject to vadose enlargement where surface water has entered the already open joint and flowed along it to the river.

The interesting diversity of stages in early cave genesis available in the area provides a good opportunity for geomorphological studies.

McEachern Cave and Amphitheatre Cave contain very valuable palaeontological deposits. Study of the deposits has thrown considerable light on the changes that have occurred to the climate, flora, and fauna of the area over the past 20,000 years.

The cliffs on the Glenelg River reveal cross-sections of strata of interest to geologists.

(4) Recreation

This block has some of the best recreational features of the study area. Most of these are centred around the Glenelg River.

The river itself is used for boating, water-skiing, and fishing. Mulloway, yellow-eye mullet, Australian salmon, southern black bream, and bass (Gippsland perch), all highly regarded as sporting fish, are found in the river, which is an important breeding area for the last two species.

The high limestone cliffs and densely forested rim of the gorge through which the Glenelg flows makes it one of the most scenic rivers in Victoria. More than 100 holiday shacks are scattered along both sides of the river. (These shacks are built on land held under Permissive Occupancy - all such occupancies will end in 1983, or on the prior death of the holder.)

Vehicular access is available to scenic lookouts at several points along the rim of the gorge, the most heavily used being at Jones Look-out on the Nelson-Winnap Road.

The Princess Margaret Rose Cave is a well-known tourist attraction. It is quite beautiful, with a diversity of decorative forms, and has easy internal access. Many of the other caves in the area are used by speleologists.

The varied nature of the vegetation in the area is an attraction to tourists, especially during early spring when wildflowers are in bloom. The Bulley Ranges and Moleside Creek areas are especially popular.

(5) Agriculture

Most of the public land in this block has only a low capability for agriculture (category 3). Pasture would dry off quickly in late spring, and in areas with deeper sands maintenance costs would be considerable.

Small areas of wet heath in the parishes of Kinkella, Malanganee, and Palpara have a higher capability for agriculture (category 2) and would support productive pastures, although maintenance costs

may be high. The Palpara settlement scheme has developed this type of land for agriculture.

(6) Softwood

A large proportion of the public land in this block has already been converted to softwood plantations. These plantations are generally in two areas north of the river in the western part and south of the river in the eastern part.

The coloured sands in this block are the most suitable soils for pines in the study area. Large areas suitable for pines still remain, especially on the northern side of the river. These areas fall into category A, with some areas of Category C.

Extensive areas of similar land in South Australia have been converted to softwoods.

(7) Hardwood

Satisfactory growth of hardwood timber from native species (brown stringybark) could only be expected in areas where stand height exceeds 60 ft (category C). The few areas of this type of forest not already converted to pine are in the east of the block, fringing both sides of the Glenelg River. The present condition of these stands is poor due to their history of selective logging and wild fires. Even under intensive management, the growth rates on these areas would be well below those possible for messmate areas in the Cobboboonee and Annya blocks, where soils are more fertile and rainfall higher.

(8) Honey

This block contains extensive areas of brown stringybark and manna gum, which are both important trees to apiarists. Brown stringybark yields good flows of honey and pollen over the period February to March. Average yields of almost 60 lb per hive per year have been obtained over a 10-year period, with maximum yields reaching 180 lb per hive in a good year. Manna gum is valuable because it produces high quality pollen in autumn, which puts hives in top condition for winter. The understorey species, silver banksia and sweet bursaria, provide very good pollen and enough honey for breeding purposes. Unlike the eucalypts, they flower regularly every year, thus providing apiarists with sure breeding conditions if required.

Coast beard-heath has a flowering period from June to September and provides excellent conditions for over-wintering hives.

(9) Minerals

Large quantities of dune limestone suitable for road-making are available. In the past, polyzoal limestone has been

quarried for building stone near Moleside Creek at the foot of the fault scarp and near Nelson. Basalt outcrops at the top of the Jones Ridge fault scarp.

(10) Water

The Glenelg River is tidal throughout most of its length in this block, and the water is too saline for any use. Some underground water is available from the sands and dune limestones, and large supplies are available from the Whalers Bluff Formation-Gambier Limestone aquifer system and deeper aquifers. Fresh groundwater flowing into the Glenelg is an important part of the riverine and estuarine environment.

D. Hazards and Conflicts

Some areas are susceptible to wind erosion, but the hazard is not great owing to the readiness with which protective bracken will grow. Near the coast, strong winds and weak growth of bracken result in a higher hazard.

Wildfire hazard during the summer months is high particularly along the Glenelg River because of the number of people using the river and its margins, and the access problems created by the river itself (fires can readily cross from bank to bank, but the fire-fighters cannot).

The establishment of pine plantations close to the Glenelg River gorge, and the invasion of native forest by pine seedlings, are hazards to nature conservation, and conflict with the natural scenery of the area.

E. Significance

This block has significant potential for flora and fauna conservation, recreation, and softwood timber production.

A swamp margin of low woolly tea tree and swamp gum in the Lower Glenelg block.

MOUNT RICHMOND

A. General

(1) Location

West of Portland to the Discovery Bay dunes. One main parcel of land (6,900 acres) and five smaller parcels - total area 9,200 acres. Parishes of Tarragal and Trewalla - County Normanby.

(2) Present tenure

National Park - 2,000 acres (Mount Richmond)
Faunal Reserve - 300 acres (Bats Ridge and Lawrence Rocks)
Reserved forest - 1,100 acres
Reserved Crown land - 100 acres
Unoccupied Crown land - 5,700 acres

(3) General description

Generally similar to the Lower Glenelg block. Mount Richmond is a volcanic hill thinly covered with white and orange sands. Most of the public land is in the Nelson Land-Zone - a heathy area east of Mount Richmond is in the Kanawinka.

(4) Present use

Conservation of flora and fauna is the primary function of the National Park and Faunal Reserves, with recreation important in the former. Three grazing licences cover about 900 acres. Some minor forest produce is cut, and dune limestone in quarried for road-making.

B. Nature of the Land

(1) Climate

Average annual rainfall is about 34 in. The exposed aspects of Mount Richmond are subjected to strong salt-laden winds.

(2) Geology and physiography

The area lies on the southern edge of the Normanby Platform, and is raised about 400 ft above the coastal plains on its south-western extremities by the Swan Lake-Bridgewater and Kentbruck Fault scarps. The basement of the block is Miocene limestone, which is covered with basalts from Mount Richmond and other volcanoes on Capes Bridgewater and Nelson. In turn, at least one major dune limestone ridge and siliceous sand cover the basalt. Mount Richmond is a tuff and scoria cone, covered with sand. The volcanic rocks are exposed in a few places.

At the western end of the block, Johnstone's Creek, draining the southern part of the Kentbruck Heath, flows across the fault escarpment via a waterfall in which basalt is exposed.

(3) Soils

Black and red soils on limestone are found on the limestone dunes - the black soils occur on the dunes nearest the coast. Variable leached sands, similar to those found in the Lower Glenelg block, occur over the remainder of the area. Clayey red gradational soils have formed on the small areas on Mount Richmond where volcanic rocks are exposed.

(4) Vegetation

The leached sands covering most of this block carry low forests of brown stringybark, with manna gum where the soils are most fertile. On deep strongly leached sands, a wet scrub of peppermint with some brown stringybark occurs over a heathy understorey. Shallow soils on limestone at Bats Ridge carry a dry scrub of acacias, coast wattle, and coast beard-heath. On the upper slopes of Mount Richmond, a low forest of swamp gum and grass occurs on the areas of volcanic soils.

The understorey of the low forests on Mount Richmond contains a rich flora of heathy species. Bog gum occurs northeast of Mount Richmond.

Johnstone's Creek has an interesting and varied flora, and contains some rare and endangered species.

An unusual occurrence of the soap mallee *(Eucalyptus diversifolia)* may be seen on Cape Nelson. This species also occurs at a number of sites around the Australian Bight, but usually in drier-rainfall zones (15-22 in. per annum). Cape Nelson is the eastern extremity of this species (the nearest occurrence being 110 miles to the west in South Australia), and is by far the wettest (about 33 in. per annum).

(5) Fauna

The fauna of the area are considerably diverse and interesting. The grey kangaroo, the red-necked wallaby, and arboreal mammals are present at Mount Richmond and at Bat's Ridge. More unusual observations include the white-footed dunnart, yellow-footed phascgale, swamp phascogale, tiger cat, and heath rat for the Bat's Ridge area. A colony of wombats, formerly known in the Johnstone's Creek area, has not been seen in the past few years. The bent-winged bat occurs in large colonies in caves of the area. The many bird species present include the rufous bristle bird and beautiful firetail on the mainland, and the Australian gannet, little penguin, and fairy prion on Lawrence Rocks, which are also visited by the Australian fur seal.

C. Capabilities

(1) Flora

The soap mallee at Cape Nelson and the rich flora of Mount Richmond give this block a high potential for flora conservation.

(2) Fauna

The presence of the swamp phascogale, white-footed dunnart, bent-winged bat, rufous bristle bird, and beautiful firetail give this block a high potential for fauna conservation.

(3) Other features

A number of interesting geological features add to the conservation value of this block. These include the petrified trees that have been exposed at Cape Duquesne, the sections through the Stony Hill volcano at Cape Bridgewater, and Mount Richmond itself.

(4) Recreation

The public lands of this block are close to the growing town of Portland, and contain features of interest to people seeking recreation. An access road, look-out tower, and picnic grounds have been constructed at Mount Richmond, and the wildflowers in this area attract visitors. The coastline is popular with fishermen, and there are blowholes and a petrified forest at Cape Bridgewater. A

Petrified trees exposed near Cape Duquesne

lighthouse and associated buildings, situated on top of a rugged cliff at Cape Nelson, have been classified B by the National Trust. A popular surf beach lies at the western end of Bridgewater Bay. The block has a high potential for recreation.

(5) Agriculture

Most of the land has low potential for agriculture and falls within land category 3 or 4. Some of the reserved forest in the area is former farmland that has been sold to the Forests Commission. This usually indicates that farming on that land has not proved especially profitable under earlier

The bush rat

circumstances. It is highly unlikely that the development of completely new farms from bushland in this block would prove economic. However the addition of some of the lightly timbered areas of better soil types to existing farms could be profitable for individuals concerned. Pasture development and maintenance requires the heavy use of fertilizers and minor elements are frequently needed for both livestock health and plant growth.

(6) Softwood

The softwood potential of the public lands varies according to soil type. The distribution of soil types is complex, but to the north-west of Mount Richmond red soils on limestone and orange sands predominate. The land here has a high potential for growing radiata pine (category A), and trial plots indicate a Site Quality rating of II to IV. The leached sands that occur in smaller pockets in the north-west, and in larger areas elsewhere, have a much lower capacity, categories C & D.

(7) Hardwood

The potential of this block for hardwood production is very low. Stand height is low in most of it, and the trees exhibit poor form (category F).

(8) Honey

The stringybarks of the area have a moderate potential for honey production at infrequent intervals. However, the heaths and understorey plants provide a more important source of pollen during the winter. The capability of the land for honey production is low generally, but it may be high for winter hive maintenance.

(9) Minerals

In mineral resources, the block contains dune limestone, quartz sand, and basalt at Capes Bridgewater and Nelson.

(10) Water

The block makes little contribution to stream flow, except for Johnstone's Creek in the west. Underground water is available from several aquifers.

D. Hazards and Conflicts

The petrified forest at Cape Bridgewater is eroding, and requires protection. Apart from this, few hazards are associated with the block.

Conflicts between recreation and flora and fauna conservation could arise if the level of recreation use increased greatly.

Dune limestone as an early building material

E. Significance

The public land in this block is significant for flora and fauna conservation and recreation.

KENTBRUCK HEATH

A. General

(1) Location

North-west of Portland and mid-way between Heywood and the South Australian border. One large parcel (20,600 acres) and two small parcels (400 acres and 800 acres) - total area 21,800 acres. Parishes of Kentbruck and Cobboboonee - County Normanby.

(2) Present tenure

National Park - 11,400 acres (Lower Glenelg)
Reserved forest - 300 acres
Unoccupied Crown land - 10,100 acres.

(3) General description

This block is a large sandy plain of scrubby heathland perched on the uplifted south-western extremity of the Normanby Platform. Topography of the plain is very gentle, but the relatively steep slopes of its western escarpment have been dissected by the Moleside Creek and its tributaries. Substantial areas of basaltic land, carrying tall forests of messmate and brown stringybark, occupy the northern part of the block. These latter areas are in the Portland Land-Zone, while most of the Heath is in the Kanawinka Land-Zone.

(4) Present use

The public land is largely unused. Naturalists and tourists frequent the accessible parts of the block along the eastern margin, particularly during the spring when there is a magnificent display of wildflowers. The tall forests in the northern part of the block have been used for hardwood timber production.

B. Nature of the Land

(1) Climate

This is one of the wettest parts of the study area. Average annual rainfall is about 35 in. with a marked winter incidence. Being close to the coast, temperatures in both summer and winter are more moderate than for areas further inland.

(2) Geology and physiography

The basement rocks of the area are Miocene limestones, partially covered

Kentbruck Heath from Mitchell's Hillock

with Pleistocene basalt. Overlying the basalt are sheets and some dunes of white sand (Malanganee Sands) blown over the area from the Follett Plains during dry periods in Recent times.

The highest dunes are found along the top of the western escarpment, close to the original source of sand and where the winds are strongest. In some places the basalt is exposed at the surface, particularly in the north of the block and along the Jones Ridge fault scarp.

Topography over most of the block is flat and the stream pattern is very poorly developed. A very indistinct divide traverses the block, separating water flowing east through anastomosing swamps (leading to the ill-defined headwater of the Surry and Fitzroy Rivers) from water flowing west over the fault scarp to the Glenelg River. The most important of the western streams are Moleside and Little Moleside Creeks, which have clearly defined valleys where they cross the escarpment.

Elevations on the plain range from 300 to 500 ft. Elevation at the foot of the escarpment is about 150 ft.

(3) Soils

Chief characteristics of the soils of the blocks are the wetness and poverty of the surface sands. The most common soil types are brownish gleyed soils, with some leached sands. Clayey gradational soils have formed on the basaltic areas.

(4) Vegetation

Heath and scrub cover a very large proportion of the block. The heaths, which are particularly rich floristically, are dominated by the genera *Melaleuca, Leptospermum, Casuarina, Banksia, Hakea,* and *Acacia.* Brown stringybark and

peppermint with an understorey of bracken, acacias, and bush peas occur on well-drained areas of deeper sand.

Wherever basalt is exposed, a tall forest of messmate, often in mixture with peppermint and with an understorey including acacias, bush peas, and daisy bushes, is found. This type of vegetation occurs mainly in the north and extreme east of the block, adjoining much larger areas of similar vegetation in the Cobboboonee block.

Scrambling coral fern *(Gleichenia microphylla)* and tree ferns *(Cyathea australis* and *Dicksonia antarctica)* are the commonest of a number growing along Moleside and Little Moleside Creeks.

(5) Fauna

Heath, the most widespread vegetation type, provides habitat for a number of small birds and mammals, including brown thornbills, white-browed scrub wren, southern emu wren, several species of honeyeater, short-nosed bandicoot, bush rat, swamp rat, heath rat, and potoroo.

The forest vegetation types add considerable variety to the animal species of the area and provide habitat for arboreal mammals such as yellow-bellied sugar and pigmy gliders, ringtail and brushtail possums, and the greater long-eared bat.

Emus and grey kangaroos are common throughout the block.

C. Capabilities

(1) Flora

The block has a particularly rich flora, more than 500 species of flowering plants and 30 species of ferns having been recorded.

More than 100 of these species are at the extreme western edge of their distribution, or are absent or only infrequently encountered in other parts of south-western Victoria.

They include *Polystichum proliferum, Dicksonia antarctica, Gleichenia circinnata, Todea barbata, Tmesipteris billardieri, Selaginella uliginosa, Tetrarrhena juncea, Calectasia cyanea, Grevillea aquifolium, Exocarpus strictus, Haloragis digyna, Myriophyllum pedunculatum, Pomaderris elachophylla, Pultenaea subumbellata, Olearia speciosa,* 12 species in the family Cyperaceae, 15 species in the Orchidaceae, and 5 species in the Liliaceae.

The block also has a very rich flora of liverworts and mosses (Bryophytes) and algae (Thallophytes). Its potential for flora conservation is extremely high.

(2) Fauna

The Kentbruck Heath and the Grampians are the only two localities in which the heath rat has been recorded. The rat is locally common in both these areas and

inhabits heath woodland. It is possible that further investigations will lead to its discovery in some other heathlands in south-western Victoria.

Other species of particular significance inhabiting this heathland are the potoroo, king quail, and southern emu wren.

(3) Other features

The Kentbruck Heath is of particular scientific importance because it lies in a relatively high-rainfall area and at the extreme western limit of the range of many plant and animal species. In addition, it is the most extensive tract of heathland remaining in south-western Victoria, and its varied soils support a particularly rich flora and fauna.

The Fern Cave contains valuable palaeontological deposits.

The Inkpot, in the north-western corner of the block, is an unusual circular waterhole approximately 1 acre in extent, which has a layer of black organic material on the bottom giving the water a dark appearance. When full, it is more than 30 ft deep. It occupies an infilled sinkhole in the Miocene limestones.

(4) Recreation

The magnificent wildflower display, especially during the spring months, makes this area particularly important for recreational activities related to the enjoyment of natural environments.

Other features adding to its recreational value are the fern gullies and waterfalls of the Moleside Creek and a high dune in the south-west of the block that offers good views towards Mounts Richmond and Kincaid, and across the coastal plains to Discovery Bay.

(5) Agriculture

Almost the entire eastern half of the block has a high capability for agriculture. The basaltic areas have the highest capability (category 1). They adjoin similar but more extensive areas in the Cobboboonee block and could support highly productive pasture with low maintenance costs. Clearing costs would be high.

The heath and scrub areas on shallow sand could also support productive pastures, but maintenance costs would be higher (category 2). Development costs would be very high, as extensive drainage would be required. Application of large amounts of fertilizer, including trace elements, would be necessary.

Capability for agriculture is low on the deeper sands (categories 4 and 5), which occur in the west of the block. In these areas maintenance costs would be considerable and pasture would dry out quickly in late spring.

(6) Softwood

The areas of basaltic soils carrying tall native forests have a moderate to high potential for softwood production (category B). However, most of the land in the block, the wet heath, is unsuitable for pines.

(7) Hardwood

The basaltic areas supporting tall forests of messmate have a high potential for timber production (categories A and B). They adjoin similar but much larger areas in the Cobboboonee block and are discussed more fully there. Other parts of the block have a low potential for timber production.

A wet heath from a drier sandy rise in the north-east of Kentbruck Heath

(8) Honey

This block, being largely heathland, has a lower value to the apiarists than the adjoining tall forest areas of the Cobboboonee block. The same honey-supporting species, such as messmate, brown stringybark, and silver banksia, do occur in the block, but not in such extensive stands. Moreover, access is more difficult.

(9) Minerals

No reserves of minerals are known in the block.

(10) Water

Surface water from the area flows into the Fitzroy and Surry Rivers and into Johnstone's, Moleside, and Little Moleside Creeks. Flows are reliable in winter and low in summer. The water is not of a desirable quality for domestic use as it contains more than 1,000 p.p.m. of total dissolved solids. Underground water from the underlying Dartmoor Formation and Glenelg Group aquifers can be supplied in large quantities. These aquifers are recharged with water from this area.

D. Hazards and Conflicts

After clearing, a moderate wind erosion hazard would exist on the deep sands, especially those near the exposed western escarpment.

Drainage of large parts of the Heath could lower the water table of the entire Heath, with deleterious effects on the flora.

Increased run-off following clearing could cause erosion in the creeks draining the block.

Application of large amounts of fertilizer to farmlands in the Heath could conceivably result in pollution of these creeks and alteration of the plant communities they contain.

Conservation and scientific uses could come into conflict with recreational use.

E. Significance

The block has a significant potential for conservation of flora and fauna, scientific study, and recreation.

COBBOBOONEE

A. General

(1) Location

North-west of Portland, extending almost to Dartmoor. One large parcel of public land - total area 83,000 acres. Parishes of Drik Drik, Glenaulin, Balrook, Kentbruck, Cobboboonee, Heywood, Gorae, and Mouzie - County Normanby.

(2) Present tenure

Reserved forest - 68,500 acres
Unoccupied Crown land - 14,500 acres

(3) General description

A gently dissected basalt plateau covered in places by a veneer of acid white sands supports tall forests of stringybark, peppermint, and gums, with some heaths.

(4) Present use

This area has been used for intensive hardwood timber production for many years. Other uses of the land are recreation, gravel extraction, and some grazing.

B. Nature of the Land

(1) Climate

This is in the wettest part of the study area. Average annual rainfall varies from 34 to 36 in., with a marked winter incidence.

(2) Geology and physiography

The area lies on the Normanby Platform which in this area is covered by thick flows of basalt extruded from Mounts Vandyke, Deception, and Kincaid during early Pleistocene times. Tuff and scoria cover the basalt in the Mount Vandyke - Red Hill area. Beneath the basalt the basement rocks are Miocene limestones. Strong weathering of the basalt, which occurred during warm humid conditions in the mid-Pleistocene, has resulted in the formation of a residual layer of pisolitic ironstone and a finely mottled red clay.

Thin sheets and low dunes of wind-blown sand from the coastal plains to the west have been deposited across parts of the basalt surface, mainly in the centre of the block.

A fern hole in Cobboboonee with blackwood and swamp gum

The stream pattern is not well developed and most of the streams are dry in summer. It mainly drains eastwards as a result of the slight downward tilt of the Normanby Platform in that direction. Dissection is mild and only the main streams such as the Surry and Fitzroy Rivers have penetrated the basalt into the underlying limestone.

By contrast, in the extreme north-west of the block, a number of short deeply entrenched streams have dissected the western escarpment of the Platform. These streams include Doctor, Horse, and Bacci Creeks, all tributaries of Glenaulin Creek, which in turn flows into the Glenelg River.

(3) Soils

Weakly bleached gradational soils are the most widespread in the area. They occur on the strongly weathered basalt, and have clayey textures. Ironstone gravel is abundant in their profiles. Limited areas of friable reddish gradational soil occur where deep dissection has exposed fresh basalt.

Brownish gleyed soils are found in swampy areas. The wind-blown sands have been heavily leached, and a well-developed layer of coffee rock has formed.

(4) Vegetation

The main vegetation type in this block is an Open-forest II dominated by messmate or peppermint. Heaths and swamps occupy the poorly drained sites. The sheltered gullies of the Fitzroy River support species such as rough tree fern *(Cyathea australis)*, soft tree fern *(Dicksonia antarctica)*, and hazel pomaderris *(Pomaderris aspera)*, which are more typical of mountain areas elsewhere in the State.

Messmate occurs largely in pure stands, and sometimes in mixture with peppermint, brown stringybark, swamp gum, and occasionally manna gum. The understorey

varies with fire history, density of overstorey, and site, but usually consists of blackwood, myrtle acacia, hop acacia, bursaria, bracken, and grasses. On poor sites the understorey consists of heathy plants. Peppermint and scent bark occur in mixtures over large areas, especially in the northern and north-western parts of the block. The peppermint usually comprises more than 70% of the mixture. Understorey usually includes native cherry, myrtle acacia, silver banksia, common heath, and occasionally bracken, wallaby grass, and tussock grass.

Brown stringybark occurs in pure stands on the acid white sands in the centre and west of the area. Silky tea-tree, Mitchell's acacia, bracken, low silver banksia, and yacca are common undergrowth species. Brown stringybark also occurs with messmate on compacted gravelly clay soils.

Swamp gum is widely distributed, occurring in drainage lines and around heaths and swamps throughout the area. Near Gorae it grows on banks of heavy grey soils as well as in gullies. It occurs in mixtures with all other eucalypts.

Manna gum has a restricted distribution, occurring only on some red loams and alluvial soils. It reaches its best development near Lyons in the north-east of the block. Usually it grows over a sparse understorey of bracken, grasses, guinea flowers, and ground berry.

The heaths, which occur mainly on sandy areas, are dominated by swamp sheoak, silky sheoak, and silky tea-tree with sedges and yacca. Swamps are surrounded by tall thickets of scented paperbark and prickly moses.

Red gums occur only in an isolated patch of about 100 acres in the north-west of the block. The sparse ground cover consists of grasses and sedge.

(5) Fauna

The characteristic animals of this block are those that frequent tall open forest. This type of vegetation provides the tall trees and nesting hollows required by arboreal mammals such as the yellow-bellied glider, sugar glider, and brush-tailed possum, and birds such as the gang gang cockatoo, crimson rosella, and white-throated tree creeper.

Forest birds commonly seen are the fantail cuckoo, kookaburra, scarlet robin, yellow robin, golden and rufous whistlers, and grey fantail. Blue wrens, brown thornbills, and white-browed scrub wrens inhabit the low understorey, while spotted pardalotes, striated thornbills, and white-naped honeyeaters frequent the foliage of the trees. At least seven other species of honeyeater can be seen. Summer migrants to the forest include golden bronze cuckoo, satin flycatcher, and rufous fantail. Ravens, currawongs, and the Australian goshawk are among the larger birds of the area.

Common mammals include grey kangaroo, red-necked wallaby, short-nosed bandicoot, echidna, ring-tailed possum, and brown phascogale. Bush rat and dusky phascogale occur where the understorey is dense and moist.

A colony of koalas is established in a stand of manna gum and peppermint in the north-eastern corner of the block.

The swamp, heath, and red gum woodlands add further variety to the fauna of the block.

C. Capabilities

(1) Flora

The tall mixed-species eucalypt forests characteristic of the coastal and foothill areas of south-eastern Australia terminate in western Victoria along the top of the Kanawinka-Kentbruck fault scarp. With the exception of isolated pockets in favoured positions, the messmate-peppermint forests of this block and the adjoining Annya block are the most westerly example of this forest type. Even to the east 80-100 miles separate them from similar forests in the Otway Ranges and the Grampians

In addition, the block contains a range of diverse habitats and so is floristically rich. Many species have their western-most occurrences here. Thus the block has a high potential for flora conservation.

(2) Fauna

The western limit of many animal species roughly coincides with the western limit of the tall eucalypt forests. The forests of this block therefore provide the last extensive area of habitat available to species such as the yellow-bellied glider, brown phascogale, tiger cat, pink robin, rose robin, rufous fantail, and satin flycatcher.

The swamps of the area, especially Grassy Flats, Red Gum Swamp, and Tremanines Swamp, are of considerable value for water-fowl.

(3) Other features

The block contains a wide range of soils supporting diverse vegetation types growing under the highest-rainfall conditions in wouth-western Victoria. It is the western-most occurrence of many species of birds and animals, and is thus of general scientific interest. The Mount Vandyke and Mount Deception volcanoes have geological interest.

(4) Recreation

The area's chief attractions are a good display of wildflowers, especially in the heath areas during spring, and the beauty of the relatively diverse eucalypt forests. Duck shooting takes place at some of the swamps. The present level of recreational use is low, being restricted to driving for

pleasure and some picnicking at the fireplaces that are scattered through the area.

As the block is close to Portland and Heywood, its recreational use will probably increase as the population grows.

(5) Agriculture

The combination of high rainfall and relatively fertile soils make most parts of this block suitable for agriculture (land category 1). The gradational soils can support pastures or orchards at low maintenance costs. Development would be costly, largely because of the required clearing of the existing forest.

The shallow sands, at present covered with heath, are also capable of supporting pasture, but with higher maintenance costs (land category 2). Draining and heavy fertilizing would be necessary. Development costs would be high.

The deep sands have a low capability for agriculture (category 4). Land development costs would be high and maintenance costs considerable, and pastures would die out in late spring due to lack of moisture.

(6) Softwood

Experimental plots have been established in the block to test radiata pine growth on various soil types with site treatments of ripping, ploughing, and fertilizing. Most of the plots were established in 1970 and 1971 although some were started in 1963.

On present indications, the gradational soils should support satisfactory pine growth provided suitable phosphate fertilizers are added (category B). The trials show that soil ripping increases pine growth. Estimated yields from a plantation in this area would be of the order of 300 cubic ft of wood per acre per annum. This compares with estimated yields of the order of 100 cubic ft for intensively managed hardwood stands and 30 cubic ft for the existing stands.

(7) Hardwood

The Cobboboonee block, with the Annya, Homerton, and Narrawong blocks, supports the only hardwood stands suitable for intensive management in the study area (category A). Many of the messmate stands are at present in poor condition, as they are understocked and carry a large proportion of culls (trees unsuitable for harvesting). Intensive management of the stands could increase productivity three- or fourfold. Thus the block has a high potential for hardwood timber production.

(8) Honey

This block and parts of the adjoining Annya block contain very extensive areas of messmate, which for apiarists is the most important tree in the study area.

It flowers during December and January, one or two months earlier than in other parts of the State. Although used largely to revitalize run-down hives, messmate in the area has also yielded an average of 26 lb of honey per hive annually over the past 10 years.

(9) Minerals

Ironstone gravel is the only mineral available in this block. Though quartz sands are present, larger supplies are available elsewhere. The basalt in this area is deeply weathered, and so is unsuitable for aggregate, though drilling may prove reserves if demand rises.

(10) Water

Surface water from the area flows into two main streams, the Fitzroy and Surry Rivers. Flows in most summers are low. The water is of undesirable quality for domestic use, as it contains more than 1,000 p.p.m. of total dissolved solids. Underground water is available from several formations.

D. Hazards and Conflicts

The high rainfall and flat landscape of this block result in a low hazard of land deterioration.

E. Significance

The land in this block has a high potential for flora and fauna conservation, agriculture, hardwood and softwood timber production, and recreation. The land is thus a very valuable resource.

NARRAWONG

A. General

(1) Location

South-west of Heywood adjacent to the coast. One parcel of public land - total area, 12,000 acres. Parish of Narrawong - County of Normanby.

(2) Present tenure

Reserved forest - 11,600 acres
Gravel reserve - 150 acres
Unoccupied Crown land - 250 acres

(3) General description

A tableland raised above the coastal plain, carries a low volcano, volcanic rocks and sheets and dunes of siliceous sands. Vegetation consists of tall forests of messmate, gum, and brown stringybark, with a large area of heath and some swamps. The sand sheets are in the Kanawinka Land-Zone - the remainder is in the Portland Land-Zone.

(4) Present use

Hardwood timber production is the main use in the forested parts of the block. Sand pits in the north-western corner of the block contain a fine red sand suitable for mortar and cement, and coarser white sand for filling. Ironstone gravel is extracted from shallow pits.

Narrawong is popular with sight-seers and naturalists from Portland. There is some duck shooting on the swamps.

B. Nature of the Land

(1) Climate

Average annual rainfall is about 34 in.

(2) Geology and physiography

The public land in this block lies on the Mount Clay physiographic unit. This is a small tableland raised above the coastal plains. The Mount Clay volcano rises above the tableland surface. The basement is Miocene limestone, which is exposed on the edges of the tableland but elsewhere is covered by basalt and tuff. These rocks are covered on the western half of the tableland by wind-blown siliceous sands. The tableland is drained by short

streams flowing north into the Fitzroy River and south into the Surry River, and by internal percolation through swamps.

(3) Soils

Gradational soils have formed on the basalts and tuffs. Leached sands occur on the western part of the area, with peaty soils in the heaths and swamps.

(4) Vegetation

The vegetation of this block is quite diverse. The basaltic soils to the east carry tall open forests with pure messmate stands, shining peppermint, and mixtures of these species with swamp gum and brown stringybark. The understorey is quite variable, with bursaria, bracken, and grasses in the gullies, and sword grass, prickly moses, and tea-tree common on the flat tableland.

On the sand-covered western section, the major vegetation types are tall and low forests of brown stringybark with some messmate where outliers of basaltic soils occur, and extensive heaths. The understorey and heath components are similar to those described for the Kanawinka Land-Zone

(5) Fauna

The animal populations of this block are similar to those found in the Cobboboonee block.

C. Capabilities

(1) Flora

The block has considerable potential for flora conservation due to the diverse habitats present, and the compactness and size of the block.

(2) Fauna

The assessment of potential for fauna conservation is similar to that for flora conservation given above.

(3) Other features

No other features of natural interest are known in this block at present.

(4) Recreation

The proximity of Narrawong to Portland and the Princes Highway and the diversity of the bushland give this block a moderate to high potential for recreational uses that require natural surroundings. The swamps provide opportunities for duck-shooters.

(5) Agriculture

The agricultural potential of the block can be treated in two sections. The eastern and southern areas of basaltic soils have very high agricultural potential and would fall within land category 1. The sandy western slopes have much lower potential, but because

of the high rainfall could still be developed to support reasonable pastures. However, this would involve heavier than usual expenditure on fertilizers.

(6) Softwood

The potential of the clayey gradational soils and the sandy soils is probably similar to the assessments given for the corresponding soils in the Cobboboonee block. The block does not contain any plantations or trials of radiata pine from which softwood assessments can be made.

While proximity to Portland and Heywood is an advantage, the relatively small area (5,000 acres) of suitable soils in this block is a serious disadvantage with respect to softwood production.

(7) Hardwood

This block has a relatively high potential for hardwood production, the better sites being along the northern fall to the Fitzroy River. The remainder of the tableland and the westerly fall have also been extensively managed and contain some even-aged and uneven-aged stands of messmate and brown stringybark. The even-aged stands result from silvicultural work done in the 1930s, and were thinned by drought relief workers in 1968. The area has the capacity to produce substantial quantities of hardwood logs.

(8) Honey

The area's value for apiculture is similar to that of adjacent blocks of messmate and brown stringybark with patches of heath (Cobboboonee). It could produce more honey and pollen than it currently does, but the irregular and seasonal nature of flowering complicates this.

(9) Minerals

Ironstone gravel is available from pits in the reserved forest and along the Princes Highway, but the demand for this material is declining as public roads are sealed. Two sand pits are worked in the north-western corner of the block. One yields an excellent red sand that is in great demand for building, but it is almost worked out and no new deposits have yet been located. The other yields a coarser white sand, of which large reserves remain.

The marly limestones outcropping below the edges of the tableland could be exploited for lime or cement manufacture.

(10) Water

The block contributes small winter flows to the Surry and Fitzroy Rivers.

D. Hazards and Conflicts

Some erosion hazard would attend the clearing of the native vegetation on the steep edges of the tableland, but given

the high rainfall, this risk would not be great.

E. Significance

The proximity of this block to Portland and Heywood gives it some significance for recreation, its diversity and compactness give it significance for flora and fauna conservation, and the hardwood stands give it significance for hardwood timber production.

ANNYA

A. General

(1) Location

North of Heywood and south of the Crawford River. One large parcel of public land (26,000 acres) with several small parcels - total area 32,900 acres. Parishes of Glenaulin, Hotspur, Curracurt, Annya, and Myamyn - County Normanby.

(2) Present tenure

Reserved forest - 25,000 acres
Unoccupied Crown land - 7,900 acres.

(3) General description

A lightly dissected basalt plain is covered in part by wind-blown siliceous sands. Deeper dissection along the Crawford River has exposed Tertiary sediments and formed steep slopes. Vegetation consists of tall forest of messmate, brown stringybark, and peppermint gum, with some heaths and swamps. The land is in the Portland Land-Zone.

(4) Present use

Hardwood timber production is the major use. Grazing licences are held over about 1,600 acres of Crown land, and some ironstone gravel is extracted for road construction.

B. Nature of the Land

(1) Climate

Average annual rainfall varies from 30 in. in the east to 34 in. in the west.

(2) Geology and physiography

This block lies near the boundary of the Merino Dissected Tablelands and the Normanby Platform. Basalts similar to those of the Cobboboonee block rest on thick Tertiary sediments. Dissection by Sunday Creek in the south and by the Crawford River and its tributaries in the north has produced broad shallow valleys filled with alluvium. On the north-western margin of the block, the Crawford River has cut a deeper, steep-sided valley, exposing a variety of Tertiary sediments.

All of these features are covered by thin sheets of Malanganee Sands in some places. Surface water drains into the Crawford River (a tributary of the Glenelg) and the Sunday and Hunter

Creeks (which flow into the Fitzroy River) via numerous small swampy drainage lines.

(3) Soils

The soils on the Tertiary sediments in the centre of the block are clayey, weakly bleached, gradational soils and brownish gleyed soils; soils on the basaltic areas are gradational soils of clay loam to clay textures, with some ironstone; soils on the sands are leached sands or duplex. All of these types, except the sandy soils, are at least moderately fertile.

(4) Vegetation

The most common vegetation type is a tall forest of messmate with blackwood, bursaria, bracken, tea-tree, yacca, and grasses present in the understorey. On those areas covered by acid sands, the major eucalypt, brown stringybark, occurs as a tall forest accompanied by tea-tree, silver banksia, bracken, sedges, and yacca. To the west, tall forests contain a mixture of manna gum, peppermint, and swamp gum, and have a low understorey of grasses and herbs rather than shrubs. Annya block contains only small areas of heathland.

(5) Fauna

The animal population is similar to that found in the adjoining Cobboboonee block, but is somewhat less varied, because the swamp and heathland habitats that are present cover only small areas.

The short-nosed bandicoot

C. Capabilities

(1) Flora

The potential of this block for flora conservation is similar to that of Cobboboonee. Annya includes areas of forest on Tertiary sediments, and some unusually luxuriant vegetation along the Crawford River, but lacks the large heaths and swamps of Cobboboonee.

(2) Fauna

The Annya block can support considerable populations of those native animals that require a tall open forest habitat. In particular, Annya could support substantial populations of the grey kangaroo, the red-necked wallaby, and possums and gliders, as well as parrots, cockatoos, and many other native birds. It has little potential for water-fowl or for species that live in heathland.

(3) Other features

The valley of the Crawford River has natural interest. An excellent example of stream capture can be observed on private land at Lower Crawford. The Glenaulin landslips, on private land in the west of the block, are of great geological importance.

(4) Recreation

The area receives little use at present, but has capabilities similar to Cobboboonee. There is no ready access to the southern bank of the Crawford River from public land, except at one place north of Lyons.

(5) Agriculture

The favourable rainfall and fertile soils place most of this land in category 1 for agriculture.

Much of the block has the potential to grow pastures capable of carrying 4 to 5 Sheep Equivalents per acre. Nearby private lands support intensive agricultural industries such as dairying, orchards, and a vineyard. However, development costs for these enterprises are high and unless an assured demand at satisfactory prices can be demonstrated the establishment of new units would be risky.

(6) Softwood

The potential of the gradational soils is probably similar to those of the Cobboboonee block (category B), although slightly lower due to the drier climate. The potential of the sandy soils is much lower. The block does not contain any trials or plantations from which definite assessments can be made.

(7) Hardwood

This block has a high potential for hardwood timber production (categories A and B). Most of the messmate stands in

Snigging hardwood logs in the Annya block

the block have received silvicultural treatment in the form of cull-removal and thinning of regrowth stands, so the stands growing in the block at present are capable of supplying large quantities of logs. The brown stringybark stands have lower potential (category C), although they can continue to contribute to log supplies. The potential of the peppermint gum stands is low (category D).

(8) Honey

The messmate areas of this block are very important to migratory apiarists, who use this area to build up depleted hives. Both the messmate and brown stringybark, together with under-storey species such as bursaria and silver banksia, produce moderate quantities of honey as well as pollen. Occasionally the eucalypts provide an excellent honey flow.

(9) Minerals

Ironstone gravel is the only mineral known to occur in the area. The basalts present are too deeply weathered to be of economic importance.

(10) Water

The catchments of this block yield small quantities of run-off, which adds to the flow of the Fitzroy and Crawford Rivers. These waters are not suitable for domestic purposes although they do provide stock supplies. Supplies of underground water are available in most places.

D. Hazards and Conflicts

Few potential hazards arise on this block, although some erosion hazard exists on the slopes into the Crawford River.

E. Significance

The Annya block has a high potential for all the land uses considered above. However, the large areas of carefully managed hardwood stands are of some significance.

HOMERTON

A. General

(1) Location

East of Heywood. Public land in eight scattered parcels - total area 10,700 acres. Parishes of Myamyn, Condah, Homerton, Dunmore, Bessiebelle, and Narrawong, County Normanby.

(2) Present tenure

Reserved forest - 2,600 acres
Faunal reserve - 300 acres (The Stones)
Crown land reserves - 400 acres
Unoccupied Crown land - 7,400 acres

(3) General description

This flat coastal plain has been largely cleared for agriculture. The remaining public lands support tall forests of messmate and manna gum, with some swamp gum and numerous small swamps and heaths. Most of the public land is in the Heywood Land-Zone; a small area of Recent lava flows lies in the Hamilton Land-Zone.

(4) Present use

There are current grazing licences for about 1,350 acres of Crown land around Lake Condah and 250 acres south of Tyrendarra. The reserved forest in Bessiebelle is also grazed. The block has produced moderate quantities of messmate logs and other forest produce. The small swamps are used by duck-shooters in conjunction with larger swamps on private land, and Darlot Creek.

B. Nature of the Land

(1) Climate

Average annual rainfall is about 31 in.

(2) Geology and physiography

The basement of the area is Miocene limestone of the Glenelg Group. Extensive alluviums and thin deposits of Malanganee Sands overlie this, but it is exposed in some places

The limestones contain numerous small sink holes, and the overlying alluviums and sands have slumped into these, forming numerous small swamps aligned north-west to south-east.

In the north-east of the block is a

small part of "The Stones" - an extensive area of Holocene lava flows with typical "stony rise" topography. The lava flowed to the sea down the valley at present occupied by Darlot Creek.

The block is drained by the Fitzroy River and Darlot Creek. However, the surface drainage lines are not efficient, and much of the water percolates through swamps to the underlying beds. Many of the swamps are dry at the end of summer.

(3) Soils

The most common soils are weakly bleached gradational soils of sandy loam over sandy clay; brownish gleyed soils (dark clays) occur in low positions and leached sands occur on sandy rises. Thick layers of ironstone gravel are present in the gradational soils. With the exception of the leached sands, these soils are moderately fertile, with adequate moisture capacities in this zone of relatively high rainfall.

(4) Vegetation

Open-forest II of messmate is the most common vegetation type in the block, over an understorey of sparse bursaria, blackwood, and black wattle and a ground cover of bracken and grasses. Brown stringybark grows with tall bracken on sandy soils. Manna gum occurs throughout the block, and in pure stands on the stony rises land, over blackwood, bracken, and grasses. Swamp gum and peppermint occur throughout the block, and an isolated patch of red gum grows north-east of Homerton.

(5) Fauna

The fauna of this block have not been studied, but the mammals and birds described for Cobboboonee and reported in Annya would be expected to occur in the messmate forests of Homerton. In addition, the seasonal swamps would provide a suitable habitat for transitory water-fowl.

C. Capabilities

(1) Flora

The potential of this land for flora conservation is difficult to assess, except that, as so much of the vegetation of this type of land has been cleared, examples of the communities present should be conserved.

(2) Fauna

The crown land on the eastern boundary of the block is contiguous with "The Stones" faunal reserve, which is believed to contain substantial populations of the tiger cat. However little detailed information is available regarding the fauna of the area, and so the assessment of its potential for fauna conservation must be based upon the habitat. On this basis, the

The tiger cat is found in "The Stones" faunal reserve

capacity of the larger areas of public land would be high.

(3) Other Features

The recent lava flow in the valley of Darlot Creek, running from Lake Condah to Tyrendarra and then out to sea, is of considerable natural interest.

(4) Recreation

The block does not have any features that make it particularly suitable for recreation.

(5) Agriculture

Agricultural potential is high, with most of the land falling within category 2. It is capable of development and will support pastures able to carry 3-5 Sheep Equivalents per acre. However, in addition to the cost of clearing, structures, pasture, and livestock, many areas would require expensive drainage before grazing would be practicable in the winter. Thus, establishment of a completely new farming unit would be unlikely to prove a profitable investment, but some new land could conceivably be integrated with an existing local farm. Livestock enterprises would appear to be the only activities feasible on this land at present.

(6) Softwood

The suitability of the land for softwood production is unclear. Rainfall and moisture supplies and soil fertility are adequate, and considerable aggregate areas of suitable soils exist. However, the land is broken by numerous small swamps and drainage problems would be likely in any substantial block of radiata pine established in the block. Thus the general capability is assumed to be low due to the widespread dispersion of areas of poor drainage through otherwise suitable lands.

(7) Hardwood

The Homerton, Dunmore, and Bessiebelle

areas have been logged for many years, but little silvicultural work has been done and the area has only supported intermittent hardwood log production in recent years. Although messmate occupies a very large proportion of the area, the stands are in poor condition from the viewpoint of log production, with a high proportion of cull trees and little regrowth and small size classes. However, the long-term potential for hardwood is high (category B), given appropriate silvicultural practices.

(8) Honey

This block has a similar potential for apiculture to the messmate forests of adjacent blocks. It can provide pollen and rejuvenate hives, and will support occasional flows of good quality honey.

(9) Minerals

The thick beds of polyzoal limestone present in the area are a potential source of high-grade calcium carbonate. However, other occurrences in the district would be easier to exploit. Large resources of ironstone gravel are present.

(10) Water

The block has little potential for providing supplies of surface water. The swamps contribute to regional groundwater supplies.

D. Hazards and Conflicts

There are few known hazards associated with any development of this land.

. E. Significance

The land in this block has significance for hardwood timber production, conservation of flora and fauna, and the preservation of diversity in a cleared agricultural area.

HOTSPUR

A. General

(1) Location

South of the Digby and Dartmoor Road north of the Crawford River. One large parcel of public land (14,800 acres), and two smaller parcels - total area 21,200 acres. Parishes of Wataepoolan, Hotspur, and Winyayung - County Normanby.

(2) Present tenure

Reserved forest - 13,000 acres
Unoccupied Crown land - 8,200 acres

(3) General description

The block consists of lightly dissected lateritized tablelands lying between the valleys of the Stokes River to the north and the Crawford River to the south. Sand sheets cover the landscape in the western part of the block.

Vegetation consists of tall forests of messmate and brown stringybark, with heaths and some swamps. The lateritized tablelands are in the Dundas Land-Zone, and the sand sheets are in the Kanawinka Land-Zone.

(4) Present use

The main use of this land is hardwood timber production. Some areas are used for supplementary grazing from time to time. Large quantities of ironstone gravel have been extracted from shallow pits. The southern part of the area along the Crawford River is used for recreation - pleasure driving, picnicking and fishing are the main activities.

B. Nature of the Land

(1) Climate

Average annual rainfall varies from about 30 in. in the east to 34 in. in the west.

(2) Geology and physiography

The land is on the southern edge of the Merino Dissected Tablelands. Lateritized thin Tertiary sediments overlie Lower Cretaceous Otway Group sediments. In this area the tablelands have been dissected by the Stokes River and the Crawford River, and the public land lies on a tableland remnant between the valleys cut by these two streams, and in the valley of the Crawford. In the

western part of the block the lightly eroded lateritic surface is covered by sheets of wind-blown Malanaganee Sands.

(3) Soils

On the old lateritic surface in the east, and in much of the valley of the Crawford River, soils are weakly bleached gradational soils, of clay loam over clay, often with thick layers of ironstone gravel. In the west, soils are leached sands where the sand sheets are thick, and duplex (sand over gravelly clay) where the sheets are thin.

(4) Vegetation

The main vegetation types on the weakly bleached gradational soils are Open-forest II of messmate, manna gum, peppermint, and swamp gum, over tea-tree, bracken, and grasses. Open forest II of brown stringybark, interspersed with large heaths, occurs over most of the sandy soils.

The vegetation of the deep steep-sided valley of the Crawford River is unusually luxuriant for Western Victoria, with small areas of tree ferns and tall blackwoods, and dense thickets of woolly tea-tree.

(5) Fauna

The typical animals of this block include those inhabiting forest areas of messmate and brown stringybark, heath, and reed-filled swamps. Grey kangaroo, red-necked wallaby, crimson rosella, white-browed scrub wren, brown thornbill, white-eared honeyeater, grey shrike-thrush, yellow robin, and white-throated tree creeper are among those commonly seen.

C. Capabilities

(1) Flora

The messmate and peppermint gum forests on the lateritized tablelands are the last remnants of this type, and so these areas are of importance to flora conservation. Although the large heaths and tall brown stringybark forests are not unique to this block, they occur in a large, compact area well suited to the conservation of habitat. The vegetation along the Crawford River is unusual in the study area. Thus the block has a moderate to high potential for flora conservation.

(2) Fauna

The area is considered to have moderate to high potential for the conservation of fauna that normally inhabits tall open forests. This large, well-consolidated block of forest forms part of a chain of natural bushland that stretches north-nor-west from Portland to the northern extremity of the study area. The presence of the Crawford River adds to the block's value for those species

A few snow gums (E. pauciflora) *are found in the south-west - near the western extremity of their distribution*

requiring free water. This is especially important during drought, and for species not able to use farm water supplies.

(3) Other features

No features of natural interest are known in this block at present.

(4) Recreation

The Crawford River has a high potential for recreational use. A road runs along the northern bank of the river, and access to the water and picnic facilities are provided at several places. The steep-sided valley is scenically attractive in an otherwise relatively featureless region. The area is, however, remote from centres of population.

(5) Agriculture

The agricultural capability of the land is variable. Much of the brown stringybark areas are poor and fall within land category 4, however the messmate and gum areas are of high potential (category 1) and the central heaths of moderate potential (category 2). About half of the area, including Winyayung, has a moderate to high agricultural potential and here pastures could be developed to support 3 - 5 Sheep Equivalents per acre. However, the total cost of such development, excluding stock and assuming a completely new farm was established, could exceed $150 per acre.

(6) Softwood

The eastern parts of the block have a

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A quiet pool on a bend of the Crawford River

moderate to high potential for radiata pine (category B). However, it is remote from any milling centre. The potential of the brown stringybark areas is lower (category C). A small stand of radiata pines in the brown stringybark forest type has achieved only a low growth rate and shows symptoms of phosphorus deficiency. However, the potential of the sandy soil in the block is higher than for the blocks further north, due to higher rainfall and shallower soils.

(7) Hardwood

The block has a moderate potential for hardwood timber production. The messmate areas in the east have a high potential (category B), but not as high as for Annya and Cobboboonee. The brown stringybark stands are less productive (category C), but make an important contribution to local log supplies. Two sawmills draw logs from the block at present.

(8) Honey

The messmate and brown stringybark of this block have a high potential for pollen production, and a moderate but variable potential for honey production. They are used to build up hives that have been weakened while producing honey in other parts of the State. This block and those to the south therefore have considerable value for apiarists.

(9) Minerals

Ironstone gravel is the main mineral resource in this block. Some limestone is available in the valley of the Crawford River.

(10) Water

Surface run-off flows into the Crawford and Stokes Rivers, and is of little significance. The salinities of these streams may at times be too high for domestic use. Underground supplies are

poor generally, although they are better in the west where the Tertiary deposits thicken.

D. Hazards and Conflicts

Clearing the existing vegetation could precipitate erosion hazards on this block. Spectacular and serious examples of gully erosion and land-slips have occurred on the steep valley sides of adjacent, cleared private lands. This potential hazard would be most serious to the west of the area along the Weecurra escarpment and along the Crawford River. The situation does not apply on the flat plateau away from the rivers.

E. Significance

While this block has some potential for several land uses, recreation, flora and fauna conservation, and hardwood timber production are the most significant.

STRATHDOWNIE

A. General

(1) Location

West of Casterton and north-west of Dartmoor to the South Australian border. 15 scattered parcels of public land - total area 6,600 acres. Parishes of Nagwarry, Tullich, Kaladbro, Ardno, Wilkin, and Werrikoo - County Follett

(2) Present tenure

Unoccupied Crown land - 5,630 acres
Permissive occupancy - 963 acres
(SAPFOR Ltd)

(3) General description

This block is entirely on the Follett Plains and is a flat to very gently undulating plain of clayey lagoon deposits with many swamps and small areas of wind-blown acid white sands. Most of it has been cleared for agriculture, and the public land consists of swamps and sands unsuitable for such development. It lies in the Heywood Land-Zone.

(4) Present use

Many of the swamps are used to hold water drained from surrounding grazing land. Most of the areas are used for supplementary grazing from time to time. Radiata pine has been planted on the land held under permissive occupancy.

B. Nature of the Land

(1) Climate

Average annual rainfall varies from 23 in. in the south to 26 in. in the north.

(2) Geology and Physiography

The Whalers Bluff Formation rests at shallow depth on Miocene limestone (Glenelg Group), and is overlain by flat sandy and clayey lagoon deposits. There are a few areas of dune limestone of the Bridgewater Formation, and banks of deeper siliceous sands. Some of the swamps have sandy lunettes. Regional drainage is very slow and in winter the area becomes a vast swampland.

(3) Soils

The most common soils on public land are brownish gleyed soils (in the swamps), brown duplex soils, and leached sands.

(4) Vegetation

The swamps contain reeds and rushes, and some are surrounded by woodlands of red gum, manna gum, or swamp gum. Brown stringybark occurs as Open forest I and II on the sandy rises and lunettes. Small areas support heath.

(5) Fauna

The swamps are used by water-fowl and the small forested blocks provide useful cover for transitory birds and mammals. However more than 90% of the area is alienated and the contribution that the small, scattered blocks of public land make to wildlife habitat is not great.

C. Capabilities

(1) Flora

The small scattered areas in this block make some contribution to the preservation of a diversified flora in the study area.

(2) Fauna

The public lands in this block do not support large animal populations. However they do provide some low forest and swampland refuges for the few resident species as well as for migratory and nomadic species in an area where almost all other native vegetation has been cleared.

(3) Other features

Caves in dune limestone ridges at Puralka and Strathdownie contain deposits of vertebrate fossil bones. Well-developed lunettes on the eastern edge of large swamps are of geomorphological interest.

(4) Recreation

The recreation potential is low.

(5) Agriculture

The potential of the land for agriculture is low - the swamps remaining as public land are difficult to drain, and the sandy rises are land category 4 or 5.

(6) Softwood

The land is generally category 4 and 5. Small isolated areas are not attractive for conversion to softwood. The area on which plantations have been established is on the South Australian border, and forms part of a large plantation mainly established on private property.

(7) Hardwood

The land has the potential to supply farm timbers only.

(8) Honey

The area has a low potential for honey production.

(9) Minerals

Only quartz sand, Whalers Bluff Formation, and dune limestone are present.

(10) Water

High-quality groundwater is available at shallow depth from the Whaler's Bluff Formation, and recharge to this aquifer takes place through the numerous swamps and surface sands.

D. Hazards and Conflicts

No hazards of land deterioration are known in this block at present.

E. Significance

The public lands in this block have some significance as drainage basins, and as small reserves of natural habitat for flora and fauna in a predominantly agricultural area.

WEECURRA

A. General

(1) Location

North-east of Dartmoor and west of Digby, bounded by the Glenelg River to the west and north. Two large parcels of public land, and five smaller parcels - total area 52,500 acres. Parishes of Killara, Mocamboro, Myaring, Weecurra, and Wataepoolan - County Normanby.

(2) Present tenure

Reserved forest - 11,000 acres
Game refuge - 130 acres (Burgess Swamp)
Plantation area lease - 2,000 acres (SAPFOR Ltd)
Unoccupied Crown land - 39,400 acres

(3) General description

The landscape consists of sheets and low-lying dunes of siliceous white sand, overlying clayey deposits on the Follet Plains and lateritized swampy tablelands east of the Weecurra Fault. Soils are infertile strongly leached sands, though in a few places where the sand sheets are thin or absent more fertile clayey soils occur. Vegetation consists of forests of brown stringybark over most of the area, with heaths and swamps in low topographic positions, and gum woodlands where the sands are thin or absent. The public land in this block is in the Kanawinka Land-Zone, and is similar to the public land in the seven blocks to the north.

In this block the areas of gum woodlands, and most large areas of heaths, have been alienated for agriculture.

(4) Present use

Some hardwood logs, posts, and firewood are cut. Radiata pine is planted on the Plantation area leases, and there is a 360-acre plantation on reserved forest in Mocamboro parish. Current grazing licences cover about 3,100 acres of this block, and most of the public land has provided supplementary grazing at some time. Ironstone gravel is extracted for road-making in several places.

B. Nature of the Land

(1) Climate

Average annual rainfall varies from 34 in. in the south to 28 in. in the north.

(2) Geology and physiography

The Weecurra Fault traverses this block. To the west of the escarpment, Malanganee Sands cover Pleistocene lagoon deposits on the Follett Plains; to the east sheets and dunes of sand cover the lateritized Merino Dissected Tablelands. The Tablelands in this area are lightly dissected and consist of thin, lateritized Pliocene sands capping middle and lower Tertiary deposits. The Tertiary deposits (Glenelg and Knight Groups), which overlie Mesozcic Otway Group sediments, thin rapidly to the east of the escarpment.

In the west the drainage is poor and swamps and heaths are common. In the east the massive sand deposits occasionally impede local drainage but the regional drainage is free, water moving to the Glenelg River via the Stokes River and Morgan Creek in the south and Dwyers' Creek, Clarke Creek, and the Wannon River in the north.

(3) Soils

Deep leached sands, with or without a layer of "coffee rock" at depth, are found where the sand sheets are thick. Where the sheets are thinner, the "coffee rock" may be closer to the surface. The leached sands are acid and extremely infertile, and have very low water-holding capacities. Where the sheets are very thin, duplex soils occur, and clay or ironstone over clay forms the subsoil. A similar range of soils is found in swamps and heaths, but they contain more organic matter. Where the sand sheets are absent, duplex or brownish gleyed soils occur.

(4) Vegetation

The most common type of vegetation in this area is an Open forest I of brown stringybark, over bracken on the deep sands and over an increasingly heathy understorey as soil depth decreases. Heaths and swamps are common. Manna gum, peppermint, and red gum may occur where soils are shallow. Some scattered areas of yellow gum occur west of Digby. The heaths typically contain species of the genera *Leptospermum*, *Epacris*, *Casuarina*, *Melaleuca*, *Goodenia*, *Danthonia*, *Centrolepis*, and *Cyperus*.

The higher rainfall in the southern part of this block has enabled better growth, and brown stringybark occurs as Open forest II. On a small area of better soil in the south-east of the block it occurs with messmate, manna gum, peppermint, and a few snow gums *(E. Pauciflora)*.

Some small areas of fertile soils on public land just west of Digby contain many interesting plants. These include *Corybas fordhamii*, usually restricted to far-eastern Gippsland; *Helichrysum dealbatum*, normally found east of Melbourne, *Calochilus campestris* and *C. herbaceus*, *Goodenia lineata*, and *Xyris*

A stumpy-tail lizard - common in northern blocks

gracilis. *Melaleuca squamea* occurs in profusion and there are excellent examples of the widespread *Viminaria juncea* and *Pultenaea laxiflora*. *Thelymitra epipactoides* and *T. grandiflora* also occur in this south-western corner of the block.

C. Capabilities

(1) Flora

The south-eastern corner has a high potential for the preservation of native flora due to the richness and variety of the minor species and the occurrence of several plants close to the extremity of their range. Several small areas of public land along the Dartmoor-Casterton road also contain many orchids. The heaths and wetlands of this block are good examples of the vegetation of this type of land.

(2) Fauna

The remaining public lands can provide shelter for birds and animals, both transitory and local inhabitants. However, they are so fragmented that the private lands of the area probably contribute most to the maintenance of the populations of larger animals and water-fowl found there. The relative uniformity of large parts of the public land and the poor consolidation of this land do not allow it a high potential as a self-contained fauna reserve. However, for as long as the

private landholders are prepared to accept the presence of native animals, the mixture of private and public land as a whole does have the capacity to support a rich and interesting fauna.

(3) Other features

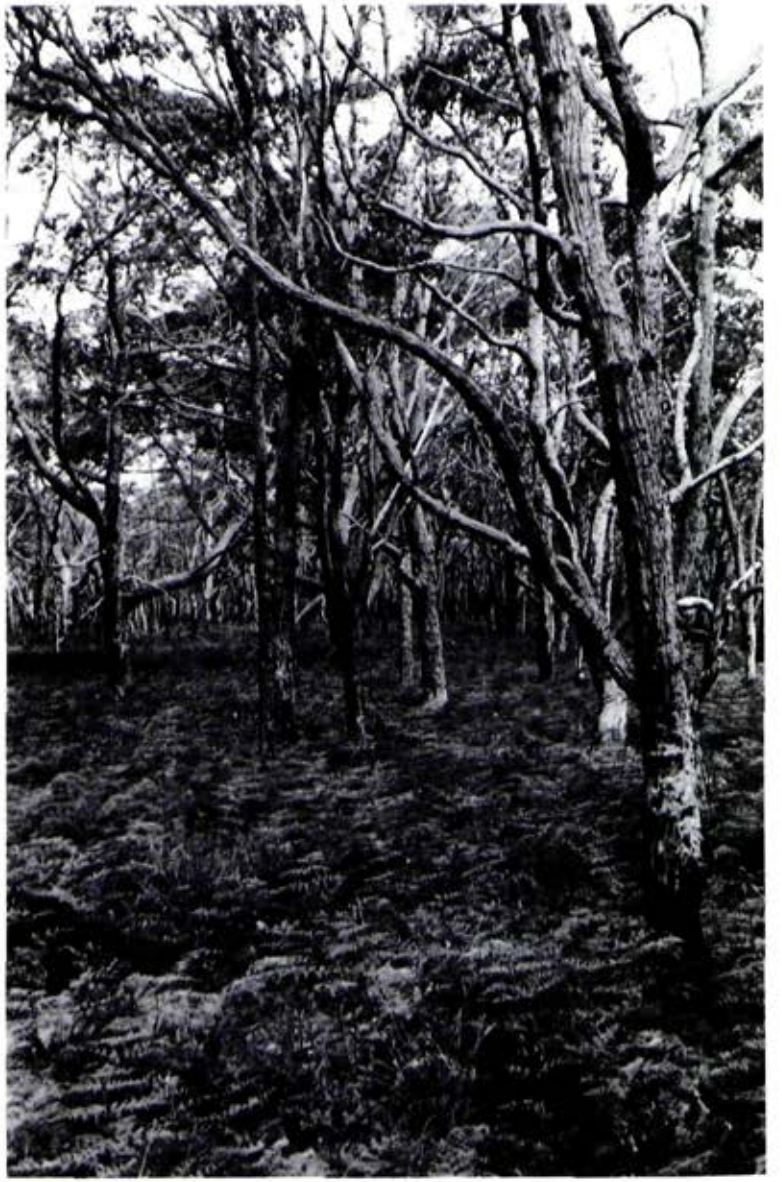
The banks of the Glenelg River contain many exposures of geological interest. The most important are the Killara Bluff in the north, which is the type section of the Bahgallah Formation, and Caldwell's Cliff, south of Myaring Bridge.

(4) Recreation

The recreational value of the area is difficult to assess. It has some potential for duck shooting, the study of natural history, picnicking, and the enjoyment of bushland surroundings. However, no features peculiar to this block give it a particular value for recreation over other more accessible ones in the study area.

(5) Agriculture

Although this block receives the highest rainfall in the Shire of Glenelg, the agricultural potential of the public land is generally low, most falling within land category 4. The development of category 4 land for grazing is not likely to prove as profitable as the further development of the better private land. Small areas of heathland,



Brown stringybark with a bracken understorey

category 2, have higher agricultural potential. However, size, shape, and location of these heaths make them unsuitable for development. All the heaths and gum woodlands that were convenient to develop for grazing have been alienated.

(6) Softwood

The land in this block falls into categories C and D with respect to softwood timber production. The block is favoured in relation to the other northern blocks by a high rainfall and good soil moisture conditions, especially in the western part. Scattered small areas of better soils occur in the eastern part. About 2,500 acres of plantations have been established in the block to date. It is well placed to supply logs for milling at Casterton or Dartmoor.

(7) Hardwood

Potential for hardwood production is moderate (category C) in some places where known stringybark approaches 60 ft in height. These stands are scattered through forest of low potential (category F). A small area of messmate (category B) occurs west of Digby.

(8) Honey

This block has moderate, but variable, capability for honey production. In particular the taller brown stringybark areas, to the west of Digby and north of the Stokes River, have been used by apiarists for many years. The current use is probably below the potential capacity of the area for honey production, but the seasonal and migratory nature of the industry makes it difficult to match temporary honey flows and hives.

(9) Minerals

The only known minerals of actual or potential economic significance in this area are ironstone for road-making, quartz sand, and limestone. The Whalers Bluff limestone has been extensively worked on private lands near the Myaring Bridge, and used for the construction of local roads.

(10) Water

Weecurra is not a regionally important source of surface water, although the drainage lines do provide stock supplies to the adjacent private lands. The part of this block to the west of the fault escarpment is an important intake area for the shallow Whalers Bluff aquifer and for deeper aquifers.

Supplies of underground water are probably available in the east but have not been investigated by drilling. Large resources of good-quality water are present in several formations to the west of the escarpment.

D. Hazards and Conflicts

Few physical hazards are known within this block at present. Some erosion could occur on the fall into the Stokes River and along the fault escarpment if the native vegetation was cleared. Plantations of radiata pine on the Follett Plains would reduce the recharge of shallow aquifers.

E. Significance

The area west of Digby contains interesting plants. The wetlands are important intake areas for shallow aquifers. Adequate rainfall, established plantations, and proximity to Casterton and Dartmoor give the block significance for softwood production. It also has some significance for hardwood production.

WILKIN

A. General

(1) Location

South-east of Casterton between the Glenelg River and the Glenelg Highway. Three parcels of public land - total area 8,200 acres. Parishes of Wilkin, Werrikoo, Drajurk, and Bahgallah - County Follett.

(2) Present tenure

Plantation area lease - 500 acres
Permissive occupancy - 600 acres (Forests Commission)
Unoccupied Crown land - 7,100 acres

(3) General description

As for Weecurra block. Wilkin contains some large swamps and shallow drainage lines pass through it to the Glenelg River. The block is entirely on the Follett Plains, in the Kanawinka Land-Zone.

(4) Present use

The area has been grazed in the past. Minor forest produce is cut. The Forests Commission has a 600-acre plantation in the Parish of Bahgallah. The Casterton racecourse is Crown land in this block.

B. Nature of the Land

(1) Climate

Average annual rainfall is about 27 in.

(2) Geology and physiography

Low dunes and sheets of acid white Malanganee Sands of variable thickness rest on Pleistocene calcareous sands and limestones of the Whalers Bluff Formation. These beds are about 80 ft thick and rest on Tertiary sands and silts. Some drainage occurs via short streams to the Glenelg River, and there are swamps in the south.

(3) Soils

As for Weecurra block.

(4) Vegetation

The vegetation of the Wilkin block shows very considerable diversity - although half of the area is covered by brown stringybark as both Open forest II and

Open forest I, the understorey and heaths and swamps are particularly rich in species. Only small areas of gum woodlands occur. In the Wilkin area 50 species of orchids have been identified, including the naked sun-orchid *(Thelymitra nuda)*. Other species of interest are *Baeckia ramosissima*, *Pterostylis plumosa*, *Thelymitra fusco-lutea*, and *Baumea laxum*.

The north-eastern part of the block is similar to Drajurk, and the vegetation shows much less diversity.

(5) Fauna

The southern parts of this block provide a good variety of habitats and a correspondingly varied animal population. Mill swamp is one of the better-known water-fowl habitats in the area. The north-east is less varied, although the Glenelg River is an important feature.

C. Capabilities

(1) Flora

Wilkin is well suited to flora conservation and stands out among the northern blocks because of the large number of species it contains, especially orchids.

(2) Fauna

No species of particular significance are known to occur in the block. How-

Glenelg River, public lands, and pine plantations in the south of the Wilkin block.

ever, its varied range of habitats provides the best refuge on public land for resident, migratory, and nomadic species in this part of the study area.

(3) Other features

The Glenelg River cliffs contain sections of geological interest.

(4) Recreation

Easy access to the Wilkin block from the nearby Glenelg Highway adds to its value for passive recreation and the study of nature. The Glenelg River here has special beauty with tall limestone cliffs and spreading red gums.

(5) Agriculture

As for Weecurra.

(6) Softwood

As for Weecurra. The Forest Commission plantation at Bahgallah was established on a pocket of less strongly leached sands.

(7) Hardwood

The area has a low potential for hardwood production (category F). Although brown stringybark is a preferred timber species, the stands in this block are low and the trees are heavily branched, rendering them useful only for posts, short poles, and firewood.

(8) Honey

This block has a good potential for honey and pollen production, but the irregularity of flowering by brown stringybark can lead to wide seasonal fluctuations.

(9) Minerals

Quartz sand is the only mineral resource known in the area. Limestone of the Whalers Bluff Formation lies at variable depth beneath the sand, and large quantities have been quarried for the construction of the Glenelg Highway.

(10) Water

The area makes some contribution to the flow of the Glenelg River. The Whalers Bluff Formation is an unconfined aquifer containing good-quality water extending from about 20 to 105 ft below the surface. Deeper, confined aquifers in the Lower Tertiary and Upper Cretaceous deposits are thought to contain considerable reserves of water, but its use would involve much higher pumping costs.

D. Hazards and Conflicts

There are no known hazards of land deterioration in this block.

E. Significance

The Wilkin block is of significance for flora conservation.

DRAJURK

A. General

(1) Location

Generally west of Casterton and north of the Glenelg Highway. One large parcel of public land (31,800 acres), and one small parcel - total area 32,400 acres. Parishes of Drajurk and Nangeela - County Follett.

(2) Present tenure

Reserved forest - 29,400 acres
Unoccupied Crown land - 3,000 acres.

(3) General description

Drajurk resembles Weecurra block and has small areas of red gum woodlands. The Kanawinka Fault separating the Follett Plains from the Dergholm Platform passes through it.

Most of the public land in this block is in the Kanawinka Land-Zone.

(4) Present use

Small quantities of minor forest produce are cut including sleepers from the red gum areas. Two bores supply part of the Casterton water supply.

B. Nature of the land

(1) Climate

Average annual rainfall is about 27 in.

(2) Geology and physiography

As for Wilkin block. The Malanganee Sands are up to 50 ft thick where they are piled up against the Kanawinka escarpment.

(3) Soils

As for Weecurra. The impoverished leached sands are the most common soils in this block.

(4) Vegetation

The vegetation type over most of this block is a low forest of stunted brown stringybark with a heath and bracken understorey. The soil moisture characteristics provide some variation within this major vegetation class. Where a clay or coffee rock horizon im-

pedes drainage, bracken is often absent and yellow gum, manna gum, peppermint, and swamp gum may be present. The wetter is the site, the fewer stringybarks occur until it meets the open heaths and swamps. Such sites occupy about one-sixth of the area of public land.

Small red gum woodlands occur along the eastern and northern margins of the block, but as a whole it is not florally diverse compared with the Wilkin block. However, the following species were recorded in the red gum woodlands near Tullich: *Zieria veronica, Thelymitra holmesii, T. mucida, Microtis orbiculous, and Hibbertia* sp. nov.

(5) Fauna

No animals of special significance are known to occur in this block. It provides large areas of habitat suitable for those animals that prefer low stringybark forest and reed-filled swamp. It lacks any sizable areas of open water or gum woodland as found in some of the adjoining blocks, and therefore has a lower value for wildlife.

C. Capabilities

(1) Flora

The potential of this block for flora conservation is low in comparison with others in the area.

Stunted brown stringybark with yacca and bracken

(2) Fauna

The lack of diverse habitats makes the potential for fauna conservation relatively low.

(3) Other features

No other features of natural interest are known in this block at present.

(4) Recreation

The block contains no features of special significance for recreation. However its proximity to Casterton increases its potential for bushland recreation activities.

(5) Agriculture

The agricultural capability of this block is very low - the bulk of the area falling into land category 5. The smaller areas of heath, gum woodland, and swamp have higher potential, probably land category 2, but they are distributed in an irregular fashion and workable blocks would be difficult to locate. Some of the gum woodland on the boundaries could conceivably be added to existing agricultural lands, but these are also the areas with the highest hardwood timber potential, and are floristically the most diverse areas in the block. High drainage costs may also preclude the economic development of swamplands.

(6) Softwood

The area has a poor softwood potential compared with the surrounding blocks, and much of it falls within category D. Several experimental plantings of radiata pine were made in this block during the 1930s, but changes in fertilizer techniques since that time and the effects of fires make it difficult to draw definite conclusions. One favourable aspect of this site for softwood production is its location - close to Casterton and a possible future mill site.

(7) Hardwood

In general the land has a low potential (category F). The small red gum woodlands are capable of producing limited amounts of sleepers and posts, and the stringybark areas firewood, posts, and poles. Although the quantity of such production is likely to remain very small, it is of some local significance for farm timbers and for town firewood supplies due to the proximity of Casterton.

(8) Honey

The brown stringybarks of this block occasionally provide large honey flows, and it has been used by up to eight apiarists in recent years. But its potential for apiculture varies, as the ground flora is poorer than that of other blocks and the flowering of brown stringybark can be irregular.

(9) Minerals

The block contains quartz sand and some ironstone gravel.

(10) Water

The surface water resources of the block have little significance except in their contribution to wildlife habitat and as

part of the recharge process for aquifers. The groundwater underlying Drajurk in the Whalers Bluff Formation is of high quality and currently supplements the Casterton town water supply. It is relatively cheap and may supply an increasing proportion of the town's needs in the future.

D. Hazards and Conflicts

The development of the area immediately surrounding the Casterton town water-supply bores, for either agriculture or softwood production, could pose a threat to the quality and quantity of the shallow groundwater supplies. At this site, recharge depends upon the downward percolation of rainfall in the immediate vicinity of the bores. Compared with the existing vegetation, pine plantations could reduce such infiltration and in most areas would be able to directly tap the shallow water table. The clearing of such land for agriculture may increase infiltration, but would also present dangers of pollution through the use of pesticides and fertilizers, and the presence of sewerage and garbage. The intensive development of other bores for irrigation would also conflict with the use of this water for town supplies.

The area over which the suggested hazards and conflicts may occur depends upon the eventual rate of extraction of water from the bores. It has been suggested that these problems would not exist in areas more than one mile from the bores except in the direction of intake of the water, to the north-east, where conflict is possible for about 3 miles.

E. Significance

A small part of this block is of considerable importance for the supply of groundwater for Casterton township.

TOOLOY

A. General

(1) Location

North of the Casterton-Penola Road, adjacent to the South Australian border. Two large parcels of public land - total area 30,600 acres. Parishes of Tooloy, Tullich, and Byjuke - County Follett.

(2) Present tenure

Reserved forest - 1,300 acres
Gravel reserve - 100 acres
Plantation area lease - 4,800 acres
Unoccupied Crown land - 24,400 acres.

(3) General description

As for Weecurra block. Tooloy is entirely on the Follett Plains. Some areas of manna gum woodlands grow in places where sand sheets are thin or absent, and there are swamps and heaths north of Lake Mundi.

(4) Present use

A number of grazing licences are current in the area. Licences covering Lake Mundi and Mosquito Swamp permit cultivation. Ironstone gravel is extracted in large quantities from shallow pits. Minor forest produce is cut. The area is used by duck shooters.

B. Nature of the Land

(1) Climate

Average annual rainfall is about 26 in.

(2) Geology and physiography

As for Wilkin block. This block has no streams, and in winter water collects in swamps and lakes, and infiltrates into the siliceous sands and the underlying Whalers Bluff Formation.

(3) Soils

The nature of the soils and vegetation depends upon the thickness of the sand cover, as this determines the water relations and fertility of the subsoil. In general, the sands of this block are not as acid (pH greater than 5.5) and leached as they are in other northern blocks of the study area.

(4) Vegetation

The dominant vegetation type is an Open

forest I of brown stringybark. In the central part of the area, where more fertile soils occur, the forest is almost 60 ft tall, and manna gum, yellow gum, and swamp gum form part of the stand. Some manna gum woodlands also occur in this area. On these better sites, a stratum of silver banksia grows more than 6 ft high, with sparse blackwoods over bracken, grasses, and yacca. In the western and south-eastern parts of the block, swamps, heaths, and shallow lakes form a mosaic with small areas of red gum woodlands.

(5) Fauna

The low forest of brown stringybark that predominates in this block, while not supporting a particularly rich fauna, does provide better and more varied habitat than the similar but drier areas of this vegetation further north. The small areas of woodland add more variety, but they are very limited in extent.

The most important feature of the block is the number of swamps and shallow lakes, which provide refuge and breeding areas for many water-fowl, including the blue-billed duck.

C. Capabilities

(1) Flora

This block does not have outstanding potential for flora conservation, with

Silver banksia on a sandy rise north of Lake Mundi

the exception of the area of manna gum woodlands, which differ in form and understorey composition from manna gum areas in the Lower Glenelg block.

(2) Fauna

Although no species of special significance are known to occur in it, this block, together with parts of the adjoining Roseneath block, provides examples of all the habitats found in the northern part of the study area.

The many swamps and shallow lakes of the area lie along a major flight line

of water-fowl and are therefore important in the conservation of these species.

(3) Other features

No features of natural interest are known in this area at present.

(4) Recreation

The block is relatively remote from towns and is unused, except for duck shooting.

(5) Agriculture

The agricultural potential of the block varies - a large part of the stringybark country falls into category 4 and is quite unsuited to development. However, the heaths, the best areas of low forest, and the swamps are of higher potential - land category 2. These areas could be developed to support pastures capable of carrying about 3 Sheep Equivalents per acre as at Dorodong and Tullich. The availability of good-quality groundwater in shallow aquifers between 40 and 120 ft below the surface introduces the possibility of irrigated agriculture, similar to the kind that has become widespread in South Australia. However, within this block such development is only in the initial stages on the existing private lands.

(6) Softwood

The areas of manna gum woodland fall between categories A and B with respect to suitability for radiata pine. Surrounding areas would fall into category D, while the heaths, swamps, and red gum woodlands are unsuitable.

(7) Hardwood

The potential of the area for hardwood production is low (category F). The very small areas of gum woodland and the better patches of stringybark could continue to provide small quantities of sleepers, fence posts, poles, and firewood, but there is little potential for significant hardwood production.

(8) Honey

This block makes a minor contribution to apiculture and has carried small numbers of hives at irregular intervals. It has a moderate potential, especially for pollen production and rebuilding weak hives.

(9) Minerals

The mineral resources of the area are quartz sand and ironstone gravel that is present locally in the central part of the area.

(10) Water

Surface water discharge is very small. The shallow unconfined Whalers Bluff Formation aquifer is recharged from swamps and general infiltration within

this block and is a potential source of irrigation and stock and domestic supplies.

Other deeper confined aquifers, particularly the Dartmoor Formation and the Sherbrook Group, probably contain large reserves of good-quality water.

D. Hazards and Conflicts

Extraction of ironstone gravel from shallow pits detracts from the amenity of the area, especially if the topsoil is not replaced. Drainage of wetlands would destroy valuable wildlife habitats and lower the rate of recharge into the shallow aquifer system.

E. Significance

The Tooloy block and the adjacent parts of the Roseneath block contain a large compact area of diverse wildlife habitat. Tooloy is better suited to agriculture and softwood production than the surrounding blocks. The wetlands are important recharge areas for shallow aquifers.

ROSENEATH

A. General

(1) Location

North-west of Casterton on the South Australian border. One large parcel of public land (43,800 acres) and three smaller ones - total area 45,300 acres. Parishes of Nangeela, Byjuke, Roseneath, and Kanawinka - County Follett.

(2) Present tenure

Reserved forest - 4,500 acres
Unoccupied Crown land - 40,800 acres

(3) General description

As for Weecurra block. It contains some areas of red gum, yellow gum, and pink gum woodlands where the sand sheets are thin or absent. The Kanawinka Fault, separating Follett Plains from the Dergholm Platform, passes through the block, and a belt of swampy and heathy country lies at its foot. Most of the public land is in the Kanawinka Land-Zone.

(4) Present use

The land is used for supplementary grazing, especially in the areas of gum woodland. Minor forest produce and sleepers are cut.

B. Nature of the Land

(1) Climate

Average annual rainfall is about 27 in.

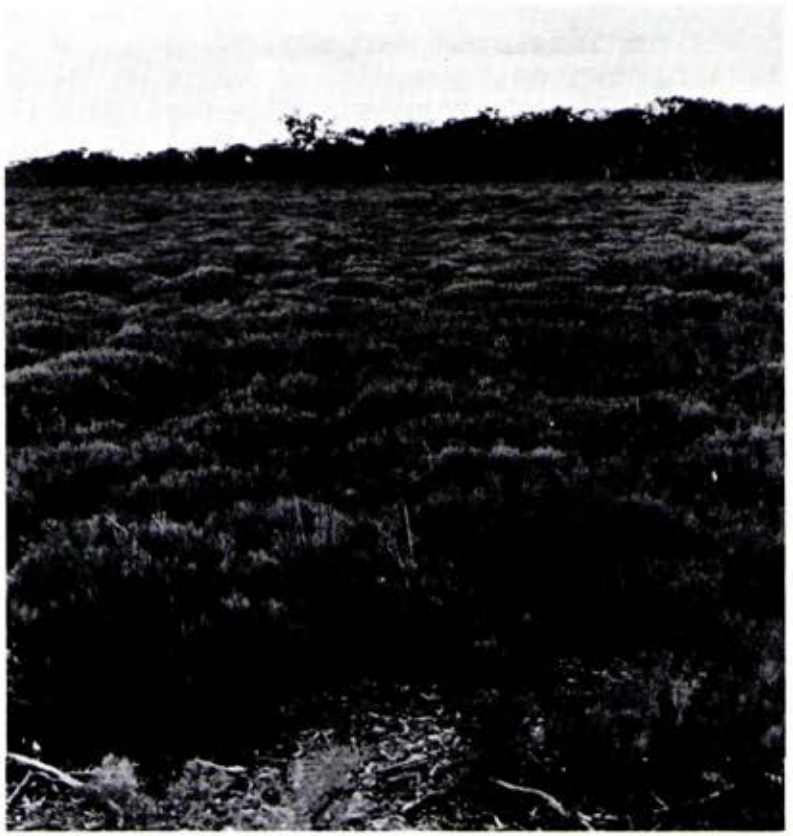
(2) Geology and physiography

The area south-west of the Kanawinka Fault resembles the Wilkin and Drajurk blocks. North-east of the fault, the land comprises sheets and dunes of acid Malanganee Sands covering the lateritized Dergholm Platform. The thickness of the sand cover varies from less than 2 ft over about one-third of the area up to 40 ft in other parts.

Several short streams drain the Dergholm Platform. Some flow east to the Glenelg River; others flow west across the escarpment to a line of swamps at its foot. The platform proper is mainly flat, with little variation in relief and few swamps.

(3) Soils

As for Weecurra.



A dry heath in the Roseneath block

(4) Vegetation

A low forest of brown stringybark and peppermint is the major vegetation type. However, quite substantial areas of heath and swampland occur, covering perhaps one-third of the total area. These are characterized by species of *Casuarina*, *Epacris*, *Leptospermum*, *Banksia*, *Melaleuca*, and *Juncus*. The northern parts of the block contain some of the larger areas of gum woodland remaining on public land in the south-west. Red gum *(Eucalyptus camaldulensis)* yellow gum *(E. leucoxylon)* and the rare pink gum *(E. fasciculosa)* are found on these areas.

(5) Fauna

The low forests of brown stringybark that cover almost half the public land in this block do not support a very varied or prolific animal population. But the extensive areas of gum woodland provide good habitat for many species, including tuan, black-faced kangaroo, hooded robin, brown tree creeper, eastern striated pardalote, jacky winter, several species of honeyeater, and (in the summer months) wood-swallows and rufous songlarks.

The swamps provide refuge and breeding areas for a number of water-fowl, including the blue-billed duck.

C. Capabilities

(1) Flora

The block contains a compact area of gum woodland that is the best remaining example of this type on public land. Pink gum, which has a very restricted range in Victoria, abounds near the north-eastern margin of the public land. Thus the northern parts of this block

have a high potential for flora conservation.

(2) Fauna

The woodland type of habitat probably supports the most interesting fauna populations found in the northern part of the study area. The block is therefore important in the general conservation of these fauna populations.

The swamps in the southern part of the block provide refuge and breeding areas for a number of resident and nomadic water birds.

(3) Other features

No other natural features of special interest are known.

(4) Recreation

The block contains pleasant bushland settings, but, being remote from centres of population, is unlikely to be heavily used for recreational use.

(5) Agriculture

The agricultural capability of the stringybark areas is very low; the land falls within categories 4 and 5. Potential carrying capacity is 1-2 Sheep Equivalents per acre and development costs would be high. The heaths, swamps, and gum woodlands have much higher agricultural potential largely falling within land category 2. These areas could be developed for agriculture, but development costs would be high in relation to likely returns. The further development of cleared land in the area is probably more profitable.

(6) Softwood

The potential of the area for softwood production is low on the whole, because

Lightly cleared red gum woodland

of the large areas of heaths, swamps, and gum woodlands, which are unsuitable. Some areas of stringybark would fall into category C, especially those in the south. Moisture availability would be a serious problem, as rainfall is relatively low and groundwater supplies may not be available to tree roots on the Dergholm Platform.

(7) Hardwood

The red gum and yellow gum woodlands produce valuable durable timbers (category E). The potential of the stringybark forests is low.

(8) Honey

The tree vegetation types of the block are valuable to apiarists. The gum woodlands are accessible and produce very good honey flows, and other areas contribute to winter hive maintenance as well as honey production.

(9) Minerals

Red Dergholm granite has been quarried in a small area south-west of Dergholm near Boiler Swamp; ironstone gravel is used for road-making; and substantial reserves of quartz sand are present.

(10) Water

The area makes little contribution to surface water supplies. Underground water varies in quality and quantity according to the presence and thickness of bands and lenses of the Gambier Limestone.

D. Hazards and Conflicts

Erosion of the slopes of the fault escarpment could result from clearing of this land. There are few potential hazards apart from this.

E. Significance

The areas of gum woodland, especially the pink gum stands, are quite rare and are important examples of this type of vegetation. The many swamps towards the western and central parts of the block are significant breeding grounds for water-fowl. The value of the block for conservation use would be increased if the Crown purchased some alienated pockets of gum woodlands and swamps.

YOUPAYANG

A. General

(1) Location

North of Casterton and bounded to the west and north by the Glenelg River. One main parcel of public land (32,100 acres) and one small parcel - total area 33,200 acres. Parishes of Youpayang, Warrock, and Ganoo Ganoo - County Dundas.

(2) Present tenure

Reserved forest - 3,300 acres
Unoccupied Crown land - 29,900 acres

(3) General description

As for Weecurra block. Youpayang is on the Dundas Tablelands. Numerous large round swamps are a feature of the block. The public land is in the Kanawinka Land-Zone.

(4) Present use

The Youpayang block supports supplementary grazing. It also produces small quantities of posts, sleepers, and firewood.

B. Nature of the Land

(1) Climate

Average annual rainfall is approximately 26 in.

(2) Geology and physiography

The land consists of sheets and dunes of acid Malanganee Sands overlying the western extremity of the lateritized Dundas Tablelands. The central part of the block is a slightly dissected plateau with large circular swamps and small drainage lines leading to the deep valleys of the Glenelg and Chetwynd Rivers, Nolans Creek, and Steepbank Rivulet. The plateau is capped by the ferruginous Dorodong Sands, over some Glenelg Group limestones that rest on a basement of Palaeozoic rocks.

(3) Soils

Soils over one-third of the block are deep leached sands, and thin sands over gravelly clay cover another third. The remainder comprises soils in swamps, heaths, and drainage lines, and some fertile soils carrying gum woodlands.

(4) Vegetation

The vegetation of the area is closely related to the depth of sand cover, although the underlying material and topographic position are also important. The dominant vegetation is a low forest of brown stringybark with bracken and heathy understorey. The shallower sands are indicated by the presence of duck-bush *(Hakea rostrata)* and the relative sparseness of the heath understorey. This low forest covers about 70% of the public lands. The remainder is largely open heath, heathy drainage lines fringed with swamp gum, and large seasonal swamps. Only small areas of gum woodland remain on public land, as the two large ones have been alienated.

This block is floristically one of the richest of the northern blocks, due to the varied habitats present. Interesting species recorded from the block include *Caladenia carnea* var. ornata, *Dianella tasmanica, Epacris obtusifolia, Micromyrtus ciliatus, Hibbertia aspera,* and *Callitris rhomboidea*.

(5) Fauna

Youpayang has a varied animal population, for although a low forest of brown stringybark covers most of the area it is interspersed with heathlands, swamps, and small areas of gum woodland.

Some of the species commonly seen here are the black-faced kangaroo, ring-tailed possum, echidna, crimson rosella, superb blue wren, white-browed scrub wren, brown thornbill, buff-rumped thornbill, jacky winter, brown tree creeper, white-eared honeyeater, and New Holland honeyeater. Red-tailed black cockatoos are recorded in this block.

C. Capabilities

(1) Flora

A high potential for flora conservation results from the large number of species present, including some uncommon ones.

(2) Fauna

No species of particular significance are known to occur in the block. It does however provide habitat for a wide range of resident, nomadic, and migratory species

A sighting of the barred bandicoot in private property in the northern part near Burke's Bridge has been reported.

(3) Other features

The large circular swamps in the centre of the block are of natural interest. These swamps do not have lunettes.

(4) Recreation

The area is remote from any population centre and has no special features of significance for recreation.

(5) Agriculture

The agricultural capability of the land is generally very low, mostly falling within land categories 4 and 5. Total investment required for development would be high (of the order of $130 per acre) and potential carrying capacity would be well under 2 Sheep Equivalents per acre. The heath and swamps have a higher capability. Although the total area of heath and swamp is quite high, it consists of many small areas distributed in such a way as to make development of farms or paddocks difficult.

(6) Softwood

Potential for softwood production is low - categories C and D. Plantation establishment on the shallow sands may be feasible with site preparation and fertilizers, but the economics of this would be doubtful in this area of low rainfall at considerable distance from a milling centre. The deep sands and the wetlands are unsuitable.

(7) Hardwood

The block has a low hardwood potential, and can produce only small amounts of minor forest produce.

(8) Honey

In contrast, the area has a high potential for apiculture. The diversity of heath and eucalypt species provide pollen for over-wintering as well as favouring spring and summer production. The availability of water in this block increases its capability for honey production.

(9) Minerals

Ironstone gravels and quartz sand are the only minerals known in the area. However it is possible that metallic minerals could occur in the basement, which comprises Palaeozoic sedimentary, igneous, and metamorphic rocks.

(10) Water

Run-off from the block makes a minor

Young red gum

contribution to the flow in the Glenelg River. Underground water supplies are probably poor, but have not been tested by drilling. Some water may be found in the Dorodong Sands, but the main aquifer, the Gambier Limestone, is thin or absent. Groundwater in the underlying Palaeozoic rocks is very salty (4,000 - 5,000 p.p.m. TDS), and is suitable only for stock.

D. Hazards and Conflicts

Clearing of the native vegetation of this block would cause increased discharge from the saline Palaeozoic aquifers, so the streams draining them would become salty. This has occurred on similar areas nearby.

E. Significance

This block has significance for flora and fauna conservation, as it contains diverse habitat and is a large compact area. Its value for conservation would be increased by purchase of the small areas of alienated land within the block.

BOGALARA

A. General

(1) Location

On the northern boundary of the study area between Salt Creek and the Glenelg River. Two large parcels of public land (14,300 acres and 4,800 acres) and one small one - total area 19,500 acres. Parishes of Mageppa, Dergholm, and Bogalara - County Follett.

(2) Present tenure

Reserved forest - 640 acres
Unoccupied Crown land - 18,860 acres.

(3) General description

As for Weecurra block. Several tributaries of Salt Creek flow through the southern part of the block. The public land is in the Kanawinka Land Zone.

(4) Present use

The land is occasionally used for grazing and small quantities of minor forest produce are cut.

B. Nature of the Land

(1) Climate

Average annual rainfall is about 26 in.

(2) Geology and physiography

This land lies on the boundary of the Dergholm Platform and the Wimmera Plains. It is underlain by Pliocene Dorodong Sands and Ordovician granite, which outcrops in several creeks. Thin sheets and small dunes of acid sands cover the block. Diversity in land and vegetation is due to variation in the thickness of these sands and in the underlying material, which may be ferruginous sandstone or clayey sand.

No swamps lie within the public land, but a stream pattern has been established around the perimeter. The watercourses are normally dry and flow only in winter.

(3) Soils

On the eastern part of the block near Powers Creek, the sand sheets are thick

and deep leached sands have developed. Over much of the larger area the sand sheets are thin and duplex soils (sand over clay) have developed.

(4) Vegetation

The main vegetation type is low brown stringybark forest. On deep sands the understorey consists of tea-tree and bracken, but where the sands are thin duckbush is a prominent understorey species. There are also large areas of heath, and substantial areas of red gum, yellow gum, pink gum, and manna gum woodlands on the edges of the block. Interesting understorey species recorded in the block include: slaty sheoak *(Casuarina muelleriana)*, porcupine grass *(Triodia irritans)*, winged spyridium *(Spyridium vexilliferum)*, rock fern *(Cheilanthes tenuifolia)*, necklace fern *(Asplenium flabellifolium)*, daphne heath *(Brachyloma daphnoides)*, and tiger orchid *(Diuris sulphurea)*.

(5) Fauna

No detailed investigation has been made of the animal species present in this particular block, but those most likely to be seen can be ascertained from Appendix II.

The low forest of brown stringybark that is the major vegetation type in the block does not support a very varied or prolific animal population. However, when the trees are in flower these areas

Yellow gum and pink gum woodland

provide a good source of food for nectar and pollen-eating birds such as the lorikeets and the brown-headed, white-eared, and yellow-tufted honeyeaters. The irregular patches of heath scattered through the area, enhance its habitat value.

The fairly extensive gum woodland areas adjoining private property provide good animal habitat. Species found here include the tuan, black-faced kangaroo, ringtail possum, jacky winter, hooded robin, brown tree creeper, restless flycatcher, and white-browed babblers.

Unlike most areas of public land in the study area, the Bogalara block does not contain any swamps, and so it has little value for water-fowl.

C. Capabilities

(1) Flora

The presence of gum woodlands, low forest, heath, and some streams render the block of moderate potential for flora conservation.

(2) Fauna

Apart from its value as a refuge for the resident, migratory, and nomadic species of the district, its most important feature is the presence near Bailey's Rocks of two of the few remaining colonies of wombats in western Victoria.

(3) Other features

Bailey's Rocks is one of the best exposures of the granite basement in this area and is of some geological interest.

(4) Recreation

Bailey's Rocks, a group of large granite tors in the shallow Rocky Creek valley, attracts picnickers and naturalists.

(5) Agriculture

Most of the land is of low potential, categories 4 and 5. The gum woodlands and heaths would be category 2, but they tend to occur in irregular patches or on the margins of the block.

(6) Softwood

Although there are no plantations in the area from which suitability for pines can be judged, the potential of the block is rated as low, mainly category D, due to low rainfall and infertile soils. The land is isolated from any milling centre.

(7) Hardwood

The gum woodlands are capable of producing durable timbers for posts, poles, and sleepers (category E). However, these stands cover very small areas. The potential of the stringybark forests is very low (category F).

(8) Honey

The area has considerable value for honey production, especially in late autumn and early winter. In addition to the gum woodlands and stringybark, the heath flora is of special value.

(9) Minerals

Granite outcrops at several places in the tributaries of Salt Creek and is quarried near Rocky Creek. The granite is unusual in colour - green to greenish pink and smoky blue - and is used as a facing for buildings. Other minerals in

the block are ironstone gravels and granitic quartz sand.

(10) Water

Surface run-off is small. Underground supplies are probably limited to small quantities from the Dorodong Sands, and supplies from the Gambier Limestone, which varies greatly in thickness and extent.

D. Hazards and Conflicts

Clearing the native forest on this block would increase salt levels in Salt Creek and the Glenelg River. Erosion could occur on the banks of the streams draining into Salt Creek, especially Rocky Creek, if recreational use at Bailey's Rocks increased.

E. Significance

Bogalara has significance for recreation at Bailey's Rocks, which are also of scientific interest. The two colonies of wombats may be the last in south-western Victoria. No roads or tracks run through most of the large area of public land.

KANAWINKA

A. General

(1) Location

West of the Dergholm - Apsley Road to the South Australian border. One large parcel of public land (5,700 acres) and one small parcel - total area 6,100 acres. Parishes of Langkoop, Mageppa, and Kanawinka - County Follett.

(2) Present tenure

Unoccupied Crown land - 6,100 acres.

(3) General description

As for Weecurra block. The public land is on the Dergholm Platform and in the Kanawinka Land-Zone.

(4) Present use

It provides rough supplementary grazing. Minor forest produce is cut.

B. Nature of the Land

(1) Climate

Average annual rainfall is approximately 25 in.

(2) Geology and physiography

This block consists of deep sheets of acid white Malanganee Sands overlying the swampy surface of the Dergholm Platform. The Dorodong Sands and the Gambier Limestone underlie the Malanganee Sands at shallow depth. Surface drainage is poor, and there are several swamps around the main area of public land.

(3) Soils

Deep, strongly leached sands are the most common soils in this block, as all areas of shallower sands and clayey soils were alienated for an agricultural settlement scheme in 1956.

(4) Vegetation

The major vegetation type is a low forest of brown stringybark over bracken and heathy plants. Woodlands of pink gum, red gum, and yellow gum occur along the southern and north-western margins of the main block, where the sand layer is thinner and soils are more fertile. Very small patches of heathland, and small swamps, are also scattered through the block.

The small area of public land to the north-east of the main area comprises a large swamp of about 500 acres complete with lunette and surrounded by a strip of gum woodland. It has been held under grazing licence for many years.

(5) Fauna

No detailed investigation has been made of the animal species present in this particular block, but those species most likely to be seen can be ascertained from Appendix II.

The low forest of brown stringybark that is the major vegetation type in the block does not support a very varied or prolific animal population. Better habitat is provided by the gum woodland areas, especially when they are in flower, but they are very limited in extent. The swamps when full are used by water birds.

C. Capabilities

(1) Flora

The block contains typical examples of low brown stringybark forest, but apart from this, has no special features of botanical interest.

(2) Fauna

It is unlikely that any species of special significance occur in the area, although its value as a refuge for migratory and nomadic species will undoubtedly increase as surrounding private property is cleared.

A rosetting mallee form of pink gum in Kanawinka

(3) Other features

The swamp and lunette referred to above are good examples of these geomorphological features.

(4) Recreation

The area has little potential for recreation.

(5) Agriculture

The land has a very low potential for agriculture and is in category 5, with a carrying capacity of less than 2 Sheep Equivalents per acre.

(6) Softwood

Kanawinka has a low potential for softwood production, and is category D.

(7) Hardwood

The gum woodlands can produce a little timber, but the hardwood potential is low generally.

(8) Honey

The area has some value for honey production in the autumn.

(9) Minerals

Quartz sand is the only mineral resource known in the block.

(10) Water

The land does not contribute to surface supplies, but underground water of variable quality and quantity is present. Availability improves to the west and south-west.

D. Hazards and Conflicts

An economic hazard would probably attend any attempt to develop this block for agriculture or softwood forestry.

E. Significance

The block is significant as a relatively undisturbed example of brown stringybark forest, with some swamps and a small area of pink gum. The isolated area of public land is a good example of a swamp with lunette.

APPENDIX I

LIST OF COMMON PLANTS

This list includes only the most common plant species found in the study area and indicates the formations or habitats in which they are most likely to be seen.

OF = open forest I and open forest II
WL = woodland
CC = coastal complex
H - heath
S = swamp
W = water courses

	OF	WL	CC	H	S	W
Acacia mearnsii	X					
melanoxylon	X					X
mitchellii				X		
myrtifolia	X					
oxycedrus				X		
sophorae	X		X			
suaveolens	X	X				
verniciflua	X					
Acaena ovsterinifolia		X	X		X	
echinata		X				
Acianthus reniformis	X					
Acrotriche serrulata	X					
Adiantum aethiopicum						X
Agrostis avenacea		X				
Ajuga australis		X				
Alyxia buxifolia			X			
Amperea xiphoclada	X			X		
Amphibromus archeri		X				
neesii		X			X	
Aphelia gracilis		X		X	X	

	OF	WL	CC	H	S	W
Arthropodium minus		X				
Astroloma conostephioides	X			X		
humifusum	X					
Azolla filiculoides					X	
Banksia marginata	X			X		
ornata	X					
Baumea acuta		X				
articulata					X	
juncea					X	
rubiginosa					X	
Blechnum minus						X
nudum						X
procerum						X
Boronia nana	X					
parviflora				X		
pilosa	X			X		
Bossiaea cinerea	X					
prostrata		X		X		
Brachycome parvula	X					
readeri		X				

	OF	WL	CC	H	S	W
Brachyloma ciliatum	X					
Brunonia australis	X					
Burchardia umbellata	X			X		
Bursaria spinosa	X					X
Calorophus lateriflorus				X		
Calytrix alpestris	X			X		
tetragona	X			X		
Carex tereticaulis		X				
Cassytha glabella	X			X		
pubescens	X					
Casuarina paludosa	X			X		
stricta			X			
Caustis pentandra	X			X		
Centrolepis aristata	X	X		X		
strigosa	X	X		X	X	
Chamaescilla corymbosa				X		
Chorizandra cymbaria					X	
enodis					X	
Clematis microphylla	X		X			
Comesperma claymega	X					
volubile	X					
Conospermum mitchellii	X					
patens	X					
Correa alba			X			
reflexa	X					X
Craspedia glauca		X				
Crassula helmsii						X
Cyperus tenellus	X	X		X	X	
Danthonia geniculata	X	X				
pilosa	X					
procera		X				
setacea	X	X		X		

	OF	WL	CC	H	S	W
Daviesia latifolia	X					
Daucus glochidiatus	X					
Deyeuxia quadriseta	X					
Dianella revoluta	X					
Dichelachne crinita	X					
Dichondra repens	X				X	X
Dillwynia glaberrima	X			X		
sericea	X			X		
Distichlis distichophylla			X			
Dodonaea viscosa			X			
Drosera peltata	X	X		X		
pygmaea	X	X		X		
Echinopogon ovatus						X
Eleocharis acuta					X	
atricha		X				
sphacelata					X	
Epacris impressa	X			X		X
obtusifolia						X
Epilobium cinereum		X			X	
Eucalyptus aromaphloia	X					
baxteri	X					
camaldulensis		X				
leucoxylon		X				
nitida	X			X		
obliqua	X					
ovata	X					
viminalis	X	X				
Euphrasia collina				X		
Exocarpus cupressiformis	X					
strictus			X			
Festuca littoralis			X			
Gahnia clarkei		X				

	OF	WL	CC	H	S	W
Gahnia filum			X			
radula	X			X		
Geranium pisolum	X					
Gleichenia microphylla						X
Glyceria australis						X
Gnaphalium involucratum	X			X		
japonicum	X					
Goodenia blackii	X	X		X		
geniculata	X			X		
humilis		X		X	X	
Goodia lotifolia	X		X			
Gymnoschoenus sphaerocephalus				X		
Hakea nodosa				X		
rostrata	X	X		X		
Haloragis tetragyna	X			X		
teucrioides						X
Helichrysum apiculatum	X	X				
blandowskianum	X			X		
dendroideum						
obtusifolium	X		X	X		
scorpioides	X					
Helipterum australe				X		
Hibbertia australis	X			X		
fasciculata	X			X		
sericea	X			X		
stricta	X			X		
Hydrocotyle hirta						X
laxiflora	X	X				
muscosa					X	
sibthorpioides		X				

	OF	WL	CC	H	S	W
Hypericum gramineum		X				
Hypolaena fastigiata	X			X		
Indigofera australis	X					
Isoetes drummondii		X		X	X	
Isopogon ceratophyllus	X			X		
Ixodia achilloides	X					
Juncus bufonius	X	X		X	X	
holoschoenus		X			X	
maritimus			X			
planifolius	X	X		X		
Kennedia prostrata	X					
Lagenophora stipitata		X				
Laxmannia sessiliflora	X			X		
Lepidobolus drapetocoleus	X			X		
Lepidosperma carphoides	X			X		
congestum	X	X		X	X	X
gladiolatum	X					
longitudinale					X	
neesii				X		
semiteres	X			X		
Leptocarpus brownii					X	
tenax	X			X	X	X
Leptorhynchos tenuifolius				X		
Leptospermum juniperinum	X			X		
lanigerum			X	X	X	X
myrsinoides	X			X		
Lepyrodia meulleri	X	X		X	X	
tasmanica				X		
Leucopogon ericoides	X			X		
glacialis	X			X		
parviflorus	X		X			
virgatus	X			X		

	OF	WL	CC	H	S	W
Lilaeopsis polyantha				X		
Lindsaya linearis				X		X
Lomandra longifolia	X			X		
Lomatia ilicifolia	X			X		
Lotus australis			X			
Luzula campestris	X					
Lyperanthus nigricans	X					
Lythrum hyssopifolia		X			X	
Melaleuca decussata				X		
gibbosa				X		
pubescens			X			
squamea				X		
squarrosa			X	X	X	X
Microseris scapigera	X					
Microtis atrata		X			X	
Mitrasacme distylis	X	X		X		
pilosa				X		
Monotoca scoparia	X			X		
Montia australasica					X	X
Muehlenbeckia adpressa			X			
Myosotis australis	X					
Myriocephalus rhizocephalus	X	X				
Myriophyllum integrifolium		X		X	X	
peduncolatum					X	
propinquum					X	
Nertera reptans	X					X
Olearia axillaris			X			
ramulosa			X			
Opercularia ovata						X
Patersonia fragilis				X		

	OF	WL	CC	H	S	W
Patersonia longiscapa				X		
Pelargonium australe			X			
Pentapogon quadrifidus	X	X				
Persoonia juniperinum	X			X		
Phragmites communis					X	X
Pimelia humilis	X					
hewardiana			X			
Plantago debilis						X
Platylobium obtusangulum	X			X		
Platysace heterophylla				X		
Poa labillardieri						X
morrisii	X					
sieberana	X					
tenera						X
Polystichum proliferum						X
Pomaderris aspera						X
Pomaderris elachophylla						X
Poranthera microphylla	X					
Potamogeton tricarinatus					X	
Pratia pedunculata	X				X	X
Pteridium esculentum	X					X
Pterostylis nutans						X
Ptilotus spathulatus	X					
Pultenaea laxiflora	X					
prolifera				X		
stricta				X		
Rhagodia baccata			X			
Ranunculus inundatus					X	
robertsonii	X					
Restio complanatus				X		
Rubus parviflorus						X

	OF	WL	CC	H	S	W
Rutidosis multiflora	X	X				
Salicornia quinqueflora			X			
Samolus repens			X			
Scaevola pallida			X			
Schoenus apogon	X	X		X		
breviculmis	X			X		
fluitans				X	X	
nitens					X	
tenuissimus				X		
tesquorum		X			X	X
Scirpus fluitans		X			X	
nodosus	X		X			
productus		X			X	
stellatus				X		
Sebaea ovata	X					
Sellaginella gracillima	X	X		X	X	
Selliera radicans			X			
Senecio lautus	X		X			
Solanum laciniatum	X					
Spinifex hirsutus			X			
Sprengelia incarnata				X		
Spyridium parvifolium	X					
Stellaria pungens	X					X
Stipa muelleri				X		
Stylidium beaugleholei				X		
calcaratum		X				
graminifolium	X			X		
inundatum	X	X		X	X	
perpusillum	X			X		
Stypandra caespitosa				X		
glauca				X		
Styphelia adscendens	X					

	OF	WL	CC	H	S	W
Suaeda maritima			X			
Swainsona lessertiifolia			X			
Tetragonia implexicoma			X			
Tetraria capillaris				X		
Tetratheca ciliata	X					
Themeda australis	X	X				
Thysanotus patersonii	X					
Triglochin centrocarpa					X	
procera					X	
Trithuria submersa		X		X		
Utricularia dichotoma		X		X	X	
lateriflora				X		
violacea					X	
Villarsia reniformis		X			X	
Viminaria juncea				X		
Viola hederacea	X			X		X
sieberana	X			X		
Wahlenbergia gracilenta	X			X		
quadrifida	X					
stricta	X					
Xanthorrhoea australis	X			X		
minor	X			X		
Zoisia macrantha					X	

APPENDIX II

ANIMALS OF THE STUDY AREA

This appendix contains a list of native birds and mammals recorded in the area, with an indication of the habitats in which they are most likely to be observed and their status. Species recorded in the area only as accidental, vagrant, or beach-washed specimens have not been included in the list, as land use changes in the study area will have no significant effect on the populations of these species. A list of reptiles known to occur in the area is included.

Species that have special significance in this area and that are referred to in Chapter 11 are indicated with an asterisk (*). Horizontal lines are used to separate families.

HABITAT

1. Ocean
2. Coastline (beaches, headlands, reefs, estuaries, salt marsh)
3. Wetland (swamp communities, sedgeland, rivers, dams)
4. Sand Dune Complex (dunes, scrub, heath)
5. Heath
6. Woodland (red gum, yellow gum)
7. Open forest I (drier forest areas, including stringybark forest with low understorey)
8. Open forest II (wetter forest areas, including messmate, peppermint, gum forests with layered understorey and moist fern gullies)
9. Semi-cleared areas (including road-side strip, windbreaks)
10. Grassland (natural grassland, pasture, crops)
11. Air

STATUS

The codes given below denote status or manner of occurrence, on a relative basis, with reference to available habitat within the study area. The estimates are based on general experience rather than actual counts. The situation is changing constantly.

The first letter in the code indicates distribution of suitable habitat:

W = habitat widespread in the study area
R = habitat restricted to relatively few parts of the study area

The second letter in the code indicates population density within areas of suitable habitat:

C = commonly observed
U = uncommonly observed
R = rarely observed
N = nomadic, number observed varying greatly from time to time
SD = survival in the study area doubtful

Additional letters may be used to indicate:

S = migratory species observed in the study area during summer
W = migratory species observed in the study area during winter
H = commonly uses hollows in trees as nest sites

BIRDS

	1	2	3	4	5	6	7	8	9	10	11	Status
Emu					X	X	X		X			WC
*Little penguin	X											RC
Wandering albatross	X											RU
Black-browed albatross	X											RC
White-capped albatross	X											RR
Giant petrel	X											RC
Cape petrel	X											RR
Great-winged petrel	X											RR
White-headed petrel	X											RR
*Fairy prion	X											RU
Short-tailed shearwater	X											RC,S
Fluttering shearwater	X											RU
White-faced storm-petrel	X											RU
Diving petrel	X											RR
Australian pelican		X	X									WC
*Australian gannet	X											RC
Darter			X									WR
Black cormorant		X	X									WC
Little black cormorant		X	X									WC
Pied cormorant		X	X									WC
Little pied cormorant		X	X									WC
Black-faced cormorant		X										RC
Little grebe			X									WC
Hoary-headed grebe		X	X									WU
Great crested grebe		X	X									WR
White-necked heron			X									WC
White-faced heron		X	X									WC
Cattle egret			X							X		WR
White egret		X	X									WU
Little egret		X	X									WR
Plumed egret			X									WC
Nankeen night heron			X									RU
Little bittern			X									RR
Brown bittern			X									RU
White ibis			X									WC
Straw-necked ibis			X									WC
Glossy ibis			X									RN
Royal spoonbill		X	X									WU
Yellow-billed spoonbill		X	X									WC
Black swan		X	X									WC
*Freckled duck			X									RR
Cape barren goose			X									RR
*Mountain duck		X	X									WC,H
Black duck		X	X									WC,H
*Grey teal		X	X									WC
*Chestnut teal		X	X									RC,H
*Blue-winged shoveler		X	X									WU
Pink-eared duck			X									WR
White-eyed duck			X									WU
Wood duck			X									WC,H
*Blue-billed duck			X									RU
Musk duck			X									RU

	1	2	3	4	5	6	7	8	9	10	11	Status
Black-shouldered kite									X	X		WN
Letter-winged kite										X		WR
Fork-tailed kite									X	X		WN
Whistling eagle				X		X	X		X			WC
Grey goshawk							X	X				RR
Australia goshawk							X	X				WC
Collared sparrowhawk							X	X				WU
Aust. little eagle						X			X			WR
Wedge-tailed eagle						X	X	X	X		X	WC
White-breasted sea eagle		X										RR
Spotted harrier			X						X	X		WR
Swamp harrier			X							X		WC
Black falcon										X		WR
Peregrine falcon						X	X	X	X			WU
Little falcon						X	X	X	X			WU
Nankeen kestrel									X	X		WC
Brown hawk				X	X	X			X	X		WC
Stubble quail										X		WC
Brown quail			X		X							WU
*King quail			X	X	X							RR
Painted quail						X	X		X			WR
Little quail										X		WN
Plain wanderer										X		SD
Brolga			X							X		WU
Lewin water rail			X									WR
Banded landrail			X									WR
Marsh crake			X									WU
Aust. spotted crake			X									WU
Spotless crake			X									WR
Black-tailed native hen			X									WN
Dusky moorhen			X									WC
Swamphen			X									WC
Coot			X									WC
Australian painted snipe		X										RR,S
Pied oystercatcher		X										RU
Sooty oystercatcher		X										RU
Spur-winged plover		X	X						X			WC
Banded plover			X						X			WU
Hooded dotterel		X										RC
Red-capped dotterel		X	X									WC
Double-banded dotterel		X										RU,W
*Large sand-dotterel		X										RR,S
Black-fronted dotterel			X									WC
Eastern golden plover		X										RU,S
*Grey plover		X										RR,S
Japanese snipe			X									WU,S
*Whimbrel		X										RR,S
Eastern curlew		X										RU,S
Greenshank		X	X									RU,S
*Common sandpiper		X										RR,S
Sharp-tailed sandpiper		X	X									WC,S
Red-necked stint		X	X									RC,S
Curlew sandpiper		X	X									RU,S
*Sanderling		X										RR,S
Bar-tailed godwit		X										RU,S

	1	2	3	4	5	6	7	8	9	10	11	Status
White-headed stilt		X	X									WC
Banded stilt		X	X									RU
Avocet		X	X									RU
Southern stone curlew						X	X		X			WU
Southern skua	X											RR,W
Arctic skua	X											RU,S
Pacific gull		X										RC
Southern black-backed gull		X										RR
Silver gull		X	X							X		WC
Whiskered tern			X									WU,S
Caspian tern		X										RU
Gull-billed tern			X									WR
White-fronted tern		X										RR
Fairy tern		X										RC
Crested tern		X										RC
Peaceful dove						X			X			WU
Common bronzewing						X	X	X	X			WC
Brush bronzewing				X	X	X			X			WC
Rainbow lorikeet					X	X	X	X	X			WN,H
Musk lorikeet						X	X	X	X			WN,H
Purple-crowned lorikeet						X	X	X	X			WN,H
Little lorikeet						X	X	X	X			WN,H
Swift parrot						X	X	X	X			WN,H
Yellow-tailed black cockatoo					X	X	X	X	X			WC,H
*Red-tailed black cockatoo						X	X	X	X			RU,H
Gang-gang cockatoo						X	X	X	X			WC,H
Sulphur-crested cockatoo						X	X		X	X		WC,H
*Long-billed corella						X			X	X		WC,H
Galah						X			X	X		WC,H
Crimson rosella						X	X	X	X			WC,H
Eastern rosella						X			X			WC,H
Red-rumped parrot									X	X		WC,H
*Elegant parrot									X	X		WR,H
*Blue-winged parrot									X	X		WU,H
*Orange-bellied parrot				X								RR,H
Budgerygah									X	X		WN,H
*Ground parrot				X								RR
Pallid cuckoo						X			X	X		WC,S
Fan-tailed cuckoo						X	X	X	X			WC
Black-eared cuckoo						X			X			WR
Horsfield bronze cuckoo					X	X			X			WC,S
Golden bronze cuckoo							X	X				WR,S
Powerful owl							X	X				WR,H
Barking owl						X	X	X	X			WR,H
Boobook owl						X	X	X	X			WU,H
Barn owl						X	X	X	X	X		WU,H
Masked owl							X	X				RR,H
Tawny frogmouth						X	X	X	X			WC
Owlet-nightjar						X			X			WU,H
Spine-tailed swift											X	WC,S
Fork-tailed swift											X	WU,S
Azure kingfisher				X								RU
Laughing kookaburra						X	X	X	X			WC,H
Sacred kingfisher				X		X	X	X	X			WC,H
Rainbow bee-eater					X	X			X			WN,S

	1	2	3	4	5	6	7	8	9	10	11	Status
Singing bushlark										X		WR,S
Welcome swallow											X	WC
Tree-martin						X			X		X	WC,SH
Fairy martin											X	RC,S
Australian pipit				X	X					X		WC
Black-faced cuckoo-shrike						X	X		X			WC
Little cuckoo-shrike						X	X		X			WR
White-winged triller						X	X		X			WN,S
Aust. ground-thrush				X				X				RU
Spotted quail-thrush							X	X				RU
White-browed babbler					X			X	X			WR
Golden-headed fantail-warbler		X										WC
Little grassbird		X										WC
Reed-warbler		X										WC,S
Brown songlark										X		WU,S
Rufous songlark						X			X			WR,S
Superb blue wren				X	X	X	X	X	X			WC
*Southern emu-wren				X	X							RC
Weebill						X			X			WR
Striated thornbill						X	X	X	X			WC
Little thornbill						X			X			WR
Brown thornbill				X	X	X	X	X	X			WC
Buff-rumped thornbill						X	X		X			WC
Yellow-rumped thornbill						X			X	X		WC
White-browed scrub-wren				X	X	X	X	X	X			WC
*Heath wren				X	X							RR
Field-wren				X	X							RR
Whiteface									X	X		WR
*Rufous bristle-bird				X								RC
White fronted chat		X		X								WU
Jacky winter						X			X			WC
Scarlet robin						X	X	X	X			WU
Flame robin										X		WC,W
*Pink robin						X	X	X	X			WR
*Rose robin								X				RR
Hooded robin					X	X			X			WU
Southern yellow robin				X	X	X	X	X	X			WC
Grey fantail				X	X	X	X	X	X			WC
*Rufous fantail								X				RU,S
Willie wagtail						X			X	X		WC
*Leaden flycatcher				X			X	X				WR,S
*Satin flycatcher							X	X				WU,S
Restless flycatcher						X			X			WU
Golden whistler						X	X	X	X			WC
Rufous whistler						X	X	X	X			WC
*Olive whistler				X				X				RR
Grey shrike-thrush				X	X	X	X	X	X			WC
Shrike-tit							X	X	X			WU
Black-capped sittella						X	X	X	X			WU
Brown tree-creeper						X			X			WC,H
White-throated tree-creeper							X	X	X			WC,H
Mistletoe bird						X	X	X	X			WU
Spotted pardalote							X	X	X			WC
Yellow-tipped pardalote						X			X			WR
Eastern striated pardalote						X			X			WC

	1	2	3	4	5	6	7	8	9	10	11	Status
Grey-breasted silvereye				X	X	X			X			WC
*Singing honeyeater				X	X							RC
Yellow-faced honeyeater				X		X	X	X	X			WC,S
White-plumed honeyeater						X			X			WC
White-eared honeyeater				X	X	X	X	X	X			WC
Yellow-tufted honeyeater						X			X			WU
Brown-headed honeyeater				X	X	X	X	X	X			WC
White-naped honeyeater					X	X	X	X	X			WC
Black-chinned honeyeater						X						WR
Crescent honeyeater				X	X			X				RU
New Holland honeyeater				X	X	X	X	X	X			WC
Tawny-crowned honeyeater				X	X							RU
Regent honeyeater						X			X			WN
Eastern spinebill					X	X	X	X	X			WC
Noisy miner						X			X			RU
Spiny-cheeked honeyeater				X	X	X						RC
Little wattle-bird				X	X							RC
Red wattle-bird				X	X	X	X	X	X			WC
*Beautiful firetail				X								RR
Diamond firetail						X			X			WR
Red-browed finch				X	X	X	X	X	X			WC
*Olive-backed oriole						X	X	X	X			WU,S
Magpie lark			X			X			X	X		WC
White-winged chough						X	X		X			WC
Masked wood-swallow						X			X			WN,S
White-browed wood-swallow						X			X			WN,S
Dusky wood-swallow					X	X			X			WC
Pied currawong							X	X	X			WC
Grey currawong							X	X	X			WC
Grey butcher-bird				X	X	X			X			RR
White-backed magpie									X	X		WC
Australian raven		X		X	X	X	X	X	X	X		WC
Little raven				X		X			X	X		WC

MAMMALS

	1	2	3	4	5	6	7	8	9	10	11	Status
Echidna				X	X	X	X	X	X			WC
Platypus			X									RC
*Tiger cat							X	X				WR
Quoll												SD
Tuan						X	X		X			WR,H
Yellow-footed phascogale						X	X		X			WC,H
*Brown phascogale						X	X	X	X			WC,H
*Dusky phascogale				X	X		X	X	X			RC
*Swamp phascogale				X	X							RR
Common dunnart							X		X			WR
*White-footed dunnart				X	X		X		X			WR
Fat-tailed dunnart						X				X		WC
Short-nosed bandicoot				X	X		X	X	X			WC
*Barred bandicoot						X				X		RR
Brush-tailed possum						X	X	X	X			WC,H
Ringtail possum			X	X	X	X	X	X	X			WC,H
Sugar glider						X	X	X	X			WC,H
*Yellow-bellied glider							X	X				RC,H
Feathertail glider						X	X	X	X			WU,H
Eastern pigmy possum							X	X	X			WU,H
Koala						X	X	X	X			WU
Wombat							X	X				WR
*Eastern grey kangaroo					X	X	X	X	X	X		WC
*Black-faced kangaroo					X	X			X	X		WC
*Red-necked wallaby				X	X		X	X	X	X		WC
*Potoroo				X	X		X	X				RU
Bush rat				X	X		X	X	X			WC
Swamp rat			X	X	X		X	X	X			WC
Eastern water-rat			X									RC
*Heath rat					X							RR
Greater long-eared bat												R,H
Lesser long-eared bat						X	X	X	X			C,H caves
*Bent-winged bat						X	X	X	X			C, "
Little brown bat						X	X	X	X			C,H "
Goulds wattled bat						X	X	X	X			C,H "
Large-footed myotis												R, "
Australian fur seal	X	X										RU

REPTILES

Scientific name	Common name	Distribution		Biological Characteristics	Habitat
		warm temperate	cool temperate		
Chelodina longicollis	Long-necked tortoise	+		TO	Lakes and rivers
Amphibolurus barbatus	Bearded dragon	+		HO	)Open and forested areas on
" *muricatus*	Tree dragon	+		HO	)tree stumps and fence posts
Tympanocryptis lineata	Earless dragon	+		HO	
Phyllodactylus marmoratus	Marbled gekko	+		TO	
Aprasia striolata	Worm lizard	+		TO	Burrowing, subterranean
Anotis maccoyi	Yellow-bellied skink		+	TO	Litter layer of wet forest areas
Hemiergis peronii	Four-toed skink	+		TV	
Leiolopisma delicata		+	+	TO	Heath, woodland, forest clearings
" *entrecasteauxi*	Grass skink		+	HV	
" *guichenoti*	Garden skink	+	+	HO	Heath, woodland, forest clearings
" *trilineatum*	Three-lined skink	+	+	HO	Heath, woodland, forest clearings
Sphenomorphus tympanum	Southern water skink	+	+	HV	Water courses
Egernia luctuosa	Mourning skink	+		HV	Swampy areas
" *whitei*	White's skink	+	+	HV	Forested areas under logs and rocks
Tiliqua nigrolutea	Southern blue-tongue		+	HV	
" *rugosa*	Stumpy tail	+		HV	
" *scincoides*	Common blue-tongue	+		HV	
Demansia textilis	Brown snake	+		HO	Generally hilly drier areas
Denisonia coronoides	White-lip snake		+	HV	Under rotting logs
" *flagellum*	Little-whip snake	+		TV	Rocky areas, particularly basalt
" *masteresi*		+		HV	
" *superba*	Copperhead snake		+	HV	Generally wetter areas
Notechis scutatus	Tiger snake	+	+	HV	Favours swampy areas

T = Thigmotherm (non-basking reptiles): maintain body temperature during activity by selecting suitable temperatures in shaded situations
H = Heliotherm (basking reptiles): use solar radiation to maintain body temperature during activity

O = Oviparous: young hatch from egg
V = Viviparous: young born alive

Warm temperate = average annual rainfall generally below 30 in.
Cool temperate = average annual rainfall generally above 30 in.

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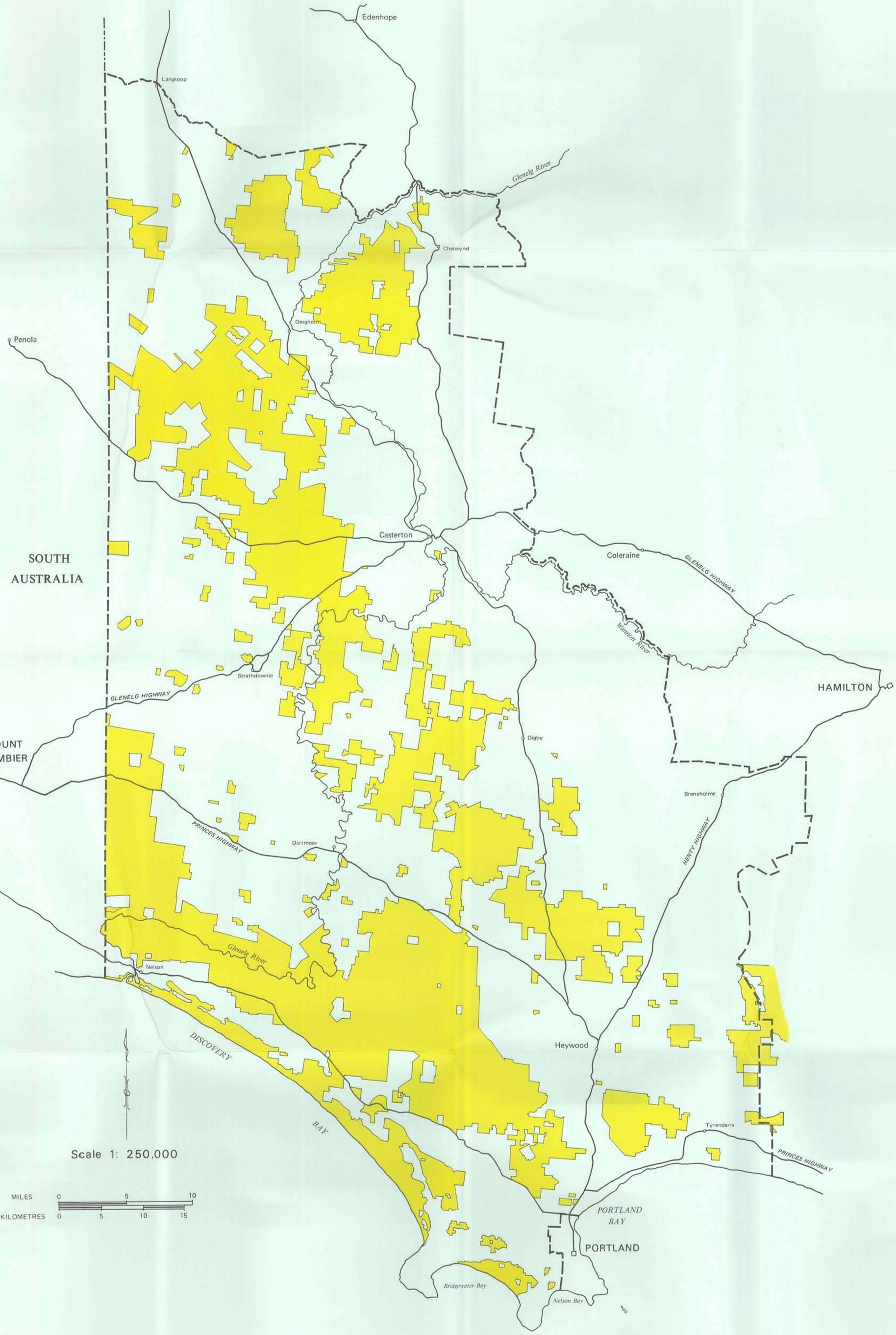
SOUTH WESTERN STUDY AREA

PUBLIC LAND



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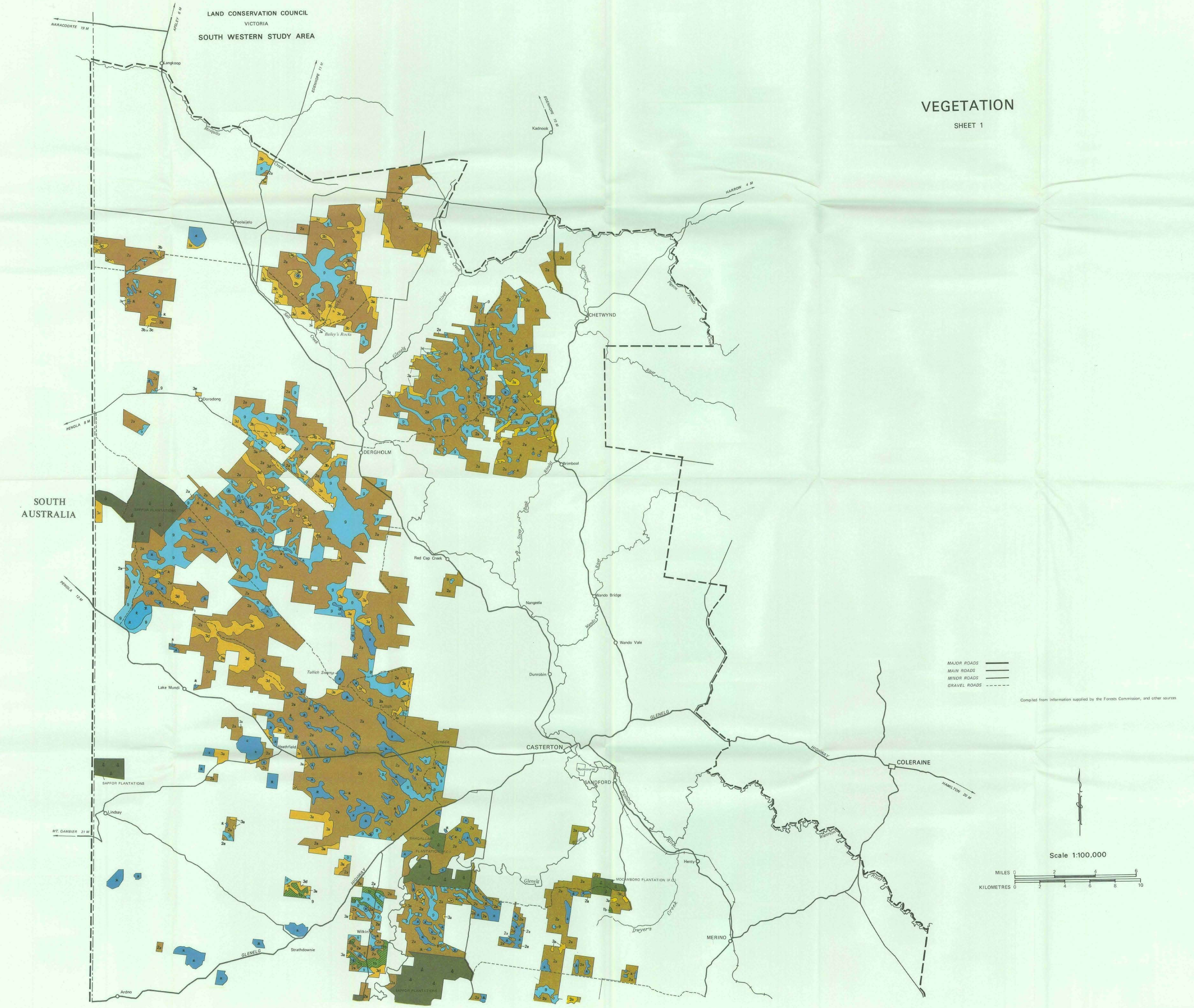

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VICTORIA
SOUTH WESTERN STUDY AREA
VEGETATION
SHEET 1
SOUTH AUSTRALIA
CHETWYND
DERGHOLM
CASTERTON
SANDFORD
COLERAINE
MERINO
SAFFOR PLANTATIONS
MOCAMBORO PLANTATION (F.C.)
MAJOR ROADS
MAIN ROADS
MINOR ROADS
GRAVEL ROADS
Compiled from information supplied by the Forests Commission, and other sources
Scale 1:100,000
MILES
KILOMETRES

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SOUTH WESTERN STUDY AREA

VEGETATION

SHEET 2

SOUTH AUSTRALIA

FORMATION		FLORISTIC UNIT	UNDERSTOREY VEGETATION
1 OPEN–FOREST II (>60 ft. height)	1a	Messmate	Bracken and grasses, scattered shrubs; heathy plants
	1b	Brown Stringybark	Bracken, Yacca; heathy plants
	1c	Manna Gum	Bracken and grasses, scattered wattles
	1d	Peppermint	heathy plants and low wattles; bracken and grasses
	1e	Swamp Gum	tea tree, sedges, Sword Grass; wattles, grasses
	1f	Messmate-Brown Stringybark	as for the corresponding species above
	1g	Messmate-Peppermint-Swamp Gum	
	1h	Manna Gum-Peppermint-Swamp Gum	
	1i	Swamp Gum-Peppermint	
2 OPEN–FOREST I (30–60 ft. height)	2a	Brown Stringybark	Bracken, Yacca, Grasstrees, low hardleaved shrubs, heathy plants
	2b	Brown Stringybark-Manna Gum	Bracken, low shrubs, grasses
	2c	Swamp Gum-Peppermint	Sword Grass, low tea tree, low shrubs
3 WOODLAND	3a	Red Gum	grasses, herbs and low sedges
	3b	Yellow Gum	grasses and low shrubs
	3c	Pink Gum	open heathy plants
	3d	Manna Gum	Bracken, grasses, low shrubs
	3e	Red Gum-Yellow Gum	as for the corresponding species above
4 WET SCRUB		Brown Stringybark-Peppermint	Yacca, heathy plants
5 DRY SCRUB		Brown Stringybark-Messmate	dense heathy plants
6 LIMESTONE DUNE COMPLEX (Bulley Ranges)	Low Open-forest	Brown Stringybark and Manna Gum	Bracken, shrubs, grasses
	Dry Scrub	Coast Beard-heath and Coast Wattle	
	Dry Heath	Yacca and Grasstrees	scattered low shrubs
7 SAND DUNE COMPLEX (Coastal)	Dry Scrub	Coast Wattle, Coast Beard-heath, Daisy Bush	grasses, succulent plants, some emergent Moonah, Drooping She-oak
	Grassland	Wallaby Grass, other grasses and sedges	
8 COASTAL SWAMP COMPLEX (Long Swamp)	Open water	Bulrush, Common Reed	
	Sedgeland	Numerous species of sedges and grasses	
	Wet Scrub	Woolly Tea Tree and Scented Paperbark	
9 HEATH		Many species including Dwarf Sheoak, Silver Banksia, Yacca, Common Heath, Sedges, Button Grass	Includes formations with sparse emergent trees or shrubs
SWAMP COMMUNITIES	Sedgelands	Rushes, sedges and grasses	
11 GRASSLAND		Includes farm land purchased for pine planting, the Palpara Settlement Scheme, some land under grazing licence, some grassland of native species, and fernland	
PINE PLANTATIONS		Predominantly Pinus radiata, with some P. pinaster and some land cleared but not yet planted	

MAJOR ROADS

MAIN ROADS

MINOR ROADS

GRAVEL ROADS

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MILES 0 2 4 6

KILOMETRES 0 2 4 6 8 10