SOUTH-WESTERN AREA, DISTRICT 1—REVIEW

Land Conservation Council Victoria

Price $4.00

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GOVERNMENT OF VICTORIA

LAND CONSERVATION COUNCIL

464 ST. KILDA ROAD, MELBOURNE, VICTORIA, 3004

REPORT

SOUTH-WESTERN AREA, DISTRICT 1 - REVIEW

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

All such submissions must reach the Secretary no later than Monday 30 November 1981.

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

I. KUNARATNAM
Secretary
Land Conservation Council

REPORT
on the
SOUTH-WESTERN AREA, DISTRICT 1 - REVIEW

39855/81—1

Land Conservation Council, Victoria
Melbourne: September, 1981

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MAPS

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 provide information for the review of the use of public land in the South-western Area, District 1. It briefly describes and assesses the physical nature and resources of the land and the alternative forms of land use.

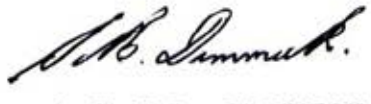
The report provides a factual basis on which members of the community may base their submissions to the Council and ensures that all those persons and bodies who have an interest in the future use of public land in this area can obtain and study the basic information, which the Council itself will study.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

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

The Council will make its recommendations only after due consideration of those submissions.

Demands for land for various purposes are many and varied; some of them 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 *Victoria Government Gazette*.



Land Conservation Council
464 St. Kilda Road
MELBOURNE 3004

S.G.McL. DIMMICK
Chairman

LAND CONSERVATION ACT 1970

EXTRACT

Public Land

Section 2.

(1) "Public land" means -

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

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

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

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

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

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

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

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

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

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

Functions of the Council

Section 5.

(1) The Council shall -

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

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

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

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

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

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

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

(d) the creation and preservation of areas for national parks;

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

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

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

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

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

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

Investigations, notices and reports

Section 9.

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

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

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

(a) publish a report of the investigation;

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

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

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

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

Section 10.

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

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

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

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

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

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

Government departments and authorities to give effect to recommendations

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

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

Section 11.

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

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

ACKNOWLEDGMENTS

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

The following bodies supplied information for maps and chapters: the Departments of Agriculture, Crown Lands and Survey, and Minerals and Energy; the Fisheries and Wildlife Division; the Forests Commission; the National Museum; the National Parks Service; the Soil Conservation Authority; and the State Rivers and Water Supply Commission. Several of these bodies supplied photographs.

Many others also readily gave information, checked drafts, or contributed valuable discussion and advice. They include other Victorian and Australian government bodies, local government agencies, universities, representatives of various industries, apiarists, members of fauna and flora study groups, outdoor recreation and sporting organizations, many individuals with expert knowledge in fields such as geomorphology, botany, zoology, and those with special knowledge of particular localities. Their assistance is gratefully acknowledged.

PART I
INTRODUCTION

1. INTRODUCTION

The Land Conservation Council first investigated the South-western Area, District 1, in 1971/72, and published final recommendations on the use of public land in April 1973.

These recommendations have been accepted by the government and have been or are being implemented. They allocated sufficient public land to meet a proportion of the requirement for State and private softwood plantations until 1981, and recommended that the balance be obtained from purchased freehold land. Council also indicated that it would review the need to provide additional land for softwood production after 1981 and this report is the first stage of that review.

In its original report Council recommended substantial areas as 'land with no primary use', which includes both multi-purpose areas and uncommitted land. It recommended that the multi-purpose areas be used for a number of low-intensity compatible uses - such as outdoor recreation, hardwood production, apiculture, gravel extraction, and grazing - without having a predominant use. It recommended that the uncommitted land be managed to protect the natural ecosystems, in order to keep options for future use open, and to produce those goods and services required by the community that can be supplied without seriously reducing the ability of the land to meet future needs. Council indicated that, as community needs changed and more information on resources became available, it would be necessary to review the use of both these types of land.

While its major impetus comes from the need to investigate whether further public land should be made available for softwood plantations, this review will cover all public land in the study area. However, emphasis will be placed on the resources and potential uses of the land categorized as 'land with no primary use'. For the purposes of this report all such land will be referred to as 'uncommitted land', in the sense that it is not committed to any one primary use, although substantial portions are reserved forest under the *Forest Act* 1958.

Aims and Methods

This report briefly describes the physical and biological characteristics of the land, examines alternative forms of land use, and assesses the hazards and conflicts associated with such uses. To give a proper perspective, the report considers the general regional characteristics of freehold and committed public lands, as well as the specific nature of the uncommitted public land.

It draws heavily on information contained in the original 'Report on the South-western Study Area - District 1', published in 1972. Where necessary, information has been updated, and additional material that was not then available has been incorporated. For a more comprehensive description of the study area, however, readers are referred to the original report, copies of which are held in many libraries and by many government departments. A copy is also available for inspection at the offices of the Land Conservation Council.

The present report is the first stage in the decision-making process for the future use of public land in the study area. It does not contain recommendations - rather, it presents factual information on which land use decisions can be made.

It is divided into four main parts: Part I is an introduction, Part II describes the physical and biological nature of the land, Part III deals with the major forms of land use, and Part IV provides more detailed information. In Part IV the study area has been divided for convenience into seven descriptive blocks, and a consistent format of headings is used so that the reader can readily find specific information for any block and compare one with another. Explanatory tables, maps, and a number of appendices complete the report.

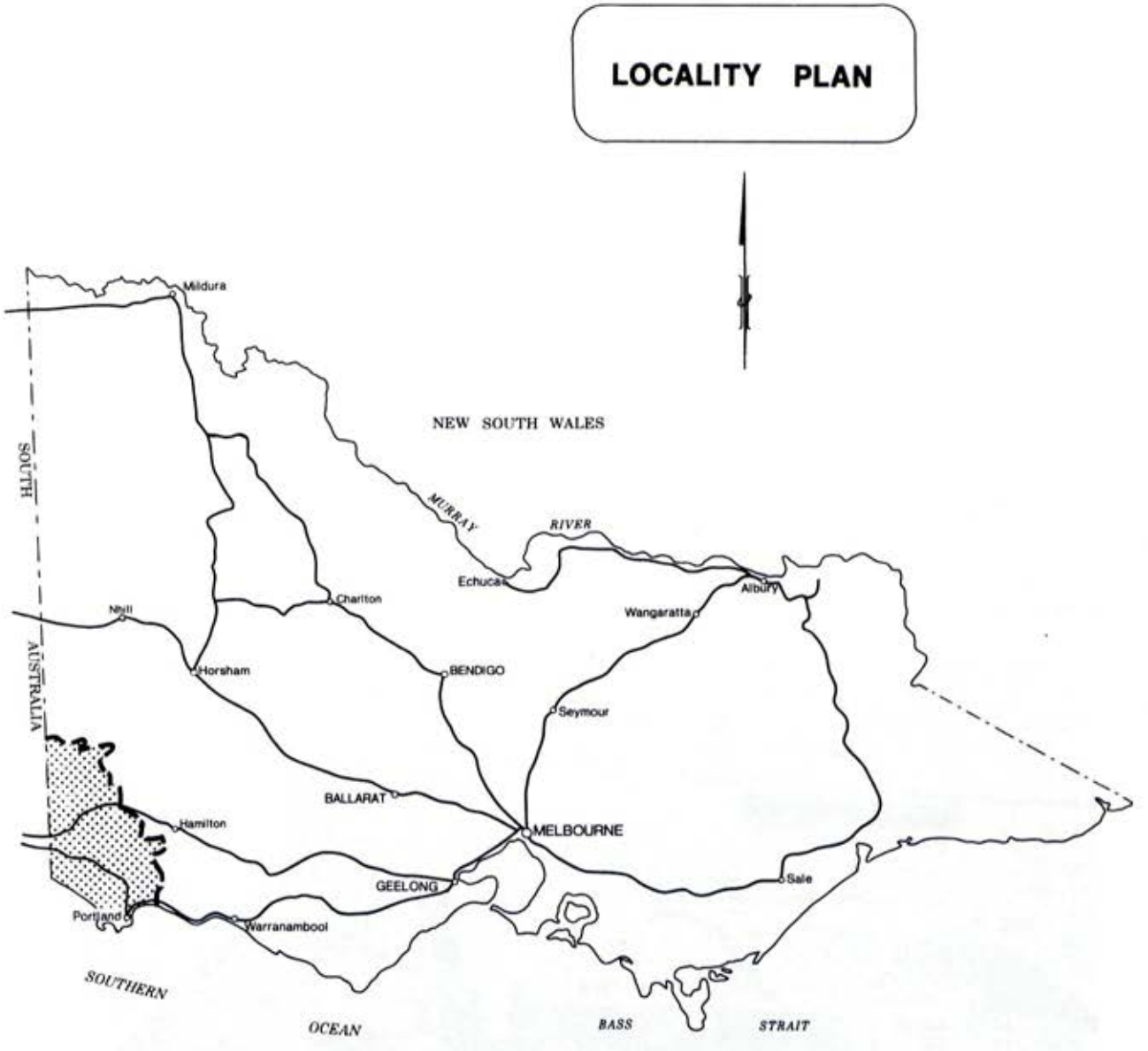
Information has been supplied by government departments, public authorities, and interested individuals, and has also been obtained from published reports and other sources.

The Study Area

The study area lies in the south-western corner of Victoria (see Map 1). It consists of all the land in the Shires of Portland (368,100 ha) and Glenelg (358,200 ha), but does not include Crown land in the town of Portland (3,411 ha). However, it would be unrealistic to describe the study area without reference to the future development of that town. Indeed, the economic future of a much larger area, encompassing most of south-western Victoria and south-eastern South Australia, will be linked closely to the development of both the town and its port.

The two shires cover a total area of 726,300 ha, of which approximately 223,000 ha or 31% is public land in substantial blocks. Smaller areas of public land - such as road reserves, stream frontages, and land in townships etc. - comprise a further 36,500 ha (approximately) or 5%.

The study area is characterized by a gentle topography of coastal and hinterland plains backed by low tablelands, generally less than 200 m above sea level but reaching 300 m on the Dundas tablelands north-east of Casterton. There are few hills and no major ranges. The most prominent relief features are associated with low escarpments of the Kanawinka Fault system and with steep slopes resulting from deep dissection of the tablelands south and east of Casterton.


LOCALITY PLAN
Mildura
NEW SOUTH WALES
SOUTH
AUSTRALIA
MURRAY
RIVER
Echuca
Albury
Wangaratta
Charlton
Nhill
Horsham
BENDIGO
Seymour
BALLARAT
Hamilton
MELBOURNE
GEELONG
Sale
Portland
Warrnambool
SOUTHERN
OCEAN
BASS
STRAIT
South Western Area
District 1
1 : 5 000 000
50 25 0 50
KILOMETRES
Land Conservation Council
Victoria
MAP No. 1

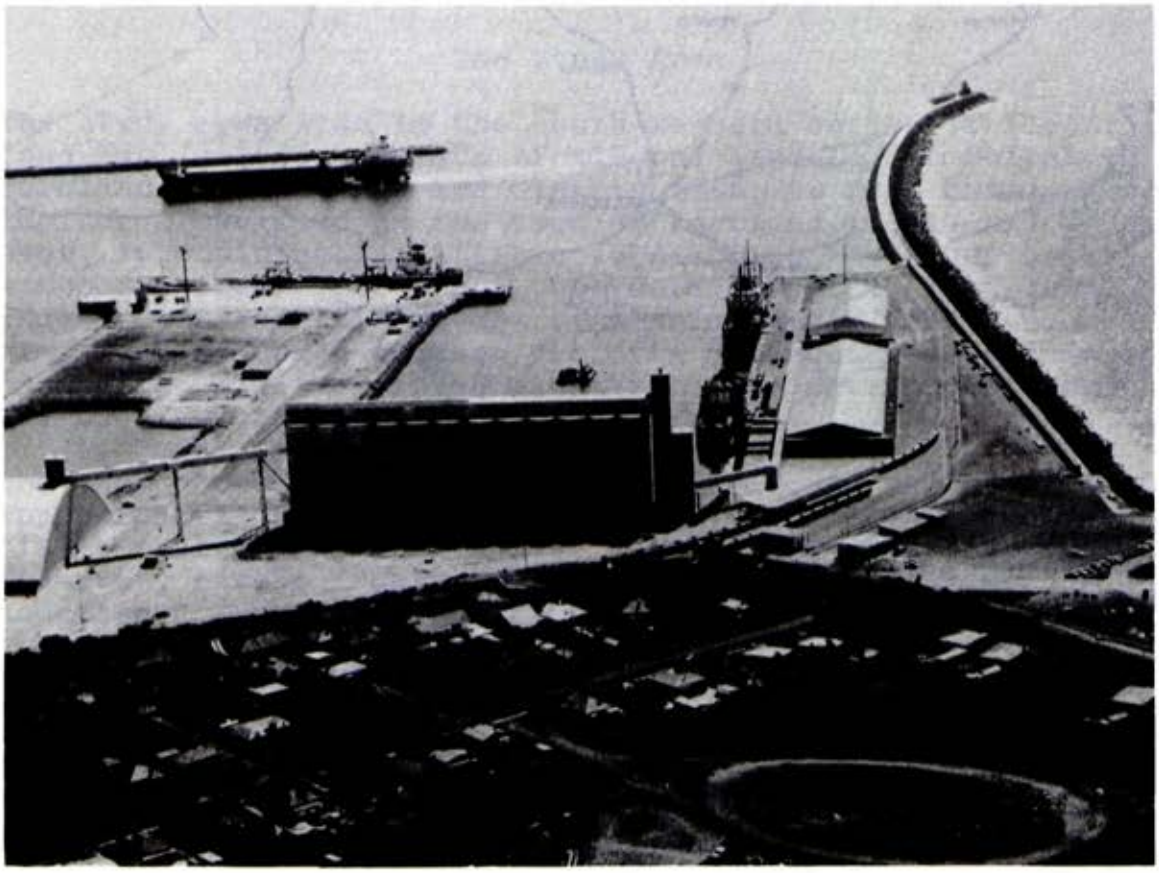
The Glenelg River is the most important drainage feature. It rises in the Grampian ranges to the north-east and flows north--south through the study area, entering the sea via a spectacular limestone gorge at Nelson. The central part of the study area, east of the Glenelg, is drained by its tributaries - the Wannon, Crawford, and Stokes Rivers. The south-east is drained by the Fitzroy and Surry Rivers and Darlots Creek. West of the Glenelg River, surface drainage is not well developed and swamps abound.

Public land in the study area carries a variety of vegetation. In the south, tall forests of messmate, brown stringybark, manna gum, or peppermint have mainly developed on fertile clay loams. In the northern and central parts woodlands of brown stringybark have developed on heavily leached and impoverished sandy soils. Numerous heaths and swamps occur throughout. Large areas of softwood plantations have been established on moderately fertile sandy soils.

Population

The population of the study area at 30 June, 1980, was estimated to be 11,400 and that of the town of Portland 8,800, giving a total of 20,200. During the last 25 years the population of the study area has declined slightly, but the population in the town of Portland increased by 63.6%.

In addition to Portland, the main population centres in the area are Casterton and Heywood. However, urban centres out-



Portland harbour and grain storage

side the study area such as Hamilton, Mount Gambier, and Warrnambool have an important influence on land use within it. Collectively, these towns have slightly increased numbers.

The loss of population from rural areas probably reflects a decline in the number of permanent employees on farms. A trend towards the ownership of small holdings in areas adjacent to the town of Portland may account for the slight increase in population in the adjoining Shire of Portland.

Future development at Portland

The town of Portland currently depends largely on activities related to primary industries for its economic base. The activities include food processing (especially meat and milk), wool and grain handling, fertilizer manufacturing, petroleum imports, and timber processing. One of Portland's major assets is its natural deep-water port less than an hour's steaming from the main coastal shipping lanes. It is likely that future development of the town will be linked closely with greater utilization and continued upgrading of port facilities.

Alcoa of Australia Limited has recently commenced building a major aluminium smelter south of Portland and expects it to be operating with a production capacity of 528,000 tonnes per year by 1989-90. However, this schedule could be altered if the demand for primary aluminium changes.

The building of the smelter will result in only a limited amount of direct employment, since many of the jobs will require a specialized work force not existing locally. However, indirect employment is certain to increase substantially in local industries servicing the parent company and its employees.

Moreover, associated diversification and increased utilization of the port, together with further upgrading of facilities, should make it more attractive as an entry and exit point for a wider range of bulk commodities and general cargoes.

Any increase in the throughput of agricultural products would increase the likelihood that industries associated with the processing of those products would establish or expand their local operations. Portland has supported a large meat-processing works for some years, but the lack of suitable port facilities to handle refrigerated meat-containers may have contributed to the severe cutbacks there during the recent national down-turn. Increased utilization of the port for grain-handling would increase the prospect of a grain-processor establishing in the region.

Extensive deep-sea trawling grounds recently discovered to the south-west could eventually support a large trawler fleet based at Portland. The catch might be processed locally at the existing factory, transported to existing facil-

ities in eastern South Australia, or supplied to the fresh-fish trade in Melbourne.

Softwood Holdings Limited have recently built a large modern particle-board mill at Portland, which began operating in 1977. A substantial increase in wood intake is planned in the future, based on supplies from company-owned plantations and an assured increase from State-owned plantations, together with expanding markets.

The development of the Alcoa aluminium smelter, and of these other projects, will have a substantial effect on the economic development of the town and on the adjoining area of south-western Victoria.

PART II
PHYSICAL AND BIOLOGICAL RESOURCES

2. LANDSCAPE EVOLUTION

This brief description of landscape evolution is more readily understood by reference to Figure 1 (which depicts the geological time scale), Map 3 (Geomorphology), and the geological map sheets for the area available from the Department of Minerals and Energy.

The regional bedrock - comprising Palaeozoic sediments, metamorphic rocks, and ancient submarine lavas - outcrops within the valleys of the major streams draining the Dundas Tablelands. To the north of the study area it underlies Tertiary sediments deposited in the extensive yet relatively shallow Murray Basin, whereas south of the Dundas Tablelands it is covered by a thick (up to 7,600 m) sequence of Mesozoic and Tertiary sediments deposited in the major east--west trough of the Otway Basin.

The Otway Basin developed in the early Cretaceous (about 135 million years ago) and extended as a major trough across western Victoria and south-eastern South Australia. The Dundas--Padthaway Ridge, extending west from the Grampians into South Australia, marked its north-western margin. Great thicknesses of non-marine mudstone and sandstone were deposited in the Lower Cretaceous and these sediments outcrop over 1,100 sq. km in the Merino--Casterton--Coleraine area as a broadly triangular tableland and elevated platform. At the end of the Lower Cretaceous (some 100 million years ago) the Otway Basin widened and the sea gained access. Non-marine sedimentation changed to marine deposition and during the Upper Cretaceous thick sequences of shales, greensands, and sands were laid down under shallow marine conditions. These do not outcrop, and are known only from bore records.

During the early Tertiary (approximately 70 million years ago) the sea began to advance further inland. To the north of the study area, the Murray Basin began to form a distinct depositional trough, and a major marine transgression took place during the Oligocene and Miocene. At this time, the Dundas Ridge formed a peninsula between the Murray and Otway Basins. Extensive deposition of fossiliferous marls and limestones occurred in both basins, but, within the study area, outcrops are restricted to the valley of the Glenelg River near Dergholm, and on the Kanawinka and related escarpments near Dorodong, Corndale, Bahgallah, and Glenaulin --Drik Drik. Bore records also indicate periods of volcanic activity during the early Tertiary.

As the sea began to retreat from its maximum landward invasion within the Murray Basin, a series of low sand ridges (Dorodong Sand), marking the positions of former shorelines, developed sub-parallel to the Kanawinka escarpment. These ridges date from late Miocene to early Pliocene times (about

Era	Period	Epoch	Age (million years)
Cainozoic	Quaternary	Recent	0.015
		Pleistocene	1.8
	Tertiary	Pliocene	5
		Miocene	22.5
		Oligocene	36
		Eocene	55
		Palaeocene	65
Mesozoic	Cretaceous		136
	Jurassic		195
	Triassic		225
Palaeozoic	Permian		289
	Carboniferous		367
	Devonian		416
	Silurian		446
	Ordovician		509
	Cambrian		575
Precambrian			

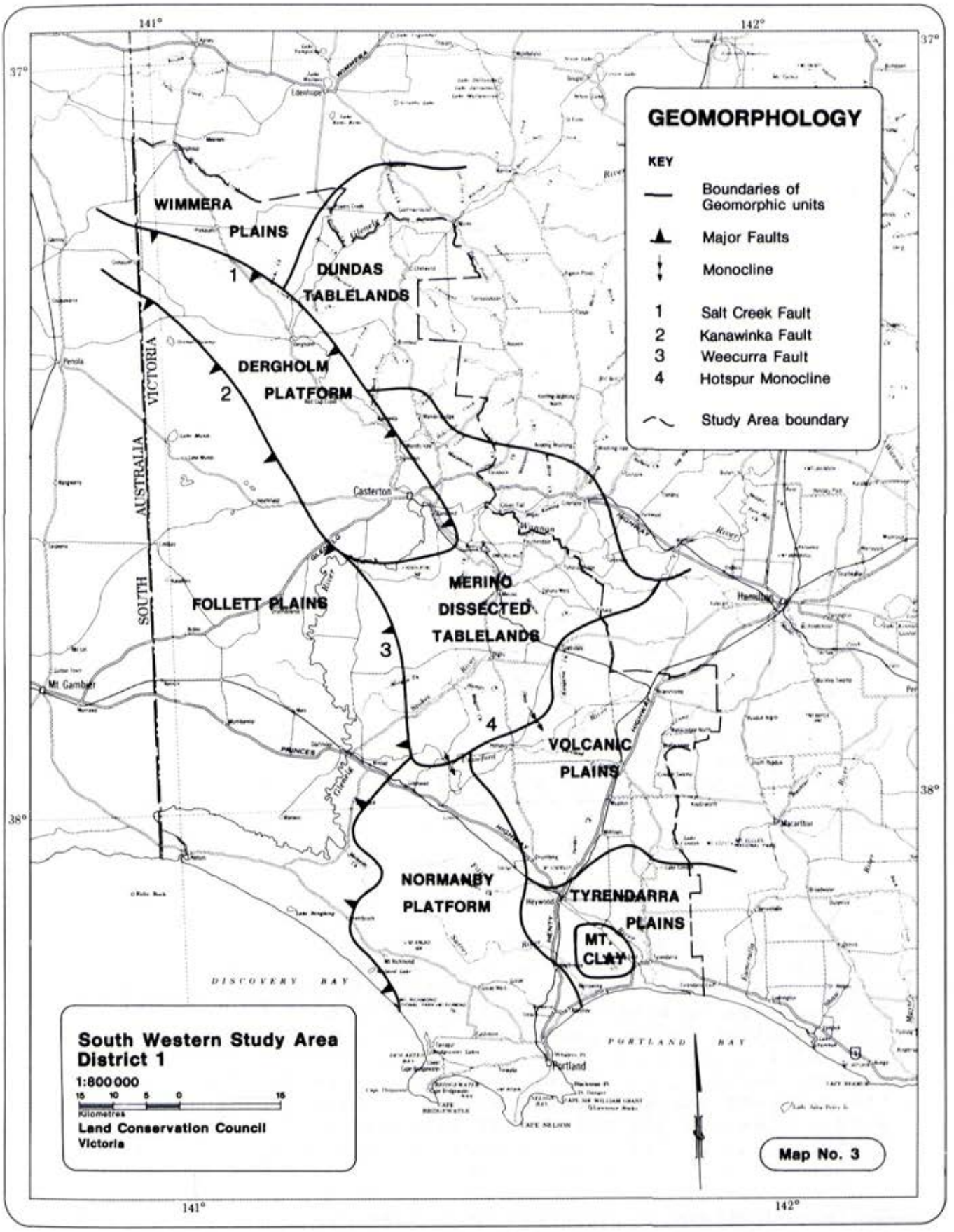
Figure 1: Geological time scale

10--5 million years ago). Although relatively poorly developed, they correlate with the prominent and extensive ridges, widespread on the Wimmera Plains, forming the Parilla Sand. Surface drainage is not well developed on the plains, and chains of swamps and small lakes are aligned along the intervening swales between dune ridges.

During the marine invasion, the Dundas and Merino Tablelands underwent prolonged erosion and deep weathering, resulting in the development of a resistant lateritic capping. The process of lateritization is thought to have extended over a long period, ending in the early Pliocene. Laterites up to 10 m thick are common throughout these tablelands today.

Major earth movements in late Pliocene to early Pleistocene times resulted in the development of a series of structural blocks, some of which were uplifted while others were depressed. The former Pliocene plain, which developed as a result of a prolonged erosional phase in the late Tertiary, was broken up into a number of tablelands, which now occur at varying elevations in response to the tectonic forces that initiated their development. The late Tertiary land surface is preserved on the tablelands because of their resistant laterite cappings. The Normanby Platform and the Mount Clay Block do not have lateritized surfaces but are capped by basalt, which is also resistant to weathering and erosional forces.

A number of geomorphic units occur within the area. These are described below and their location is shown on Map 3.


GEOMORPHOLOGY
KEY
Boundaries of Geomorphic units
Major Faults
Monocline
1 Salt Creek Fault
2 Kanawinka Fault
3 Weecurra Fault
4 Hotspur Monocline
Study Area boundary
WIMMERA PLAINS
DUNDAS TABLELANDS
DERGHOLM PLATFORM
FOLLETT PLAINS
MERINO DISSECTED TABLELANDS
VOLCANIC PLAINS
NORMANBY PLATFORM
TYRENDARRA PLAINS
MT. CLAY
SOUTH AUSTRALIA
VICTORIA
Casterton
Mt Gambier
Portland
DISCOVERY BAY
PORTLAND BAY
141°
142°
37°
38°
South Western Study Area
District 1
1:800 000
15 10 5 0 15
Kilometres
Land Conservation Council
Victoria
Map No. 3

Dundas Tablelands

This unit extends from the Grampian ranges west towards Dergholm and Coleraine where it passes into, or is faulted against, the Dergholm Platform and Merino Tablelands respectively. It is a stepped tableland complex, terminated on its western margin by the Kanawinka escarpment and in the south by the Hotspur Monocline. In the east, the southern margin passes imperceptibly into the basaltic plains and the northern margin into the Wimmera plains. Along the northern and western borders, dissection by the Glenelg River and its tributaries has exposed the Palaeozoic bedrock beneath the deeply lateritized capping. In the Youpayang area, the tableland surface passes beneath Tertiary marine sediments that in turn underlie sand sheets and irregular hummocky dunes of Quaternary age.

Merino Tablelands

The Merino Tablelands form a broadly triangular plateau at a lower elevation than the Dundas Tablelands. They are composed of soft, Lower Cretaceous sediments capped by a thin veneer of Tertiary sediments towards the west, and are lateritized to a depth of about 10 m. These sediments are less resistant to weathering than the Palaeozoic bedrock material of the Dundas Tablelands, and rivers have dissected the former Pliocene plain, leaving only small areas as flat, laterite-capped hills above deep and broad valleys.

Dergholm Platform

A sub-unit of the Merino Tablelands, the Dergholm Platform has Lower Cretaceous sediments outcropping in the valley of the Glenelg River. The platform is a relatively flat surface developed mainly on Tertiary limestones and lateritized Pliocene sands, capped by more recent siliceous sands and swamp deposits. The platform lies between the Kanawinka Fault to the west and the Salt Creek Fault to the east, and the surface is little dissected apart from the valley of the Glenelg River.

The Normanby Platform and Mount Clay Block

At the elevated western extremity of the Western District volcanic plains lies the Normanby Platform, capped by slightly dissected basalt and Quaternary sediments. The platform was uplifted and tilted to the east by movement on the Kanawinka Fault system in Plio--Pleistocene times (about 2.5 million years ago). Elevations approach 150 m along the western margins, but decline steadily towards the east until the platform surface merges with the coastal plain near Heywood. Five low volcanic cones rise above the general surface, and at least one limestone dune of Pleistocene age is perched on the south-western edge.

Surface drainage occurs through the swampy Fitzroy and Surry Rivers, although the Crawford River, now deeply incised along the northern margin of the platform, once flowed south

to join the Fitzroy River west of Heywood. In turn, these rivers were probably once linked with the Surry River and entered the sea via Heathmere. Pliocene basalt flows between Lyons and Drumborg, and subsequent river capture, were probably responsible for the Crawford River being diverted to its present course.

The Mount Clay Block is an elevated fault block consisting of Miocene limestone overlain by Pliocene and Pleistocene basalt, tuff, and scoria from the Mount Clay volcano. On the western half of the block, siliceous sands and swamps of Quaternary age overlie the basalt and Miocene limestone.

Follett coastal plain

By the end of the Tertiary period (about 1.8 million years ago), shallow sea covered most of the south and west of the study area. At its maximum extent the marine incursion extended to the Kanawinka escarpment, and the Glenelg River built a delta east of Killara Bridge, where it entered the sea. Offshore, sandy limestone with abundant oyster beds and local fossiliferous clays were deposited and now underlie most of the Victorian part of the Mount Gambier (Follett) coastal plain south-west of the Kanawinka escarpment. Remnants of similar deposits also occur at Portland and probably underlie the Tyrendarra coastal plain to the east.

Intermittent uplift of the land throughout the Pleistocene led to retreat of the sea in pulses, producing a succession of new shorelines. Former shorelines are marked by sub-parallel north-west to west-north-west dune limestone ridges (Bridgewater Formation) separated by inter-dune corridors between 2 km and 11 km wide. The ridges - of carbonate sand and characterized by cross-bedding - occur between the Kanawinka escarpment and the edge of the continental terrace, and are thought to span much of the Pleistocene (0.01--0.7 million years ago). Similar ridges of dune limestone occur on the Tyrendarra coastal plain east of Portland. The inter-dune corridors are invariably flat, with numerous lakes and small swamps aligned and elongated along a north-west--south-east axis, broadly parallel with the Kanawinka escarpment.

With each retreat of the sea the Glenelg River extended its course across the newly emerged coastal plain. Successive rejuvenation following each period of uplift caused the river and its lower tributaries to become deeply entrenched in a steep gorge. The beach and dune topography developed along the coastal strip between Cape Bridgewater and Nelson, and within Bridgewater Bay, represents the most recent phase of shoreline adjustment. The dune complex consists of irregular transverse dunes with crests up to 60 m high. Areas of parabolic dunes and blowouts are also common.

Tyrendarra coastal plain

The plain, a similar feature east of the Normanby Platform, has been modified in part as a result of Pliocene--Holocene

basaltic lava flows. An extensive lake formed south of Heywood when a lava flow dammed a former course of the combined Crawford, Surry, and Fitzroy Rivers near Heathmere. The lake sediments now form a plain about 16 km long and 8 km wide between Heywood and Heathmere. The Tyrendarra basalt flow from Mount Eccles also blocked the Fitzroy River near Homerton, forming an extensive lake north-east of the Mount Clay block. Dune limestone ridges of similar origin and age to those described on the Follett coastal plain occur between Portland and Tyrendarra.

Volcanic activity

Beginning in the middle Pliocene, volcanic activity continued throughout the Pleistocene into the Holocene (4--5,000 million years ago). Extensive lava sheets were extruded, and several flows disrupted existing drainage systems by infilling river valleys, in some places to a depth of 60 m. Basalts in the Hamilton--Branxholme and Cobboboonee--Greenwald areas, which date from the Pliocene, have developed soil profiles up to 10 m thick, but few of the volcanoes that gave rise to these older flows can be identified. More recent flows are little modified by weathering and erosion and therefore retain surface features such as stony rises, compression ridges, and lava caves. The final eruption at Mount Eccles to the east of the study area, which probably took place about 20,000 years ago, gave rise to the Tyrendarra lava flow. Highly fluid basalt filled the valleys of Darlots Creek and the lower Fitzroy River, resulting in the formation of the Condah and Homerton swamps. The flow continued offshore for 16 km and now lies about 40 m below sea level.

Not all volcanic activity resulted in lava flows. In a number of areas, explosive eruptions led to the accumulation of volcanic ash. Mount Vandyke, Mount Deception, and the Eckersley Group north of Heywood are all composed of volcanic ash and are of Quaternary age. Tower Hill, to the east of the study area, consists of very thick layers of volcanic ash, the last of which was deposited only 6,000 years ago.

Uncommitted land

Much of the uncommitted land in the study area consists of unconsolidated grey to white siliceous sand, which forms extensive dune-fields and sheets with numerous swamps. This formation probably ranges from late Pliocene to Holocene in age (5,000 to 2,500 million years ago). It is widespread throughout the study area, but is best developed immediately south-west of the Kanawinka escarpment where, for more than 50 km, it forms a belt up to 10 km wide and 30 m thick.

The heavily leached siliceous sand is thought to have been derived by winnowing and deflation of the calcarenite dune ranges and from the newly emerged sea floor. The formation is stable and well vegetated under present climatic conditions, but was probably deposited, and re-distributed, during several arid phases of the Quaternary period.

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3. SOILS

The distribution of major soil groups is controlled predominantly by the distribution of the parent material from which they are derived. For this reason the major soil types are closely related to the main geological provinces and the physiographic units.

In chapter 8, Land Systems, the soils of the study area are classified in detail following a system evolved by Northcote (1971). They belong to four main soil types; deep quartz sands, undifferentiated calcareous sands, grey-brown deep loams and clays, and duplex grey-brown sands and loams. The properties and occurrences of these soil types in the study area are discussed below.

Deep quartz sands

Heavily leached, grey-white, siliceous sands (often up to several metres deep) are overlain by a thin layer of decomposing organic material. The medium-fine sands are generally loose and structureless, with no clear differentiation of soil horizons, although an impeding layer of humic deposits and buckshot gravel is often present within the first 1.5 m.

The heavily leached sands are extremely acid and grossly deficient in nutrients, including important trace elements (such as copper and zinc). Although the addition of fertilizer may overcome the chemical deficiencies, the soils have low water-storage capacity, which is a limiting factor, and have very little potential for agricultural development.

Extensive plantations of *Pinus radiata* have been established on these heavily leached sands, generally in areas where a moisture-impeding layer occurs within 1--2 m of the surface. The addition of chemical fertilizers, especially phosphorus, is important for successful establishment.

Undifferentiated calcareous sands

The extensive mobile dunes fringing Discovery and Bridgewater Bays consist of limestone and calcareous material moved onshore from the continental shelf and reworked by wind action. The yellow-brown sands are loose and structureless, with no horizon differentiation. They are extremely alkaline, have a low nutrient content, contain little clay or organic material, are poorly vegetated, and are highly susceptible to wind erosion.

Red--black, uniform--gradational, sandy loams (terra rossa) have developed on dune limestone ridges of the Nelson land system. These soils are generally shallow, with a crumb structure, friable throughout, and show little horizon diff-

erentiation. They are more fertile than the leached and calcareous sands but are still deficient in many nutrients.

Gradational sandy loams and loamy sands have developed on an orange sand transitional between the calcareous sands fringing the dunes and the heavily leached siliceous sands. A typical profile consists of dark greyish brown, friable, porous, loamy sand that gradually merges into a light brown sand at depth. At about 1.5 m a massive, brown, loamy sand, often extending to 3 m, impedes drainage. These areas, adjacent to the Kentbruck Heath and north of the Glenelg River towards Rennick, have been planted extensively for softwood production.

Grey-brown deep loams and clays

These soils resemble black earths and prairie soils; their dark brown to black profiles at the surface may become yellowish at depth. They occur mainly on the Mesozoic sediments of the Merino Tablelands and, apart from phosphorus, have adequate supplies of plant nutrients.

The areas they occupy are treeless, and existed as extensive native grasslands at the time of European settlement. For this reason they attracted early occupation and have been used extensively for agriculture. Very little public land remains on this soil type.

Despite this attraction for early occupation, the soils are highly susceptible to erosion, and the dissected tablelands east of Merino and Casterton are the result of extensive sheet, gully, and streambank erosion, and various forms of mass wasting (for example, earth-flows, hill creep, landslips, and slumping).

Duplex grey-brown sands and loams

Duplex sands and loams are characterized by a distinct clay subsoil. Two main types occur within the study area.

The first type comprises three soils. In the broad interdune corridors of the Mount Gambier coastal plain, especially near Strathdownie, soils consist of poorly drained grey-brown sandy loams or sands overlying a mottled dull heavy clay. These soils are developed on Pleistocene and Holocene lagoon and swamp deposits, with a thin veneer of wind-blown sands.

Similar soils occur on the coastal plain south of Heywood, where dark, greyish brown, sandy loams overlie yellow-brown and olive-brown sandy clays. In the extreme north-western corner of the study area a plain of Miocene limestone, with low and irregular sand ridges and numerous circular swamps, represents the southern margin of the Wimmera plains. Soils consist of a fine brown sandy loam or grey-brown sand overlying mottled brown to orange clay. Virtually no public land remains on these soil types, and they have been extensively cleared, and drained, for agriculture.

The second group of duplex soils occurs on the Dundas Tablelands, on the Normanby Platform, and on the volcanic plains.

On the Dundas Tablelands soils consist of a brown sandy loam (A_1 horizon) overlying a very gravelly loam (A_2 horizon) that merges abruptly into a mottled, orange, gravelly heavy clay. These soils are generally derived from a fossil laterite. Land on the Dundas Tablelands was among the earliest that European settlers took up, and was used extensively for sheep grazing. Virtually none of this remains as public land.

The Normanby Platform occupies the western margin of the basaltic plains, and soils consist of a dark reddish brown gravelly loam over a grey-brown clay loam and mottled red-brown clay, with floaters of deeply weathered basalt. In part, the basaltic parent material has been weathered to an ironstone formation, which occurs as a hardened B horizon. A large area of public land in the Cobboboonee and Annya blocks occurs on this soil type, nearly all of which is currently used for hardwood production.

The main soil type of the basaltic plains consists of a very dark grey silty clay loam overlying a dark brown gravelly clay loam and mottled brown heavy clay. It is restricted to the east of the study area near Branxholme. Virtually all this land has been alienated for agriculture.

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4. CLIMATE

Rainfall

Map 4 shows the isohyets of average annual rainfall within the study area. This ranges from around 610 mm in the north to more than 910 mm in the Cobboboonee forests west of Heywood. Most of the study area receives reliable rainfall between April and November, with July and August being the wettest months. Table 1 shows the average rainfall, median rainfall, and average number of rain days for each month at six locations.

Most of the study area receives roughly twice as much rainfall in winter as in summer. For the area between Portland, Dartmoor, and Heywood, winter rainfall is higher and is generally three times that received in summer. Serious droughts are not common, especially near the coast, although extended periods of rainfall deficiency may occur in the north and west of the study area.

Temperature

January and February are the hottest months and average maximum temperatures range from about 21°C on the coast to about 27°C in the north. Average maxima fall steadily during autumn and then more slowly through winter, to reach their lowest values in July. At this time there is little variation across the study area and average July maxima range from 13.0°C at Portland to 13.8°C at Rennick (see Table 2).

Daily maximum temperatures in excess of 38°C are not uncommon between November and March, and have been recorded in October in the north. All areas have experienced temperatures greater than 42°C and the absolute maximum for the study area was 44.3°C recorded at Casterton in January 1959.

Average minimum temperatures range from February's 12°C--14°C to the June and July figures of 4°C--9°C. Sub-freezing temperatures are generally confined to the winter (June--August), but have been recorded as early as April and as late as November. Absolute minima lie in the range -1°C to -5°C and are least severe near the coast.

Frosts

Frosts, although possible at any time of year, mainly occur during the 5--7 winter months. An annual average of 10--30 light frosts could be expected and 3--15 severe frosts. Severe frosts are generally confined to winter but have been recorded in April, and are not uncommon in October or November.

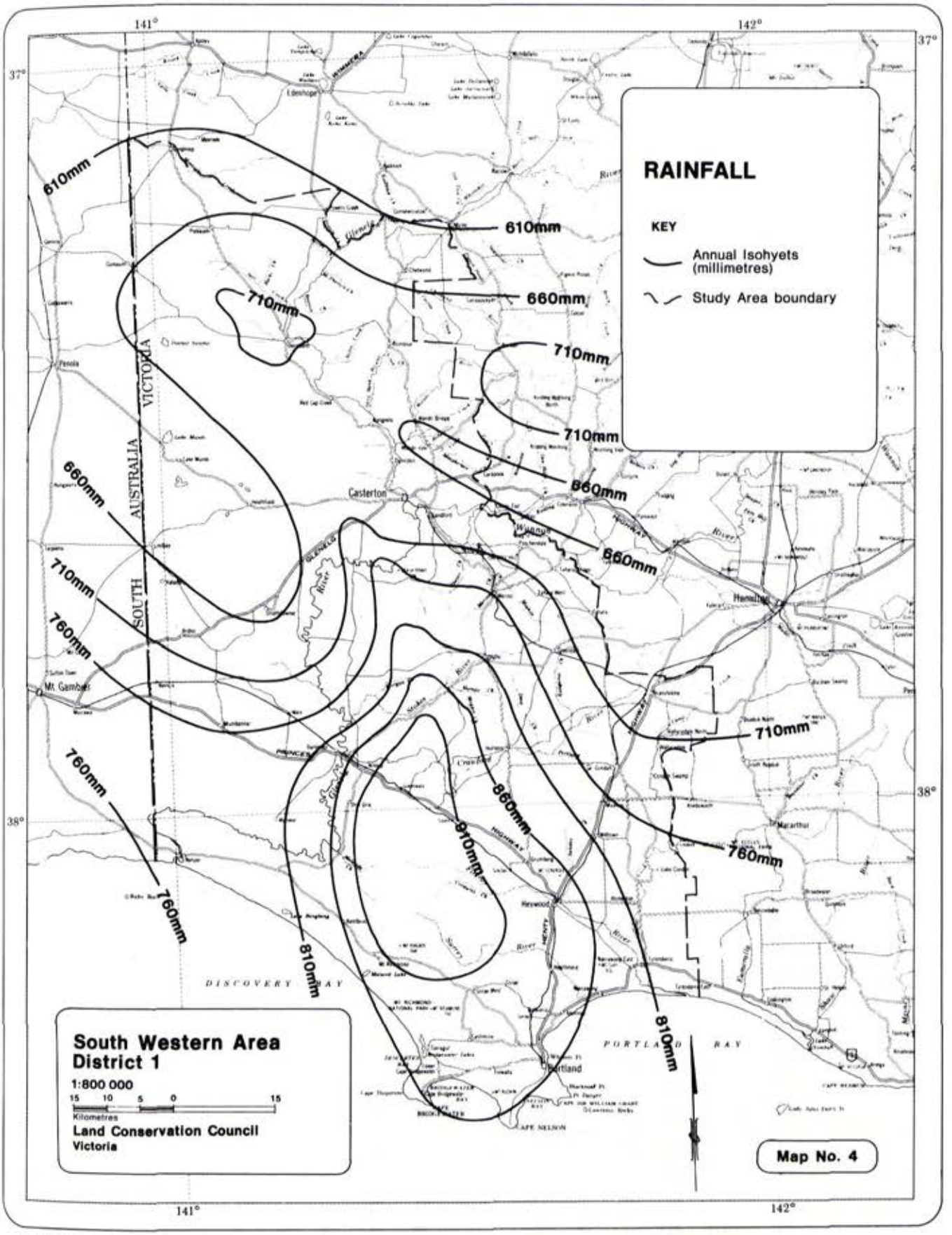
Table 1

RAINFALL

Station (number)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Portland	A	36	36	44	68	92	100	111	108	85	71	54	46	851
(090070)	B	26	28	37	66	88	95	108	106	81	69	50	40	845
	C	9	8	12	15	19	20	21	21	19	16	13	12	185
Heywood	A	35	33	41	74	92	90	105	114	84	74	67	53	862
(090048)	B	26	29	42	73	91	84	107	108	79	64	62	50	868
	C	8	9	12	15	18	18	21	21	18	16	14	12	182
Rennick	A	28	33	31	68	85	88	112	103	77	74	63	45	807
(090092)	B	21	24	28	66	73	80	110	103	77	64	63	43	803
	C	7	7	10	13	17	16	19	19	16	14	13	11	162
Casterton	A	25	30	35	49	70	60	93	86	76	61	53	42	680
(090135)	B	19	22	32	47	73	49	86	79	77	53	49	42	663
	C	7	7	10	13	17	17	21	21	18	16	13	11	171
Dergholm	A	28	32	35	55	72	80	88	86	78	68	49	40	711
(090033)	B	21	27	26	51	67	78	82	83	79	63	43	35	714
	C	6	6	7	11	15	15	18	18	15	14	10	9	144
Edenhope	A	24	24	28	45	60	65	73	69	63	55	39	30	575
(079011)	B	17	14	23	38	52	61	66	68	59	51	33	26	566
	C	4	4	5	8	11	12	14	15	12	11	7	6	109

A = Average rainfall in mm
B = Median rainfall in mm
C = Average number of rain days (that is, a day receiving at least 0.2 mm of precipitation other than frost, dew, or mist, measured between 0900 on consecutive days).

Source: Bureau of Meteorology, September 1979.


RAINFALL
KEY
Annual Isohyets (millimetres)
Study Area boundary
610mm
610mm
660mm
710mm
710mm
710mm
660mm
660mm
660mm
710mm
760mm
760mm
710mm
760mm
760mm
810mm
810mm
810mm
141°
142°
37°
38°
AUSTRALIA
VICTORIA
SOUTH
Casterton
Mt. Gambier
Hamilton
Portland
DISCOVERY BAY
PORTLAND BAY
CAPE NELSON
South Western Area
District 1
1:800 000
15 10 5 0 15
Kilometres
Land Conservation Council
Victoria
Map No. 4

39855/81—3

Table 2

MEAN MONTHLY MAXIMUM AND MINIMUM TEMPERATURES

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean monthly maximum temperatures (°C)												
Portland	20.7	20.8	19.9	18.2	15.3	14.0	13.0	13.6	14.7	16.3	17.5	18.6
Heywood	23.9	25.0	22.9	20.6	16.6	14.5	13.8	14.5	16.0	18.5	19.6	21.6
Rennick	25.2	26.0	23.3	20.6	16.5	13.7	13.3	14.2	15.9	18.8	20.3	22.9
Casterton	27.2	26.8	24.2	20.7	16.2	14.3	13.2	14.4	16.2	18.9	21.3	23.6
Mean monthly minimum temperatures (°C)												
Portland	13.9	14.4	13.7	12.1	10.0	8.8	7.8	8.0	8.9	10.0	11.1	12.4
Heywood	11.1	12.2	10.2	8.7	6.5	4.3	4.9	4.8	6.3	7.2	8.5	10.1
Rennick	10.8	11.9	10.4	8.1	6.2	3.6	4.2	4.2	5.6	6.7	8.1	9.7
Casterton	11.7	12.2	10.8	9.1	7.1	5.5	4.9	5.4	6.4	7.5	8.8	10.3

Source: 'Climatic Averages, Victoria', Bureau of Meteorology, 1975

Winds

Westerly winds predominate over the study area, but distinct seasonal variation occurs. Winds with a southerly component are most frequent between November and March. During autumn winds become more westerly, and west or north-west winds prevail in June and July. From August to November south-westerly winds are most frequent.

Winds in excess of 40 km per hour are more common along the coast than inland. At Portland, strong winds are most frequent between July and September and are generally from the west or south-west, whereas, further north, strong winds are most frequent between September and December and blow mainly from the west or north-west. Information on extreme wind gusts is limited, but speeds in excess of 100 km per hour have probably been experienced at many locations.

Length of growing season

The length of the growing season depends on effective rainfall and temperature. In this context effective rainfall is defined as 'the amount of rain required to start germination and to maintain plant growth'.

Low winter temperatures normally retard or prevent plant growth for approximately 1 month in the southern parts of the study area, where the growing season usually lasts for at least 10 months. Further inland a decrease in rainfall and lower winter temperatures reduce this to 8--9 months. The most favourable periods for plant growth are late spring and, to a lesser extent, autumn.

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5. WATER RESOURCES

Surface drainage within the study area is not well developed and very little water passes directly into streams via surface run-off. For this reason, the area contains only limited supplies of surface water and no major storage reservoirs. However, plentiful reserves of groundwater make large volumes available at shallow depth.

Surface Drainage

Major streams

The two principal streams in the study area are the Glenelg and Wannon Rivers, both of which rise in the Grampians ranges.

The Glenelg River has a total catchment of more than 11,650 sq. km, of which about 70% is within the study area. It drains the western slopes of the Grampians, part of the western Black Range, and the northern part of the Dundas Tablelands before entering the study area north-east of Chetwynd.

In its upper reaches, the Glenelg River flows in a broad, swampy, and ill-defined valley. Downstream from the Rocklands Reservoir, however, the valley becomes incised, and the river is entrenched below the level of the surrounding tablelands. South-west of Casterton the river crosses the Kanawinka escarpment and has cut a deep gorge across a broad coastal plain. At Nelson, it passes to a broadening estuary and enters the sea via a mouth shallowed and constricted by sand shoals and spits.

The Wannon River joins the Glenelg at Sandford, south-east of Casterton. It rises on the southern slopes of the Grampians and drains the southern Dundas Tablelands, including the Dundas Range, and the basaltic plains north and east of Hamilton. Above Cavendish, flow regimes are controlled by the movement of water through an extensive system of swamps, and stream flow usually ceases down to the Wannon Falls during summer. Below the falls, the Wannon flows in a broad, dissected valley through the central part of the Merino Tablelands, and numerous springs mean that stream flow usually persists year-round.

Drainage characteristics

The study area contains two major drainage basins: the Glenelg and Portland. The Glenelg drainage basin includes the Glenelg, Wannon, Chetwynd, Wando, Stokes, and Crawford Rivers, the Pigeon Ponds and Moleside Creeks, and many lesser streams and tributaries. Discharges from this basin via the

Table 3

STREAM CHARACTERISTICS

Drainage basin	Area of basin within study area (km²)	.Stream .Location .Gauging Sta.No. .Years of records	Drainage area above gauging station (km²)	Mean Monthly Discharge (ML)												Annual discharge ('000 ML)			Mean annual discharge rate (ML per km²)	Reliability % of annual discharge		Salinity (mg T.D.S. per L)		
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Max	Min	Mean		Dec-May	Jan-Mar	Max	Min	Mean
Portland	1,650	Fitzroy River at Heywood (237202) 24 years	233	390	70	49	134	1,161	4,902	6,945	12,373	8,142	5,079	3,091	675	116.3	1.3	43.5	186.8	5.8	1.2	1,300	275	823
		Darlots Creek at Somerton Bridge (237205) 10 years	774	2,325	1,499	1,434	1,538	2,505	4,201	8,116	13,349	11,948	8,911	5,673	3,466	138.4	16.4	64.9	83.9	20.3	8.1	1,933	280	1,116
Glenelg	5,120	Glenelg River at Sandford (238202) 73 years	9,420	3,293	2,687	3,339	3,399	8,793	34,927	113,095	138,966	149,673	84,949	25,623	11,748	1,711.6	32.6	600.2	63.7	5.7	1.6	5,675	150	2,090
		Glenelg River at Dartmoor (238206) 24 years	12,000	4,707	3,328	2,673	4,058	11,550	41,314	101,307	191,483	133,353	79,787	47,330	11,690	1,639.4	39.3	636.3	53.0	6.0	1.7	3,150	245	1,833
		Crawford River at Winnap (238217) 7 years	686	184	57	59	302	2,943	6,833	13,066	23,313	14,380	7,226	1,785	457	148.6	3.7	70.0	102.1	5.7	0.4	1,957	160	1,124
		Wando River at Wando Vale (238223) 9 years	144	133	92	129	237	711	1,252	3,287	5,831	3,801	2,445	905	278	40.1	1.6	17.0	118.2	9.6	2.1	6,689	210	1,963
		Wannon River at Henty (238228) 5 years	4,160	1,793	714	696	1,237	4,925	16,609	16,973	47,715	40,498	28,116	19,888	5,943	498.3	47.3	214.1	51.5	7.7	1.5	3,738	254	1,985
		Chetwynd River at Chetwynd (238229) 4 years	65	31	31	46	79	395	989	886	2,054	1,916	1,107	462	91	17.6	2.6	9.5	146.0	7.9	1.1	4,403	110	1,932

Note: Millicent Drainage Basin covers an area of approximately 490 km² in the north-west of the study area. There are no gauged streams within the study area for this drainage basin.

Glenelg River account for about 85% of the total stream flow from the study area. The Portland drainage basin is a relatively small coastal catchment, of which only 22% is within the study area. It includes the Fitzroy and Surry Rivers and Darlots Creek, which drain the hinterland north and east of Portland. Table 3 shows the characteristics of the main rivers and streams that make up these drainage basins.

It is estimated that about 15% of the annual rainfall is discharged by the river systems. The balance is retained as soil moisture, is lost by evapotranspiration, or enters the groundwater system. Consequently, rates of run-off are generally poor, as reflected in the relatively low mean annual catchment discharge rates of 51 and 53 ML per sq. km for the Wannon and Glenelg Rivers respectively. Despite these generally low discharge rates, they still maintain appreciable annual flows because of their very large catchment areas. However, stream flow almost ceases during summer, with less than 10% of the mean annual discharge being contributed in the 6 months December--May.

In the Glenelg drainage basin, about 60% of the mean annual discharge of the Wannon and Chetwynd Rivers - and 80--90% of the mean annual discharge of the Glenelg, Crawford, and Wando Rivers - is contributed between July and October. In the Portland basin, discharges during these 4 months account for 65% of the flow of Darlots Creek and about 75% of the flow of the Fitzroy River.

Storages

There are no major storages within the study area. However, Rocklands Reservoir on the Upper Glenelg River conserves some 106,000 ML, or about 10% of the total resources of the river, for use in the Wimmera--Mallee Domestic Stock system. This receives approximately 90% of its storage reserves during winter and spring, when regional streams normally carry surplus water. During summer, flushes are released to replenish pools and improve water quality in the Glenelg River.

The Konong Wootong Reservoir, east of Casterton, is on a minor tributary of the Wannon River and is just outside the study area. This relatively small reservoir provides water for the townships of Casterton, Sandford, and Coleraine.

On the coastal plains between Lake Mundi and Mumbannar, and south of Heywood, drainage and the disposal of surface water rather than water conservation have been major considerations in the past. These areas, which formerly carried numerous lakes and swamps, have been extensively drained for agriculture.

Water quality

Water quality is determined by a range of factors, including hardness, turbidity, colour, organic content, and the concentration of total dissolved solids (T.D.S.). For practic-

al purposes, T.D.S. content is the most convenient indicator of water quality. Testing under the Australian Water Resources Council (AWRC) monitoring program indicates that T.D.S. content in the Glenelg basin generally exceeds 1,500 mg per litre and increases to more than 3,000 mg per litre during very low flows (see Table 3). Within the Portland basin, salinity is generally between 500 and 1,500 mg per litre - increasing to a maximum of 1,900 mg per litre during very low flows.

Wetlands

Shallow lakes and swamps are common throughout the study area. On the Mount Gambier coastal plains numerous broad depressions hold water during wet periods, although many have been drained for agricultural use. Perennial and ephemeral swamps are also common on much of the uncommitted public land. On the basaltic plains east of Heywood, the Homerton and Condah swamps developed after the Tyrendarra lava flow filled the former valleys of Darlots Creek and the lower Fitzroy River.

Lakes on the Mount Gambier coastal plain are valuable for conserving water for stock, and they partially regulate stream flow by impounding run-off. Most of the depressions on the plain result from solution of the near-surface limestone subsoil, rather than from the incipient collapse of

The Glenelg River at Killara Bridge

underground caverns. Many are rimmed by lunettes on their eastern margin. Water levels vary seasonally, and most smaller lakes dry out during summer and are dry during periods of drought. Following good spring rains, however, many of the wetland areas on uncommitted land carry water throughout summer and autumn, and are an important source of water for wildlife.

On the coastal plains, salinity in lakes varies from around 100 mg T.D.S. per litre (suitable for stock and domestic use) to greater than sea water. Hydrological studies indicate that salt contributed by rainfall or deposited from the wind (that is, cyclic salt) accounts for less than 10% of the content of lakes and streams in the study area; most is derived from soluble salts leached from the soil and bedrock of the lake or stream catchment.

Groundwater Resources

The poorly developed surface system is supplemented by an extensive groundwater resource. Water enters the groundwater system by downward percolation of rain and from surface waters such as streams and lakes. On a regional basis, the groundwater flows south towards the coast, but local hydraulic connections between aquifers may result in a more complex discharge pattern.

Aquifers

Two types of aquifers are normally recognized - confined and unconfined. Confined aquifers occur in sedimentary basins and consist of porous formations covered by one or more impervious formations. Recharge takes place through outcrops of the porous formation, usually in higher land at the margin of the basin. Unconfined aquifers store water in shallow formations under normal hydrostatic pressure, and its upper surface forms the regional water table. These are recharged by rain falling locally and infiltrating downwards into the porous formations directly beneath the surface.

Four main aquifer systems lie within the study area: the Dartmoor Formation, the Gambier Limestone, the Whalers Bluff Formation, and the Late Cainozoic Basalts. Table 4 lists their characteristics and uses.

Hazards to groundwater supplies

The shallow groundwater system is particularly susceptible to contamination from sources such as effluent disposal, agricultural chemicals and fertilizers, and pollutants like oil or animal and vegetable waste. For this reason, it is important that land use in the vicinity of bores used to extract water for domestic purposes be compatible with the production of good-quality water.

There is little likelihood, however, that surface contamination would affect the quality of groundwater held in the deeper confined aquifers of the Dartmoor Formation.

Table 4

CHARACTERISTICS AND USES OF THE MAJOR AQUIFERS

Aquifer name	Aquifer type	Water quality (mg T.D.S. per L)	Typical yield (L per sec.)	Depth struck (m)	Uses
Dartmoor Formation	Confined	< 1,000	> 60	50--1,200	Produces large quantities of soft water suitable for domestic and industrial use; supplies the towns of Portland and Heywood
Gambier Limestone	Confined and unconfined	1,000--2,000	4--125	20--200	Produces large quantities of good-quality but hard water where limestone is present as thick bands or lenses; supplies Mt Gambier and Penola in South Australia
Whalers Bluff Formation	Unconfined	500--600	< 23	20--30	Produces large quantities of good-quality water at shallow depth; supplements water supply for Casterton
Late Cainozoic Basalts	Unconfined	500--6,000	< 6	0--60	Water produced is generally saline and is normally only suitable for watering stock

Source: Department of Minerals and Energy

Work by the CSIRO Division of Soils on the coastal plain near Mount Gambier indicates that the rate of recharge to shallow aquifers is lower beneath pine plantations than beneath adjacent pasture land. It is not clear, however, what effect, if any, this may have on the groundwater hydrology of the region, which includes south-western Victoria.

Geothermal energy

Large volumes of hot water are currently extracted from high-yielding aquifers near Portland. Water at 52°C is extracted continuously from depths near 1,400 m, and flow rates of 70 L per second can be maintained. At present, all heat is extracted at the well-head, and the water is cooled and aerated before being distributed for domestic use.

The energy available as low-grade heat is suitable for process and space heating, but not for electricity generation. It could be utilized for space heating, in particular, if reticulation systems were available to circulate hot water prior to reservoir storage. The potential industrial use of geothermal heat is limited by the existing bore capacity, which is designed primarily for the provision of a domestic water supply.

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6. VEGETATION

Large tracts of grassy woodland were common over much of the plains of south-western Victoria prior to European settlement. These areas attracted early occupation and have since been extensively cleared and modified for agriculture.

Most public land now supports woodland or open forest formations. In the northern and central areas woodlands of brown stringybark (*Eucalyptus baxteri*) are common on acid, grey sands. In those areas where rainfall exceeds 720 mm per annum, and on more fertile soils, messmate (*E. obliqua*), brown stringybark, manna gum (*E. viminalis*), shining peppermint (*E. nitida*), and swamp gum (*E. ovata*) occur as open forests, in either pure stands or mixed communities. Heaths occur extensively throughout the study area and are a common understorey component of the brown stringybark woodlands.

Maps 5A and 5B classify the vegetation that occurs on public land in the study area. They also show the areas where softwood plantations have been established on public land, but do not show the vegetation of all of the small blocks of public land and river frontages.

The system used to classify the vegetation on these maps and in the description of the different communities below is based on the structural forms of the vegetation (shown in Table 5). It follows a system proposed by Specht (1970) and is based on the height and crown density of the tallest stratum.

Table 5

STRUCTURAL FORMS OF VEGETATION
(modified from Specht 1970)

Form and height class of tallest stratum	Projective foliage cover of tallest stratum		
	Dense (70--100%)	Mid dense (30--70%)	Sparse (10-30%)
Trees (18--30 m)	Closed forest	Open forest II	
Trees (10--18 m)		Open forest I	Woodland
Shrubs (2--8 m)	Closed scrub	Open scrub	
Shrubs (under 2 m)	Closed heath	Open heath	
Grasses (0--2 m)		Grassland	

The following account describes 11 major communities identified within the study area. Attention is directed primarily to the brown stringybark and heath formations on the uncommitted land, as most of the open forest areas have been committed for hardwood production.

Brown Stringybark (*E. baxteri*)

An open forest I of brown stringybark occurs on moderately fertile and well-drained soils receiving more than 750 mm annual rainfall. However, the species is more widely distributed as a woodland on the heavily leached, well-drained, grey-white, acid sands common throughout the central and northern parts of the study area.

On these nutrient-deficient siliceous sands, brown stringybark typically grows to 15--20 m and occurs with a dense understorey of sclerophyllous shrubs. Table 6 lists the common angiospermous understorey genera in this community. Ferns are rare, although bracken (*Pteridium esculentum*) is widespread, and is the dominant understorey species in many areas. Annual grasses are uncommon, but perennial species such as *Stipa* spp. and *Deyeuxia* spp. occur in small numbers. This community generally lacks a well-developed herbaceous ground layer, although a rich orchid flora commonly adds to the floristic diversity of many sites.

Woodland of brown stringybark - Narrawong area

Woodlands and open forest I of brown stringybark occupy about 70% of the public land not already committed to a primary use.

River red gum (*E. camaldulensis*)

Prior to European settlement, river red gum was widely distributed, particularly over much of the Dundas Tablelands. It probably occurred as a woodland with a natural grassy

Table 6

COMMON ANGIOSPERM GENERA IN THE HEATH UNDERSTOREY OF BROWN STRINGYBARK WOODLANDS AND OPEN FORESTS

Family	Genus	Common name
1. Epacridaceae	*Astroloma*	Heaths
	Acrotriche	Ground-berries
	Epacris	Heaths
	Brachyloma	Heaths
	Styphelia	Heaths
	Monotoca	Broom-heaths
	Leucopogon	Beard-heaths
2. Papilionaceae	*Bossiaea*	Bossiaeas
	Dillwynia	Parrot-peas
	Platylobium	Flat-peas
	Kennedia	Coral-pea
3. Proteaceae	*Banksia*	Banksias
	Hakea	Hakeas
	Isopogon	Cone-bush
4. Myrtaceae	*Leptospermum*	Tea-trees
	Calytrix	Fringe-myrtles
5. Mimosaceae	*Acacia*	Wattles
6. Liliaceae	*Xanthorrhoea*	Grass-trees
7. Rutaceae	*Boronia*	Boronias
	Correa	Correas
8. Dilleniaceae	*Hibbertia*	Guinea flowers
9. Restionaceae	*Hypolaena*	Rope-rush
	Leptocarpus	Twine-rush
	Restio	Cord-rush

understorey, but this formation has since been modified substantially by clearing for agriculture. In some areas, however, relatively large numbers of trees have been retained on agricultural land, and a parkland of old river red gums up to 35 m tall is an attractive feature (for example, near 'Caupaul' homestead).

The species occurs only sparsely on public land, mainly in the north-west, and is generally confined to wetter sites such as drainage lines, or to small areas where Tertiary sands or limestone outcrop on the high side of the Kanawinka escarpment. It generally grows on relatively fertile soils - duplex sands and loams with a mottled grey--orange heavy clay subsoil - and a substantial layer of leaf litter is common. Waterlogging is common in the winter months.

Mature river red gum near Black Jack Swamp

River red gum stands tend to be multi-aged with mature trees 20--30 m tall and a few old specimens, with characteristic wide-spreading and drooping crowns, up to 35 m tall. Other gums, such as manna gum, swamp gum, and yellow gum (*E. leucoxylon*) may be co-dominant or sub-dominant in mixed woodland formations.

Grasses predominate in the understorey and common genera include *Poa, Danthonia, Pentapogon, Briza, Holcus,* and *Deyeuxia.* Common forbs include the genera *Hydrocotyle, Dichondra, Viola, Geranium,* and *Oxalis.* In more swampy areas, river red gum woodlands may occur with a stratified understorey of tea-tree and an associated ground layer of grasses, forbs, and sedges. Small tree species such as black wattle (*Acacia mearnsii*) or silva banksia (*Banksia marginata*) also occur in some areas.

Yellow gum (*E. leucoxylon*)

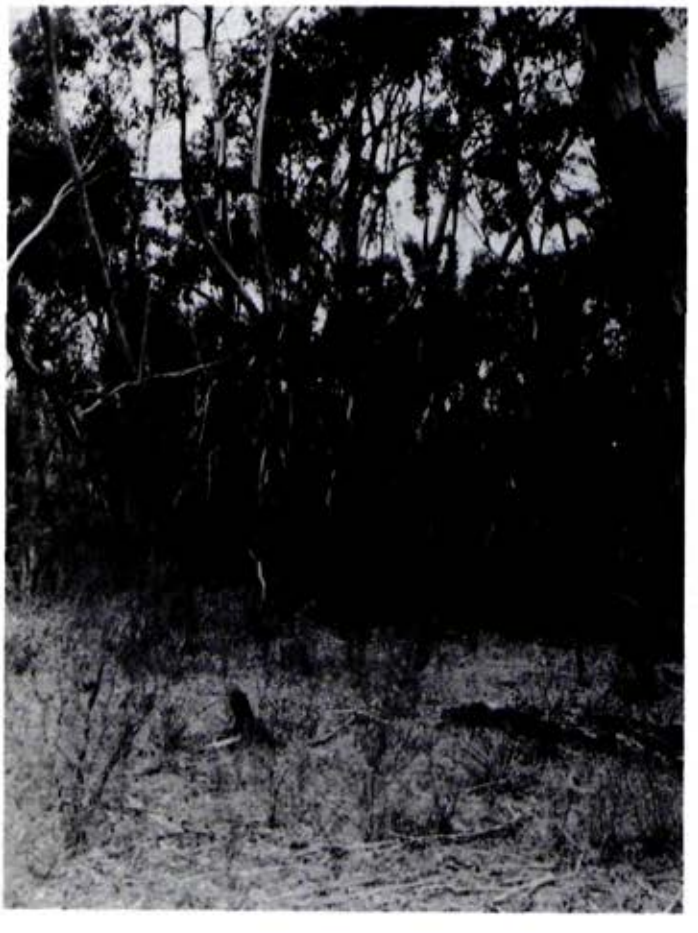
This species is generally confined to the northern parts of the study area and is common throughout the Wimmera, where it occurs typically as a woodland formation with tree heights between 20 and 30 m. It is often found in close proximity to river red gum woodlands, and the distributions of the two communities are closely related. A transitional mixed woodland, in which both species are co-dominant, often occurs between the pure-stand communities.

Understorey floristics are similar to those in river red gum woodlands, although small grass-tree (*Xanthorrhoea minor*) is a more frequent component. The ground layer typically consists of forbs of the genera *Geranium*, *Acaena*, and *Oxalis* and grasses of the genera *Poa* and *Danthonia*. Scattered small trees (less than 10 m tall) such as silver banksia or black wattle may be sub-dominant in the upper stratum.

Swamp gum (*E. ovata*)

The swamp gum has an extremely variable growth form throughout the study area. It occurs as a single-stemmed forest tree up to 30 m tall on moderately fertile soils with partially restricted drainage in the south-east of the study area; but on shallow duplex soils adjoining heaths in the north, it takes on a whipstick mallee form sometimes less than 5 m tall.

In areas where annual rainfall exceeds 760 mm, it grows in pure stands on heavy clay soils in an open forest formation. Tree height is often greater than 20 m and the understorey consists of a well-developed ground layer of grasses and forbs. The development of a shrub layer is restricted, although prickly moses (*Acacia verticillata*) and small grass-tree are common in some areas. In this formation, red gum, yellow gum, or manna gum may be co-dominant or sub-dominant. Soils typically consist of grey--orange sands with clay or buckshot gravel within 1 m of the surface.



Swamp gum with heathy understorey - Weecurra area

Along many drainage lines, swamp gum occurs as a narrow band of open forest, with a dense understorey of prickly moses (up to 3 m tall) over saw sedge (*Gahnia radula*) and prickly tea-tree (*Leptospermum juniperinum*) (1--2 m tall). Within this formation a ground layer of forbs - including genera such as *Hydrocotyle*, *Hypochoeris*, and *Oxalis* - is often well developed. Soils are wet, compact, grey to orange sands with clay or buckshot gravel within 1 m of the surface.

It also grows on the fringes of most heath and swamp communities in the northern part of the study area. It has a high tolerance to waterlogging and occupies sites that are wet in winter and experience little moisture stress in summer.

Swamp gum occurs frequently as a transitional woodland between brown stringybark woodland formations on the well-drained siliceous sands and heath communities in poorly drained topographic depressions. In these areas, the understorey consists of sclerophyllous shrubs (1 m tall) with a poorly developed ground layer. Soils are often deficient in nutrients and consist of grey sands of variable depth in which clay or buckshot gravel form the subsoil horizon.

Manna gum (*E. viminalis*)

Although widely distributed throughout the study area, manna gum does not occur in large pure stands. Rather, it is a common component of mixed open forest communities on fertile soils of basaltic origin, or it may form a layered woodland with silver banksia in the northern blocks.

Within the study area it has two distinctive growth forms and occupies at least four distinctive habitats.

On fertile basaltic soils in areas receiving more than 800 mm of rain per annum, manna gum occurs as a smooth, white, gum-barked tree to 25 m tall. It is often co-dominant with other eucalypts, such as swamp gum and shining peppermint, and forms an open forest II with an understorey of tall shrubs such as prickly tea-tree, silver banksia, and small grass-tree. Below these a layer of low shrubs, including *Acrotriche* and *Hibbertia* spp., overlies a well-developed ground layer of forbs, graminoids, and true grasses. Mosses forming small mats may occur on wetter sites.

Within this formation scattered small trees to 10 m tall, such as blackwood (*Acacia melanoxylon*) and cherry ballart (*Exocarpos cupressiformis*) may form a semi-layered open forest. Soils consist of grey to yellow-brown clays, often with a thin sand veneer, and buckshot gravel is common in the first metre of the soil profile. The formation is most common in the Cobboboonee and Homerton blocks, and it also occurs on terra rossa soils developed on limestone, in the Lower Glenelg block.

In the Tooloy block, rough-barked manna gum to 20 m forms a layered woodland over silver banksia at about 8 m, with a heathy understorey similar to that in adjoining woodlands of

brown stringybark (see Table 6) developed to 1 m. Soils consist of uniform, medium to fine, grey to orange sands overlying buckshot gravel and clay at about 0.5 m. Surface sands are well drained, but the gravel and clay subsoil acts to impede drainage. These soil and moisture conditions suit the establishment of pines, and much of this formation has been cleared for softwood plantations.

A small half-barked form, generally less than 15 m tall, often occurs as a sporadic component in heaths and along drainage lines in the north of the study area. Soils consist of grey to orange sands of variable depth over clay and are subject to seasonal waterlogging.

Routh-barked manna gum to 25 m is often co-dominant or sub-dominant with river red gum, yellow gum, or swamp gum on wet sites in northern blocks. The understorey consists of scattered shrubs such as small grass-tree overlying a well-developed ground layer of forbs of the genera *Acaena* and *Hydrocotyle* and grasses of the genera *Poa* and *Danthonia*. Soils are shallow, grey to orange sands overlying buckshot gravel and clay within 0.5 m of the surface.

The relation between the rough-barked form of manna gum and closely allied species - such as scent bark (*E. aromaphloia*) and that recognized in South Australia as *E. huberana* - has still to be resolved satisfactorily.

Pink gum (Eucalyptus fasciculosa)
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Pink gum (*E. fasciculosa*)

Within Victoria, pink gum is confined to the south-western corner (although it has a wider distribution in South Australia, where it is known as hill gum). Much of the land that originally carried stands of pink gum has been cleared for agriculture, and most of the small areas that remain are on public land in the north-west of the study area.

The species generally occurs as a woodland with an average tree height of 15 m. Individual trees are characterized by a glimmering grey-white trunk with an accumulation of orange decorticated bark at the base. A multi-stemmed, mallee-like form is also common. The understorey consists of a dense layer of shrubs up to 1.5 m tall and includes beaked hakea (*Hakea rostrata*), heath tea-tree (*Leptospermum myrsinoides*), and small grass-tree. The ground layer is seldom well developed, except in areas where the shrub layer is sparse.

Pink gum appears to favour sites where a thin veneer of sand mantles the fossil lateritic surface adjacent to the Kanawinka escarpment. Typically, site conditions are transitional between the deep, well-drained sands that carry brown stringybark woodlands and sites of impeded drainage that carry woodlands of yellow gum. Soils generally consist of grey to brown sands overlying a deeply weathered horizon of buckshot gravel, or clay, at less than 0.6 m.

Shining peppermint (*E. nitida*)

In southern areas where rainfall exceeds 760 mm per annum, shining peppermint is common and occurs in two distinct forms. On deep sand sheets and sand ridges, trees up to 4 m tall form an open scrub with a floristically diverse heath understorey. In areas of higher soil fertility, the species may also form a low woodland. On clay soils of basaltic origin, shining peppermint occurs as a mixed open forest with other eucalypts such as messmate, brown stringybark, or manna gum. Tree height averages about 20 m. Within these formations, the understorey typically consists of shrubs to 2 m, including heath tea-tree, silver banksia, beaked hakea, and small grass-tree, overlying a well-developed ground layer. Most of these forest areas have been committed for hardwood production.

On the uncommitted land in the Drajurk block, which receives an average annual rainfall of about 700 mm, shining peppermint occurs in a woodland formation with tree height averaging 15 m. The understorey consists of shrubs of genera such as *Xanthorrhoea, Leptospermum, Acacia, Banksia,* and *Hakea* overlying a poorly developed ground layer. This formation is developed on deep, wet, grey sands that become drier, and lighter in colour, with depth.

Messmate (*E. obliqua*)

While it is the main forest tree in the study area generally, messmate is most common in the south-east in areas man-

aged for hardwood production. Small areas also occur on uncommitted land.

Messmate forms an open forest II with an average tree height in excess of 30 m, and individual trees may attain heights up to 35 m at maturity. It is best developed on sandy clays and clay loams derived from weathered basalt, and is confined to areas receiving rainfall greater than 760 mm annually.

It usually occurs in pure stands, but may also form a mixed open forest II with shining peppermint, swamp gum, manna gum, or brown stringybark. Scattered small trees (5--10 m) such as blackwood and cherry ballart are not uncommon over an understorey of sclerophyllous shrubs including small grass-tree, silver banksia, prickly moses, prickly tea-tree, and saw-sedge. A low shrub layer of bracken, common heath (*Epacris impressa*), guinea flower *Hibbertia stricta*), cranberry heath (*Astroloma humifusum*), and honey pots (*Acrotriche serrulata*) is common over a well-developed ground layer of grasses (*Danthonia* sp.) and forbs (*Viola hederacea, Hypochoeris radicata,* and *Dichondra repens*). Soils consist of sandy clays and clays of basaltic origin, often overlain by a thin veneer of sand.

On uncommitted land along the southern margins of the Weecurra block, messmate forms open forest II along steep gullies draining to the Stokes River. In this riparian environment the understorey includes tall shrubs (3--4 m) such as sweet bursaria (*Bursaria spinosa*), golden tip (*Goodia lotifolia*), and *Acacia* spp. overlying a mesophytic component (1 m) of Australian indigo (*Indigofera australis*) and hop goodenia (*Goodenia ovata*). Ferns are also common, and include scrambling coral fern *(Gleichenia microphylla*), fishbone water fern (*Blechnum nudum*), and common maidenhair (*Adiantum aethiopicum*) as well as austral king-fern (*Todea barbara*). This formation is developed on humic grey to yellow sands overlying a loamy sand at about 0.5 m.

Heaths

Occurring widely throughout the study area, heaths exhibit a range of structural and floristic characteristics that reflect variations in their environment.

In the wetter southern blocks, closed heaths up to 2 m tall are generally composed of a limited number of sclerophyllous species such as scented paperbark (*Melaleuca squarrosa*), heath honey-myrtle (*M. squamea*), and prickly tea-tree. Button grass (*Gymnoschoenus sphaerocephalus*) and common heath are common in the low shrub layer, but the ground layer is generally only poorly developed due to root competition and shading. However, restionaceous plants such as slender twine-rush (*Leptocarpus tenax*) and austral cord-rush (*Restio australis*) are locally common. Soils consist of deep wet sands with a high silt content in shallow and broad topographic depressions or in similar poorly drained areas. These deep acid sands are deficient in nutrients, especially phosphorus, and are poorly aerated.

Dry heath at Roseneath

On drier sites in the north, the structure ranges from open heaths of less than 1 m to closed heaths up to 2 m tall. These drier heaths tend to be floristically more diverse. The most important genera include *Xanthorrhoea, Banksia, Leptospermum, Casuarina, Melaleuca,* and *Hakea.* Again, ground layer development is restricted and much of the surface is bare, although orchids are relatively common. In particular, red-beaks (*Lyperanthus nigricans*) is widespread on bare ground, where it may form a significant component of the ground layer. Other common orchids include slaty helmet orchid (*Corybas diemenicus*), small helmet orchid (*C. unguiculatus*), fringed hare-orchid (*Leptoceros fimbriatum*), and parson's bands (*Eriochilus cucullatus*).

In the northern areas heaths are most common in swales and depressions among sand dunes and sand sheets. Soils consist of poorly drained sands of variable but shallow depth overlying an impeding layer of clay or buckshot gravel at less than 1 m. Seasonal waterlogging and drought are probably important factors affecting the structure and composition of these northern heaths.

Heath species are also an important understorey component in open forests and woodlands, especially brown stringybark woodlands common on much of the uncommitted land. The genera occurring most frequently are listed in Table 6.

Swamps

In northern blocks, especially west of the Kanawinka escarpment, swamps are a common feature. Perennial shallow swamps carry a sedgeland of *Juncus* sp. and include tall spike-rush (*Eleocharis sphacelata*) and water-ribbons (*Triglochin procera*). Small hydrophytes such as marsh-flowers (*Villarsia* sp.) and water-milfoil (*Myriophyllum propinquum*) add diversity in these floristically restricted but ecologically important environments. Dense fringing bands of pithy sword

sedge (*Lepidosperma longitudinale*) and prickly tea-tree demonstrate zonation associated with hydroseric succession.

In the Youpayang block, circular swamps of uncertain origin are floristically similar to swamp communities described above. However, in perennial swamps a closed sedgeland up to 3 m tall may create an almost impenetrable barrier, whereas in areas of limited water availability sedgelands of black bristle-rush (*Chorizandra enodis*) and pithy sword sedge to 1 m are more common.

Coastal communities

Two types of coastal communities are found in the study area. A sand dune complex occurs on parts of the calcareous dunes fringing Discovery and Bridgewater Bays. The most common species present are low shrubs such as coast beard-heath, coast wattle, and daisy bush (*Olearia axillaris*), with a ground layer of herbs. Grasses and sedges grow in the swales between the dunes where organic matter has accumulated and the moisture regime is better. Drooping she-oak (*Casuarina stricta*) trees grow on sites that have been stabilized for some time, and moonah (*Melaleuca lanceolata*) is found on the adjacent limestone dunes.

The second community is the coastal swamp complex at Long Swamp behind the dunes of Discovery Bay. In the wetter parts this community contains extensive areas of reeds and sedges such as common reed (*Phragmites communis*) and bull-rushes (*Typha* sp.), and the slightly drier sites carry woolly tea-tree, scented paperbark, and twiggy daisy bush (*Olearia ramulosa*). Rare species found in this complex include the maroon leek orchid (*Prasophyllum hartii*) and the swamp greenhood (*Pterostylis tenuissima*).

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7. FAUNA

The study area contains substantial areas of diverse faunal habitat, including messmate open forest, brown stringybark open forest, heaths, gum woodlands, and swamps. The wide variety of habitats is reflected in the diversity of terrestrial vertebrate species, including more than 280 species of native birds, 39 species of native mammals, 23 species of reptiles, and 9 species of amphibians.

This chapter is based mainly on recent surveys of the uncommitted land carried out by the Fisheries and Wildlife Division and on material supplied by the National Museum of Victoria. The invertebrate fauna of the study area has not been studied in detail, and is not discussed in this report.

Habitat

Animal distribution reflects both the physical nature of the environment and the biological, as each species has specific habitat requirements. Many habitat preferences are related to the vegetation, which often supplies the specific requirements of individual species for food, shelter, and breeding.

This chapter discusses the fauna of six habitats within the study area. Table 7 shows the relation of these habitats to the mapped vegetation units on Maps 5A and 5B.

Table 7

RELATION BETWEEN HABITAT AND MAPPED VEGETATION UNITS

Habitat	Vegetation unit
Open forest II	1a--1i
Open forest I with heathy understorey	2a--2c, 8
Woodland	3a--3e
Closed scrub	4a, 4b
Wetland	9
Softwood plantation	11

Open forest II

The open forest II in this area is a western outlier of the Bassian faunal region of south-eastern Australia. Many species of plants and animals reach the western limits of their distribution here, while others typical of similar habitats further east do not occur, making it of consid-

erable bio-geographic interest. Birds and mammals approaching the western limits of their ranges are listed in Table 8.

Table 8

SPECIES NEARING THE WESTERN LIMITS OF THEIR DISTRIBUTION

Mammals	Birds
Tiger quoll	Gang-gang cockatoo
Brown antechinus	Powerful owl
Dusky antechinus	Pink robin
White-footed dunnart	Rose robin
Feathertail glider	Rufous fantail
Yellow-bellied glider	Satin flycatcher
Potoroo	Pied currawong
Koala	
Great pipistrelle	

This habitat contains diverse and abundant mammal, bird, and reptile communities - a result of the greater structural complexity of the vegetation, high rainfall, and fertile soils. The dense shrub understorey occurring in many areas is a particularly important habitat component for many species, such as the dusky antechinus, potoroo, and rufous fantail.

Many of the species present require tree hollows for shelter and breeding. Of a total of 24 mammal species and 63 bird species recorded in this habitat, 11 of the mammals (46%) and 18 of the birds (29%) use tree hollows. These species are listed in Table 9.

Table 9

SPECIES UTILIZING TREE HOLLOWS

Mammals	Birds
Brown antechinus	Rainbow lorikeet
Brush-tailed possum	Musk lorikeet
Sugar glider	Purple-crowned lorikeet
Yellow-bellied glider	Little lorikeet
Feathertail glider	Yellow-tailed black cockatoo
Eastern pygmy-possum	Red-tailed black cockatoo
Lesser long-eared bat	Sulphur-crested cockatoo
Little brown bat	Gang-gang cockatoo
Goulds wattled-bat	Crimson rosella
Chocolate wattled-bat	Powerful owl
Great pipistrelle	Barking owl
	Boobook owl
	Barn owl
	Masked owl
	Laughing kookaburra
	Sacred kingfisher
	White-throated treecreeper

The extensive clearing of native vegetation and the absence of open forest II in adjoining parts of South Australia increase the significance of this habitat in the study area as a faunal refuge. Five species - the tiger quoll, yellow-bellied glider, rose robin, satin flycatcher, and rufous fantail - only occur in this habitat in the study area.

The continued survival of the full range of species that utilize this habitat will depend on the retention of sufficient large old trees to provide hollows for breeding and shelter as well as a full complement of understorey communities.

Open forest I with heathy understorey

This is the most extensive vegetation formation on public land in the study area, usually with brown stringybark as the dominant tree. On wetter sites the upper layer may be reduced to a few small emergent trees, with a dense heathy understorey of high species diversity. On drier sites the tree layer is usually better developed, with a sparse heathy understorey of low species diversity.

The wide geographic distribution of this habitat and the variation in its structural form from site to site make it one of the most important in the study area. Of the 26 species of native terrestrial mammals recorded in the study area, 23 occur in the open forest I and/or in the associated heaths, the exceptions being the fat-tailed dunnart, which

Yellow-bellied glider

lives in grassland, and the tiger quoll and yellow-bellied glider, which are restricted to messmate open forest II. About 90 species of birds also regularly inhabit this formation.

In south-western Victoria the heaths that occur, or recently occurred, along both sides of the Glenelg River allow vertebrate species that are essentially coastal-heath-dwellers to extend inland to the Dergholm region. These species include the southern emu-wren, swamp antechinus, short-nosed bandicoot, and heath rat. Clearing has made this connection only intermittent, and further destruction of the habitat should be avoided. The occurrence of the heath rat is particularly important, as it appears to exist only in the heaths of the Grampians and those between Casterton and the coast in the study area (see Figure 2).

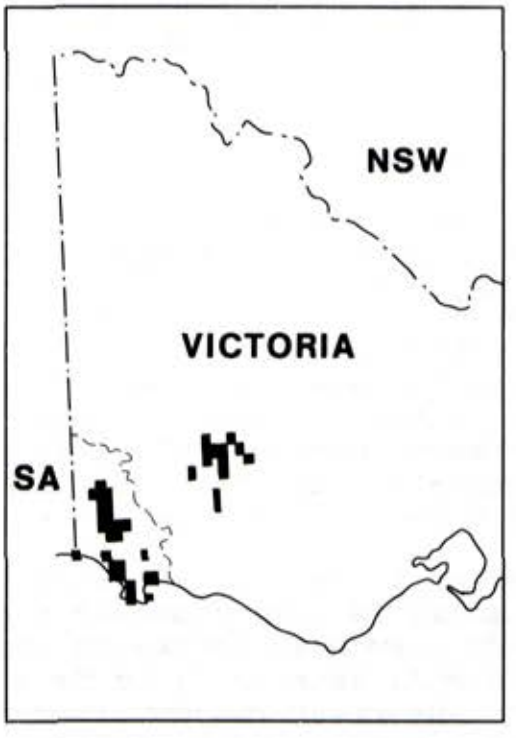

Figure 2. Distribution of the heath rat (Pseudomys shortridgei) *in Victoria*

The changes in species composition (or elimination) of dominant trees and understorey plants adversely affect populations of some honeyeaters, lorikeets, and seed-eating birds and herbivorous mammals. It also results in reduced invertebrate diversity and abundance, thus reducing food resources for small carnivorous mammals, reptiles, and birds.

Woodland

Prior to European settlement, woodlands of river red gum with a predominantly grassy understorey were widely distributed over much of the study area. However, nearly all of this land has been alienated and extensively cleared and developed for agriculture.

Some mammal species (for example, eastern quoll and white-footed tree-rat) have disappeared from the area since then. At present about 90 species of birds and 20 species of

Swamp antechinus

mammals (25% are introduced) still occupy the woodland remnants of the study area.

The populations of many of the native animals will decrease and some will disappear if clearing of those remnants continues. It is estimated that about 10% of the species either are already or will soon be experiencing difficulties in maintaining their population numbers in the study area. These include nine species of birds (bush thick-knee, rainbow lorikeet, musk lorikeet, little lorikeet, purple-crowned lorikeet, barking owl, grey-crowned babbler, blue-faced honeyeater, and grey butcherbird), a mammal species (tuan), and a reptile species (tree goanna).

Most of these species, as well as many other native woodland animals, fall into one or more of the following categories: birds - such as lorikeets and honeyeaters - that move to the woodlands seasonally to feed on pollen, nectar, and insects when the river red gums and yellow gums are flowering; animals - such as owls, possums, tuans, and tree goannas - that require hollows in the trunks or limbs of large trees for breeding or sheltering; and birds - such as thick-knees and babblers - that forage on the ground and appear to depend on woodland with relatively undisturbed understorey.

The continued survival of the species that utilize this habitat will depend upon the retention of sufficient large old trees to provide a food source for nectar-feeding birds as well as hollows for nests and shelter. In most areas the original composition of the understorey has been altered and this has reduced the extent of habitat available for those species dependent upon the understorey for feeding and breeding.

Closed scrub

This habitat is restricted to the southern portion of the study area and occurs in small patches on waterlogged soils.

Only small areas remain in south-western Victoria, and many of these have already been committed to softwood plantations or agriculture. The largest remaining area of closed scrub in the study area occurs as a narrow band in the Lower Glenelg block between the Glenelg River and Rennick.

Its dense structure and floristic diversity make this habitat particularly attractive to small mammals. It is particularly important as the prime habitat of the swamp antechinus. This small marsupial occurs in scattered populations in coastal Victoria west of Sunday Island in Shallow Inlet (see Figure 3), and much of its habitat is threatened throughout its range. Large numbers of short-nosed bandicoots, bush rats, and swamp rats also occur here.

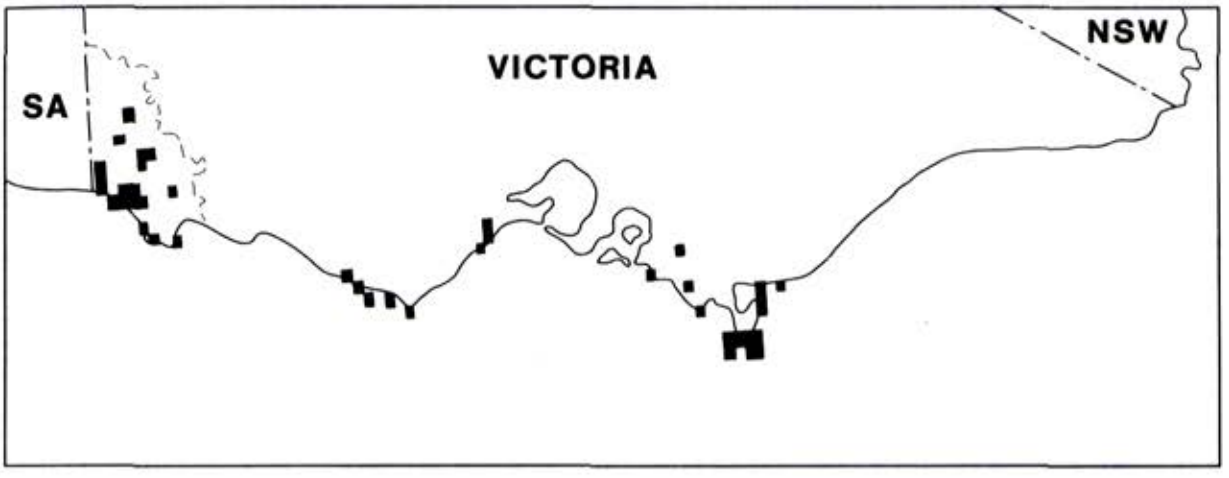

Figure 3. Distribution of the swamp antechinus (Antechinus minimus) *in Victoria*

Wetlands

Heavily vegetated shallow swamps, usually small in size, provide the main aquatic habitats in the study area. Many of these have been the target of drainage schemes in the past as the surrounding areas were alienated. In other cases the surrounding vegetation has been destroyed by grazing of domestic livestock or clearing for crop production to the water's edge.

The swamps of the study area are important for the conservation of waterfowl. They provide important refuge in times of inland drought for all 11 species of duck occurring in southern Australia, and also provide breeding habitat for significant numbers of most of them. These shallow wetlands also support one of the largest populations of the brolga remaining in Victoria.

The other important fresh-water habitat consists of the rivers and streams flowing through the study area. Most of these have already been modified by river 'improvement' schemes, extensive clearing of the catchments, grazing of domestic livestock to the water's edge, and dumping of waste. These modifications have, in most cases, been detrimental to the native fauna utilizing them.

Softwood plantations

As the trees mature, softwood plantations provide a succession of habitats. During the early stages of establishment they provide a grassland habitat. This changes to scrubland as the pines and other species (wattles, eucalypts, and shrubs) grow and eventually, as it approaches maturity, the plantation provides a closed forest with a minimal understorey. Certain native mammals and birds that depend only partially, if at all, on their preferred habitat have shown the ability to utilize some of these successional stages.

A study of the fauna of softwood plantations in north-eastern Victoria indicated that the distribution of native birds in pine plantations depends largely on the amount of remnant native vegetation. The most common species include those that, in eucalypt forests, feed and nest in the canopies and boles of trees, in the shrubby understorey, and on the ground. Those that require hollows in the eucalypts do not breed in softwood plantations, although they may forage there. Another well-documented survey of birds in pine and native forests in New South Wales showed that a considerable loss of diversity of species, and actual numbers of individuals, occurs when pines replace native forest.

Species that do not have a preferred habitat or can survive in small patches of native vegetation have been found in softwood plantations. The absent species are those that rely on eucalypt foliage, sap, and nectar for food or on hollows for shelter or that require a diverse understorey of native shrubs.

Significant Species of Birds

Brolga (*Grus rubicundra*)

The brolga prefers small shallow swamps for nesting, and the shallow wetlands of this area support one of the largest

Brolga

populations left in Victoria. However, the bird's future in Victoria is threatened, as most of the wetlands it uses for nesting are on private land and many are under threat of drainage. Poisoning, shooting, and disturbance have also contributed to a serious decline in brolga numbers.

Bush thick-knee (*Burhinus magnirostris*)

This large nocturnal bird was once common in some open forests and woodlands of Victoria. Its numbers declined with advancing settlement and today it is numerous only in the far north of Australia. While it still occurs in the study area, sightings are rare and sporadic. Destruction of its woodland habitat by clearing is probably one of the reasons for its declining numbers.

Red-tailed black cockatoo (*Calyptorhynchus magnificus*)

The Victorian distribution of this species, one of the largest members of the parrot family, is now confined largely to the brown stringybark open forests of the study area and a few similar areas to the north (see Figure 4). It feeds mainly on the fruits of brown stringybark, and the clearing of land for agriculture has greatly reduced its range. Recent surveys recorded this species at several different locations on public land in the study area.

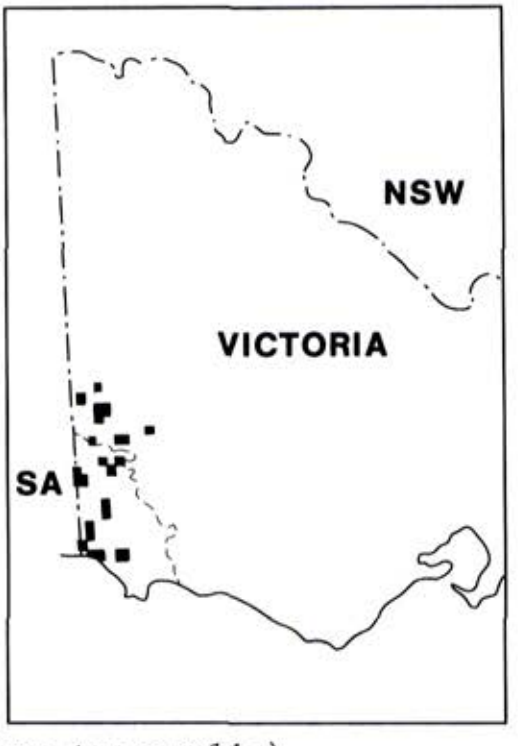

Figure 4. Distribution of the red-tailed black cockatoo (Calyptorhynchus magnificus) *in Victoria*

Grey-crowned babbler (*Pomatostomus temporalis*)

This gregarious species was previously recorded in the woodlands of the study area, but has not been seen since the 1960s. The reason for its decline may be the habitat loss due to clearing of woodland for agriculture and to removal of dense undergrowth by clearing and grazing in the few woodland areas that still remain.

Southern emu-wren (*Stipiturus malechurus*)

The southern emu-wren occurs in wet heaths, and the heaths of the study area are among the strongholds of this shy sedentary bird. There are particularly large numbers in the Weecurra and Roseneath blocks. In the taller sparser heaths immediately to the north of the study area, it is either absent or present in very low numbers.

Rufous bristlebird (*Dasyornis broadbenti*)

This bird is locally common in the thin belt of coastal scrub that extends along the Victorian coast from Torquay to the South Australian border and beyond; the only other known population occurred in Western Australia, but has not been seen there since 1940 and may no longer exist. One of the Victorian localities where the bird appears to be common occurs along the coast west of Portland. However, the thin coastal fringe is fragile, and coastal development, frequent burning, or any land use that removes the thick scrub could quickly jeopardize this population.

Chestnut-rumped hylacola (*Sericornis pyrrhopygius*)

This species is widely distributed in the heath understorey of the brown stringybark open forests of the study area. It has been observed nesting in the heaths below the eucalypts, but not in treeless heaths. The excessive removal of trees in this habitat may change the understorey enough to locally eliminate this species.

Significant Mammals

Yellow-footed antechinus (*Antechinus flavipes*)

This small species inhabits the woodlands and open forests of the study area, which provide one of its most important areas of habitat in Victoria. Recent surveys by the Fisheries and Wildlife Division recorded higher population densities for this species than ever previously recorded in the State. It is widely distributed north of the Great Dividing Range, but population numbers are usually low.

Swamp antechinus (*Antechinus minimus*)

The uncommon swamp antechinus has a restricted distribution in Victoria. It is found in scattered pockets of wet heath along the coast between Port Macdonald, S.A., and Shallow Inlet (see Figure 3). The heaths and wet scrub of the study area are the most extensive remaining habitat for this species. Its distribution extends further inland in the study area than anywhere else on the mainland due to the presence of pockets of suitable heath.

Tiger quoll (*Dasyurus maculatus*)

Although tiger quolls are widespread in Victoria, their numbers are very low. They live in forested areas and

shelter in logs and rock piles. A remnant population lives in the Stones Faunal Reserve between Mount Eccles and Lake Condah, and occasional sightings have also been reported from time to time in the Cobboboonee forest.

Yellow-bellied glider (*Petaurus australis*)

The yellow-bellied glider is found in the open forest II of the Great Dividing Range east of Melbourne. Small isolated populations also occur in the Otway Ranges, in the messmate forests in the south of the study area, and in yellow gum woodlands near Edenhope. This species requires deep tree hollows for breeding and shelter. Its long-term survival in the study area will depend on retaining sufficient mature trees to provide such hollows.

Wombat (*Vombatus ursinus*)

In eastern Victoria, wombats are so abundant they are declared vermin. By contrast, in western Victoria, where their numbers have declined significantly, they are now a protected species. A few isolated populations remain, mainly on freehold land, in the Dergholm--Kanawinka area and on public land at the Baileys Rocks Reserve, Lake Mundi, and in the Lower Glenelg National Park. However, the levels of these populations are very low and their long-term viability appears doubtful.

Silky grey mouse (*Pseudomys apodemoides*)

The silky grey mouse is widespread and common in the Little Desert and Big Desert in north-western Victoria (see Figure 5). During recent surveys it was trapped in the north of the study area. This represents the southern limit of its range.

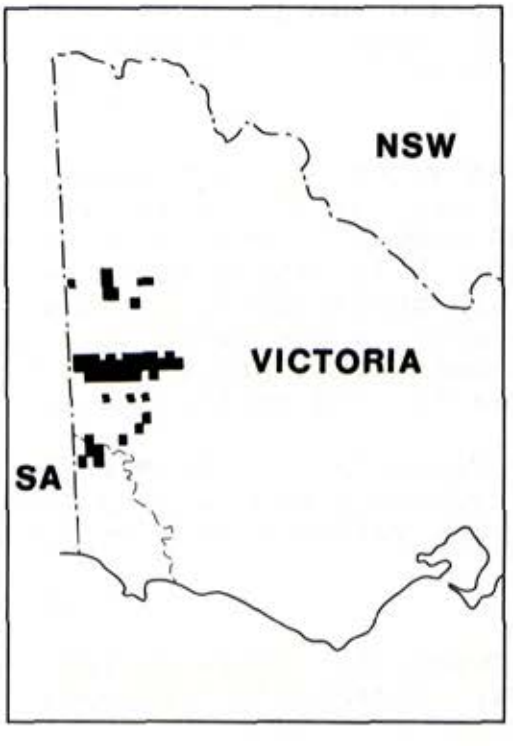

Figure 5. Distribution of the silky grey mouse (Pseudomys apodemoides) *in Victoria*

Heath rat (*Pseudomys shortridgei*)

This species has an extremely restricted distribution; and is now found only in the heaths of the Grampians and in the area bounded by Casterton, Mount Clay, and Nelson (see Figure 2). Recent work has shown the importance of fire in maintaining the floristic diversity of the heaths this mammal utilizes. The absence of fire means an increasing shortage of food for the heath rat, as it relies on that floristic diversity. In order to ensure the rat's survival, it will be necessary to draw up a carefully planned program to provide a mosaic of patches of heath at various stages of post-fire succession.

Reptiles and Amphibians

Reptiles have three major ecological requirements: a suitable thermal area, as they rely on external factors to control body temperature; a suitable micro-environment where they can remain inactive and shelter during unfavourable conditions; and a warm dry egg-laying site for oviparous species. Out of a Victorian total of about 100 species, 23 have been recorded in the study area.

The only native amphibians found in Australia are frogs. As frogs have only a limited ability to control water loss through their skin, they need fresh water or high humidity for the development of embyros and larvae, and so their distribution depends strongly on precipitation and temperature. Nine species have been recorded in the study area; one of these, *Geocrina laevis*, is restricted to the Grampians and the southern portion of the study area.

Fish

The study area contains eight large fresh-water rivers and lakes and two important estuaries. All the fresh waters carry large populations of native fish - up to 14 species - and some also contain several introduced ones. The estuaries contain 18 native fish species.

Fresh waters of high value for conservation of native fish include: Darlots Creek, which contains an excellent native fish community with a particularly good population of blackfish; Bridgewater Lakes, which carry an unusual combination of ten varieties of fresh-water fish and comprise one of the few areas where dwarf galaxiids are present in good numbers; and Swan Lake, which supports good populations of common galaxiids and spotted galaxiids.

The estuaries of the Glenelg and Fitzroy Rivers are important spawning and nursery areas for bream and estuary perch and are valuable for the conservation of native fish.

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8. LAND SYSTEMS

The preceding chapters have described the main bio-physical components of the natural environment. However, no single environmental factor determines the best land use option. Rather, it is the combined or integrated effect of them all that determines land capability.

The need to consider the interrelated effects of a number of environmental variables has resulted in the land-systems approach. This allows each feature of the environment to be considered in relation to the others, instead of separately as in a soil or vegetation survey.

The most detailed and fundamental unit for mapping and description is the land component, in which the climate, parent materials, soil, and vegetation are uniform within close limits. Land components usually occur in a limited number in a consistent repetitive sequence, and an area containing such a sequence is termed a land system. A land zone is composed of a small number of similar land systems, which together form a major area of characteristic regional topography.

Map 6 shows the 18 land systems that have been identified in the study area. They have been arranged into eight land zones that reflect the major geomorphic provinces.

Table 10 describes the characteristics of rainfall, land form, geology, soils, and vegetation for each land system. The soils are classified according to a system developed by Northcote (1971) and readers are referred to this publication for a detailed description.

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Table 10

LAND SYSTEMS

Land zone	Land system	Average annual rainfall (mm)	Land form	Geology	Soils	Vegetation	Comments
1. Nelson - coastal dunes fringing the Mount Gambier and Tyrendarra coastal plains	Discovery Bay	710--790	Coastal sand dunes	Pleistocene and Recent calcareous sands	Undifferentiated yellow-brown calcareous sands (Uc 1.11)	Large areas unvegetated; pioneering grasslands of marram grass and hairy spinifex; open scrub of *Acacia longifolia*, *Casuarina stricta*, and *Melaleuca lanceolata*; some heaths	Unstable dunes, susceptible to wind erosion
	Long Swamp	710--760	Coastal swamp and dune complex	Recent swamp deposits and calcareous dunes	Friable peat (O soils); dark grey-brown sand overlying yellow-brown sand (Uc 1.11)	Sedgeland of reeds and rushes fringed by wet heaths of *Melaleuca* and *Leptospermum* spp.; open scrub of *Melaleuca lanceolata*, *Acacia longifolia*, and *Casuarina stricta*	Dunes susceptible to wind erosion
	Nelson	680--890	Consolidated dune ridges, and sand sheets	Pleistocene dune limestone and orange siliceous sands	Shallow red and black sandy loams (terra rossa) (Uc 6.13) and rendzina (Um 6.1) over limestone, leached acid sands elsewhere (Uc 2.2)	Eucalypt woodlands including *E. viminalis*, *E. ovata*, *E. nitida*, and *E. baxteri*, with heath and scrub of *Melaleuca lanceolata*	Moderate to low sheet and wind erosion hazard; soils deficient in trace elements
2. Heywood - major component of the Mount Gambier and Tyrendarra coastal plains	Strathdownie	660--760	Broad coastal plain developed between low dune ridges	Pleistocene and Recent lagoon deposits	Grey-brown coarse sandy loam overlying mottled heavy clay (Dy 5)	Open woodland of *E. camaldulensis* and woodland of *E. ovata*; *E. viminalis* on drier sites; heaths include *Casuarina* spp., *Leptospermum* spp., and *Banksia marginata*	Largely cleared and drained for agriculture; very low erosion hazard
	Heywood	750--850	Flat to undulating coastal plain	Tertiary limestone and Quaternary alluvium	Dark grey-brown loam merging to olive brown sandy clay (Dy 5); other duplex and gradational soils, including red-brown loam overlying clay loam on limestone	Forest and woodland formations of *E. viminalis*, *E. obliqua* and *E. ovata*, with heath understorey of *Melaleuca* spp., *Banksia marginata*, *Casuarina* spp., and bracken	Mostly cleared for agriculture; low erosion hazard
3. Kanawinka - wind-blown sand dunes and sand sheets of the Mount Gambier coastal plain, also fringing the western margins of the Dergholm Platform and Dundas Tableland	Follett	630--830	Siliceous sand dunes and sand sheets with inter dune swamps - especially west of the Kanawinka escarpment	Siliceous, acidic Malanganee sands and Pleistocene lagoon deposits	Leached dark grey to white acidic sand sometimes overlying buckshot gravel; sand may be up to 30 m deep (Uc 2.33, 2.2)	Woodland of *E. baxteri* with heath understorey very widespread, some heath plains of *Leptospermum juniperinum*, *Banksia marginata*, and *Xanthorrhoea* spp.	Much of this remains uncommitted public land; not well suited for agriculture, moderately suitable for pines with adequate site preparation; low erosion hazard under current climatic conditions
	Kanawinka	630--900	Siliceous sand dunes and sand sheets mantling tablelands east of the Kanawinka escarpment	Siliceous, acidic Malanganee sands overlying Tertiary sandy deposits and fossil laterite	As above, but sand generally not as deep; buckshot gravel often present	As for Follett	As for Follett
4. Dundas - lateritized plateau and dissected plains of the Dundas Tablelands	Dundas	610--740	Extensive flat plateau; some areas of shallow dissection	Fossil laterite	Brown sandy loam overlying gravelly loam and mottled orange heavy clay (Dy 3.61); grey clays in shallow depressions	Open woodland of *E. camaldulensis*, *E. ovata*, and *E. viminalis*, with small areas of *E. nitida*, *E. obliqua*, and *E. pauciflora*	Largely cleared for agriculture; virtually no public land; low to moderate erosion and salting hazard
	Glenelg	610--810	Deeply dissected valleys cut below the tablelands	Palaeozoic sedimentary, igneous, and metamorphic rocks	Brown-grey coarse sandy loam over yellow-grey coarse sand and mottled yellow-brown heavy clay; weathered bedrock at shallow depth, sandy alluvium and clays on valley floor (Dy 3.61, 3.81)	Woodland formation of *E. camaldulensis* and *E. viminalis* with *Casuarina stricta* on drier sites; tussock grasslands on lower slopes	Widely used for agriculture, severe hazard of sheet, rill, and gully erosion, and of salting
5. Casterton - dissected tableland of the Dergholm Platform and Merino Tablelands	Casterton	600--725	Broad, dissected valleys of steeply rolling hills cut below the level of the Dundas Tablelands	Mainly Mesozoic sediments and Permian glacial deposits	Dark brown to black clay loam overlying dark brown clay, well structured and cracking throughout (Ug 5.1, Gn 3.4)	Tussock grasslands on upper slopes; open woodland of *E. camaldulensis* with grassy understorey along creek lines; *Casuarina stricta* may form a woodland on drier sites	Severe hazard of all forms of mass wasting from earth flows to rill and gully erosion; severe salting hazard on lower slopes; widely used for agriculture
6. Hamtilton - basalt plains and stony rises of the volcanic plains	Hamilton	625--750	Generally flat to broadly undulating basaltic plains	Plio--Pleistocene basalt	Grey-brown silty loam over gravelly loam and mottled brown clay (Dr 2 and Dy 3)	Woodlands of *E. viminalis* and *E. ovata* with *Acacia* spp., *Casuarina stricta*, *Banksia marginata*, and *Exocarpos cupressiformis*	Mostly cleared for agriculture; low--moderate hazard of sheet erosion, shallow gullying, and salting
	Branxholme	650--750	Broad open valleys with long gentle slopes and undulating to rolling hills	Tertiary limestone and marl exposed below the general level of the volcanic plains	Brown sandy loam and gritty sandy loam overlying a mottled red, brown, and grey sandy clay (Dy 3)	As for Hamilton	As for Hamilton
	Eccles	675--750	Stony rises associated with last eruptive phase of Mt Eccles	Moderately vesicular and blocky basalt of Holocene age	Shallow and stony red-brown organic loam (UM 6.4)	Woodland of *E. viminalis*, *Acacia melanoxylon*, and *Exocarpos cupressiformis* with understorey of bracken and grasses, mainly *Poa australis*	Excessive stoniness precludes cultivation; no serious erosion hazards
	Condah Swamp	650--750	Swamp formed upstream of impounding valley lava flow	Recent swamp deposits and some Holocene basalt	Mainly peats and peaty clays (O soils)	Closed scrub of *Leptospermum lanigerum* fringed by tussock grasses	Area drained and extensively used for agriculture; severe humification losses following drainage
7. Portland--elevated basaltic plains of the Normanby Platform and Mount Clay block	Cobboboonee	750--900	Mildly dissected basalt sheets forming a flat to undulating plain	Plio-Pleistocene lava flows	Red-brown clay loam merging into mottled red-brown clay; also gravelly loam and grey-brown gravelly clay loam merging to yellow and mottled red clay, more massive at depth (Dy 3.61)	Forest or tall woodland of *E. obliqua* with *E. nitida* and *E. viminalis*; some areas of *E. baxteri* with heaths and swamps	Large tracts committed for hardwood production; low erosion hazard
	Drumborg	800--850	Complex of cinder cones and associated lavas and tuffs	Plio--Pleistocene lava flows with cinder and tuff cones	Red-brown clay loam merging into mottled reddish-brown clay (Dy 3.61)	Forest or tall woodland of *E. viminalis*, *E. nitida*, and *E. ovata*, *Casuarina stricta* in dry places	As for Cobboboonee
	Greenwald	750--875	Dissected valleys below the level of the Cobboboonee basalt sheets	Tertiary sediments - chiefly limestone	Grey-brown loam and clay loam over yellow-brown light clay merging to mottled brown and orange clay (Dy 3)	Forest or tall woodland of *E. nitida* and *E. viminalis* with some *E. ovata* and *E. obliqua*	Some areas committed for hardwood, production; small area uncommitted land; low--moderate erosion hazard
8. Lowan - major component of the Wimmera Plains	Lowan	625--700	Regionally flat plain with subparallel low dune ridges trending NNW; swamps are a common feature	Miocene limestone with a veneer of Quaternary swamp and lagoon deposits	Fine brown sandy loam and fine grey-brown sand overlying mottled orange-brown to red clay (Dr 3.42, 3.43)	Open woodland of *E. camaldulensis* with small areas of *E. leucoxylon* and *E. fasciculosa*	Mainly cleared for agriculture; very low erosion hazard

PART III
CURRENT LAND USE

9. NATURE CONSERVATION

This chapter deals with nature conservation, which includes the protection of native species, natural features, and landscapes. Protection of these attributes is important for a number of land uses, including reference, conservation of species, recreation, and education. None of them necessarily monopolizes the land; often conservation needs are compatible with each other or with commercially productive uses of land.

The clearing of much of the land within the study area in the past for agriculture and more recently for pine plantations has greatly reduced the area of native vegetation. The remaining uncleared areas are thus important for nature conservation, particularly as much of the adjoining land in South Australia has also been cleared.

Existing Conservation Reserves

In its 1973 final recommendations for this study area, the Land Conservation Council recommended various types of conservation reserves. Table 11 lists these reserves with their areas, and their location is shown on Map 2, Public Land Use.

Table 11

EXISTING CONSERVATION RESERVES

Reserve		Area (ha)
Parks:	Lower Glenelg National Park	27,300
	Mount Richmond National Park	1,707
	Cape Nelson State Park	210
	Crawford River Forest Park	1,900
	Discovery Bay Coastal Park	8,530
	Wilkin Park (*)	3,640
Reference areas		4,310
Wildlife reserves		6,400
Flora reserves		790
Various other small conservation reserves		500 (approx.)
Total		55,287

* Wilkin Park is currently unoccupied Crown land protected by Section 36 of the *Land Act* 1958, pending possible future incorporation into the parks system. The Land Conservation Council will make a recommendation on such incorporation in the process of this review.

Since those final recommendations were published in April 1973, the National Parks Service has purchased 176 ha of land at Cape Nelson that has been reserved as a State Park, and the Fisheries and Wildlife Division has purchased 130 ha of land at Pieracle Swamp east of Wilkin for a wildlife reserve. These two areas are also shown on Map 2, Public Land Use.

Parks

The different categories of parks contain examples of the major land types and their associated biological communities within the study area.

Lower Glenelg National Park has a high value for nature conservation, as it covers an extensive area and includes a diverse range of vegetation communities. Notable botanical features of the park include the well-developed fern gully of Little Moleside Creek and the extensive, botanically diverse communities of the Kentbruck Heath. More than 660 species of vascular plants have been recorded in the park, including 10 that are rare in Victoria and 62 that reach the western-most limits of their distribution there. The park also supports a large faunal population, including more than 160 species of birds and 30 species of mammals. The limestone cliffs of the Glenelg River Gorge are used by peregrine falcons and other raptors, and the limestone caves in the park contain many fossils and provide shelter and breeding sites for two species of bats.

Mount Richmond is an extinct volcano covered with sand. Mount Richmond National Park includes a range of vegetation types growing on the different aspects of the former volcano and is noted for its heaths and heathy understorey plants, with their spectacular wildflower displays. The over-mature trees within the park provide hollows, for nesting and

Soap mallee in Cape Nelson State Park

Tarragal Caves - Discovery Bay Coastal Park

shelter, for many species of arboreal birds and mammals. The park is thus a valuable area for nature conservation, particularly as most of the adjoining land has been cleared for agriculture or pine plantations.

Cape Nelson State Park contains good examples of coastal vegetation developed on dune limestone. Although relatively small in size, the park is important for nature conservation as it includes the only Victorian occurrence of soap mallee (*Eucalyptus diversifolia*).

The dominant feature of Discovery Bay Coastal Park is the extensive system of mobile calcareous sand dunes stretching from Cape Bridgewater to Nelson. A chain of lakes and swamps behind the dunes provides habitat for coastal and estuarine fauna. Although large areas of the dunes are unvegetated, the vegetation associated with many of the wetlands is quite complex and includes several rare species of orchids. This park contains one of the largest undisturbed areas of coastal dune and swamp vegetation in western Victoria and is thus important for nature conservation.

Other parks in the study area include Crawford River Forest Park and Wilkin Park. The former contains the forested valley of the Crawford River, with good examples of the indigenous forests of this area. Wilkin Park consists of a large undeveloped area dominated by brown stringybark forests, heaths, and swamps. It contains representatives of the land types that have been extensively cleared for pine plantations.

Reference areas

The solution to problems arising from use of a particular land type is often helped by reference to an undisturbed ex-

ample of the land type. Here the soils, vegetation, and fauna can be studied under natural conditions and the knowledge gained of the basic relations operating between those components can help solve land use problems.

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

The 1973 final recommendations set aside four areas, totalling 4,309 hectares, as reference areas. They contain representatives of the major land types found in the study area. As far as possible natural processes should be allowed to continue undisturbed within these areas. Access is restricted and experimental manipulation is not permitted.

Wildlife reserves

The conservation of fauna depends on the conservation of habitat, and by far the largest remaining area of natural habitat is on public land. Although many forms of land use do not have marked detrimental effects on habitat, some areas have been set aside specifically for wildlife conservation and for developing wildlife conservation techniques.

The 15 wildlife reserves in the study area are managed primarily for the conservation of native fauna. Many of these reserves provide good breeding and feeding areas for large numbers of water-birds.

Other conservation reserves

The study area also contains flora reserves and bushland reserves. Flora reserves are managed to conserve plant species that may be rare or endangered and associations of native plants that are poorly represented on public land. Bushland reserves are small areas of public land in predominantly cleared agricultural regions that support remnants of the original vegetation. Their major use is to provide diversity in the landscape and to maintain the distinctive Australian character of the countryside.

Other small areas of public land include road reserves, river and stream frontages, and small isolated blocks of public land. These are particularly important for nature conservation in those parts of the study area that have been extensively developed for agriculture, as in many cases they support the only remnants of the original vegetation.

The conservation value of small areas of native vegetation increases greatly if they are inter-connected. Such connections allow native animals to move from one block of native vegetation to another and also assist migratory and nomadic birds. This is particularly important in the planning of pine plantations, as the conservation of native fauna is

greatly assisted by retaining inter-connected areas of native vegetation within the plantation complex.

Education is an important use of land in a natural or near-natural state. Forests, rivers, and other natural landscapes have many applications in education - from primary to post-graduate levels - giving students opportunities to see natural land forms and observe, interpret, collect, and monitor biological processes. In some cases this may involve long-term studies or alterations to the environment for experimental purposes. This may require some land to be specifically set aside for education.

10. RECREATION

Outdoor recreation is an important use of public land and is a major reason for the retention of natural areas.

The diverse natural features of the study area provide opportunities for a wide range of outdoor recreational activities. The most popular areas for outdoor recreation here are along the coast between Nelson and Portland and along the lower reaches of the Glenelg River.

These areas contain the most outstanding natural attractions and are close to the major centres of population and major tourist roads.

Table 12 shows the number of people visiting and camping in parks under the control of the National Parks Service. It should be noted that camping is only permitted in two of these - the Lower Glenelg National Park and the Discovery Bay Coastal Park. These parks already attract large numbers of visitors.

The growth in the population of the Portland area associated with the Alcoa Aluminium Smelter is likely to cause a further increase in the number of people using these parks and other areas of public land for outdoor recreation.

Table 12

ESTIMATED NUMBERS OF VISITORS AND CAMPERS IN PARKS

Park	Total visitor days		Camper nights	
	1978/79	1979/80	1978/79	1979/80
Lower Glenelg National Park	57,000	61,500	7,000	11,500
Discovery Bay Coastal Park	29,000	31,000	2,500	2,600
Mount Richmond National Park	22,500	18,300		-
Cape Nelson State Park	1,000	20,000*		-

* Better estimation technique used

Source: National Parks Service

Recreational Activities

Fishing

Fishing is one of the most popular outdoor recreational activities in the study area. Table 13 lists the main inland angling waters of the study area and the main species caught there. Many of these waters are regularly stocked with trout.

The estuaries of the Glenelg and Fitzroy Rivers are popular sport-fishing areas, with bream, yellow-eyed mullet, and estuary perch being the most abundant species caught. The Glenelg estuary also contains a seasonal population of mulloway that provides the best sports opportunity for catching this species in Victoria.

Along the coast, popular areas for surf and rock fishing include Nobles Rocks, Suttons Rocks and other points along the Discovery Bay coastline, Bridgewater Bay, and the mouth of the Surry River at Narrawong.

Table 13

ANGLING AREAS

Catchment	Site	Angling species	Comments
Fitzroy River	Arrondoovong Creek (Branxholme)	brown trout blackfish eels	stocked regularly with brown trout
	Branxholme Reservoir	redfin	bank fishing only (domestic supply)
	Bridgewater Lakes	brown trout	stocked regularly with brown trout; only northern-most lake suitable for angling
	Camp Creek (Branxholme)	brown trout blackfish eels	stocked regularly with brown trout
	Darlot Creek (Tyrendarra)	brown trout blackfish eels tupong	stocked regularly with brown trout
	Fitzroy River (Heywood)	brown trout eels tench crucian carp tupong blackfish	stocked regularly with brown trout; estuary fish found 16 km upstream from mouth

Table 13 (*continued*)

Catchment	Site	Angling species	Comments
Glenelg River	Lake Monibeong (Nelson)	rainbow trout	No longer stocked
	Crawford River (Dartmoor)	redfin brown trout rainbow trout blackfish eels fresh-water crayfish	Stocked regularly with brown trout
	Glenelg River (Casterton)	brown trout redfin eels blackfish tupong rainbow trout bream mullet salmon estuary perch mulloway	Stocked regularly with brown trout upstream from Casterton; estuary fish extend for 60 km upstream from mouth
	Kangaroo Creek (Hotspur)	brown trout blackfish eels redfin	Receives trout from Crawford River
	Stokes River (Dartmoor)	eels blackfish tupong fresh-water crayfish brown trout	Not stocked

Source: Tunbridge, B.R., and Rogan, P.L. (1977).

Boating and canoeing

The five-fold increase in boat registration in Victoria over the last 5 years reflects the increasing popularity of this activity throughout the State. Boating takes place at various locations in the study area and involves the use of boats for fishing, cruising, picnicking, and water-skiing. The Glenelg River is very popular, and boat ramps and jetties have been constructed at various locations along the river.

Water-skiing is permitted on the Main Lake at Bridgewater Lakes, and two areas are zoned for water-skiing on the Glenelg River in the Lower Glenelg National Park.

Bridgewater Lakes - a popular water skiing venue

The Glenelg River is also very popular for canoeing. It is well suited for canoe trips, as the water is safe with no sections of fast flow. It is estimated that nearly 2,000 people went canoeing on the Glenelg River in the Lower Glenelg National Park in 1979. Many of the canoeists are school groups who use the river as part of outdoor education programs. Longer canoe trips involving overnight camping are also popular.

Hunting

Ducks are the major game species hunted in the study area, and the swamps on private and public land attract many shooters. Duck-shooting takes place on a seasonal basis on the following game reserves managed by the Fisheries and Wildlife Division: Crawford Lake, Red Hill Swamp, Church Swamp, Beniagh Swamp, Lake Condah, Sinclair Lake, Tremaine Swamp, and Grassy Flats. Unlike other parts of the State, the study area contains numerous widespread small lakes and swamps rather than a few large ones.

Other game species hunted in the study area are stubble quail, which are shot in grassland and stubble paddocks on private land, and Japanese snipe. The hunting of both these birds is only permitted during the annual open season for each species and, like duck-shooting, is subject to bag limits imposed by the Fisheries and Wildlife Division. Deer sightings have been reported in the study area in the past, but the area has little potential for deer-hunting due to the very low numbers present.

Recreational driving

Most recreational driving in the study area is done in two-wheel-drive vehicles. For many people, pleasure driving and

sightseeing are major activities, while for others driving provides access to areas where they engage in some other recreational activity.

Many roads, ranging in standard from major sealed roads to forest tracks, are popular for recreational driving due to their attractive scenery. A scenic drive has been developed in the Crawford River Forest Park, and another in the Lower Glenelg National Park gives fine views of the Glenelg River Gorge.

Pleasure driving is usually associated with picnicking, and picnic areas have been developed in all of the parks and on other areas of public land. Many of these sites are close to attractive pieces of forest, fern gullies, river frontages, or features of geological interest.

Another form of recreational driving, dune buggying, takes place in a designated area in the sand dunes near Swan Lake in the Discovery Bay Coastal Park. This area, the only one of its kind in Victoria, is run by the Portland Dune Buggy Club under the supervision of the National Parks Service. The buggies are usually registered only for off-road use, and are brought to the area on trailers, off-loaded, and driven up a ramp into the dunes.

Camping

Camping is popular along the coast and the lower reaches of the Glenelg River. Bush camping is permitted by arrangement with the rangers in some areas in the Lower Glenelg National Park and the Discovery Bay Coastal Park. Few facilities are provided in these areas and only tent camping is allowed, except at the Princess Margaret Rose Caves in the former,

Picnic facilities, Long Lead Flat

where caravan camping is also permitted, and at Swan Lake and Lake Monibeong in the Discovery Bay Coastal Park. Camping is also permitted on State Forest and Crown land as long as the requirements relating to fire control and rubbish disposal are met.

The number of campers in the Lower Glenelg National Park has risen from 358 in 1976 to 2,668 in 1979, an increase of more than 500%. Many people camp in order to enjoy other outdoor activities such as fishing, water-skiing, and nature study. In addition, visitors use caravan parks in many of the towns throughout the area as a base for outdoor recreational activities on public land.

Nature study

While many people visit public land specifically to study nature, a far greater number incorporate nature study with other activities such as bushwalking, picnicking, camping, and recreational driving.

The study area has much to offer for nature study and bird-watching, due to its diverse range of habitats and vegetation types. Sites of particular interest include the botanically diverse Kentbruck Heath with its spectacular wildflower displays, the 'Petrified Forest' caused by wind and water erosion of the old scrub root system at Cape Bridgewater, and the only known Victorian occurrence of soap mallee (*Eucalyptus diversifolia*) at Cape Nelson.

A 3-kilometre nature walk has been developed in the Cape Nelson State Park, which passes through a variety of different plant formations and also offers spectacular views of Cape Nelson and Bridgewater Bay. The Benwerrin nature walk is currently being developed at Mount Richmond National Park and the Glenelg nature drive has been developed for motorists in the Lower Glenelg National Park.

Walking

Two types of activity fall within this category: short walks along prepared sign-posted tracks and extended walks of several days' duration.

Short walking tracks have been developed at Mount Richmond National Park and at Surry Ridge, Jackass Gully, and Sawpit Gully in State Forest. In addition, fire-access tracks in the Lower Glenelg National Park and in other areas of State Forest and Crown land provide a range of walks.

The study area is not currently as popular as other parts of the State for extended walks. However, it is planned to develop an extended walking track, the Great South West Walking Track, in the near future. This will start at Heathmere and will head west through the Cobboboonee forest and then along the Glenelg River through the Lower Glenelg National Park to Nelson. It will then head along the coastline around Discovery Bay, Cape Bridgewater, and Cape Nelson to

finish on the coastal reserve at She-oak Road, Portland. It is planned that this walking track will follow existing tracks as far as possible, and work has already commenced on the first portion.

Other activities

The Princess Margaret Rose caves north of Nelson on the South Australian border attract many visitors, who drive from the Princes Highway or travel by boat from Nelson. Guided tours are conducted at regular intervals through the limestone caves, which 28,785 people visited in 1978/79.

Access tracks through pine plantations and forests are used for horse-riding, which also takes place along the beach of Discovery Bay Coastal Park between Lake Monibeong and Descartes Bay. The coastal reserve provides access for swimming and surfing as well as for various forms of boating.

Small areas of public land throughout the study area are reserved for formal recreational activities such as golf, tennis, cricket, football, and horse racing.

References

Byrne, N., and Rogers, N. 'Discovery Bay Coastal Park Visitor Use Survey, January 1981.' (National Parks Service of Victoria: Melbourne 1981.)

Taylor, S. 'Mount Richmond National Park Visitor Use Survey 1978.' (National Parks Service of Victoria: Melbourne 1978.)

Tunbridge, B.R., and Rogan, P.L. 'A Guide to the Inland Angling Waters of Victoria.' (Fisheries and Wildlife Division: Melbourne 1977.)

11. PRIMARY PRODUCTION

Agriculture

The pastoral industries dominate land use on freehold land in the study area, producing wool, livestock, and dairy produce with a gross value of the order of $15 to $20 million per annum. As many of the townships of the study area are based upon service industries that transport, market, and process agricultural products and/or supply farm inputs, the pastoral industries have a significant effect on the regional economy.

Present use of developed farmland

Table 14 lists the different agricultural land uses on freehold land in the study area. It shows the dominance of pasture, and therefore of the livestock industries, in local agricultural land use. Wool, prime lamb, and beef production are the major industries; dairying is of minor importance and is restricted to small areas around Portland, Heywood, and Merino.

Table 14

AGRICULTURAL LAND USE 1978/79

Land use	Shire of Portland (ha)	Shire of Glenelg (ha)	Total (ha)
Sown pasture	159,628	161,984	321,612
Cropping	3,023	3,051	6,074
Native pasture	22,712	38,768	61,480
Other land uses*	20,992	29,419	50,411

* Includes land not used for production, such as roads, dams, rivers, rocky outcrops, land lying idle, etc.
Source: Australian Bureau of Statistics

Figure 6 shows the trends in livestock numbers for the period 1966/67 to 1979/80. Sheep numbers declined significantly between 1970/71 and 1974/75, but since then have been steadily increasing as the reserve price scheme for wool has led to more stability in the industry. Beef cattle numbers reached a peak in 1974/75 after low wool prices in the early 1970s caused many farmers to switch to beef production, but this trend reversed when beef prices collapsed and wool prices improved. The numbers of dairy cattle are steadily declining.

Small areas carry cereal crops, vegetables, potatoes, orchards, and vineyards. Although these products are of local importance, their contribution to State production is small.

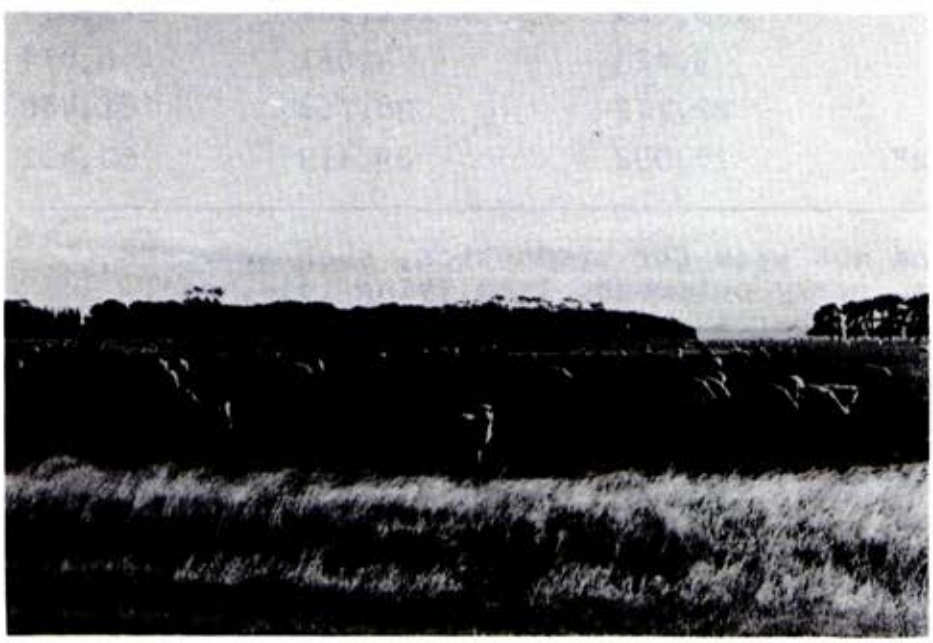
Public land

At present public land is only used for agriculture to a very limited extent. Small areas are held under grazing licence and are usually grazed in conjunction with the adjoining freehold land. An exception to this general rule is the Palpara Settlement Scheme, where a total of approximately 2,800 ha of public land has been cleared and pasture established. This land is currently being made available for agriculture by the Rural Finance and Settlement Commission.

In general, the uncommitted land in the study area has a low potential for agriculture, as clearing and development costs on the infertile sandy soils that cover much of it would be high. Some small scattered areas have a higher potential, although many also have value for other uses such as conservation of flora and fauna, gravel extraction, and recreation.

Future developments

The introduction of a reserve price scheme for wool and the development of a large-scale export market for live sheep from Portland to markets in the Middle East has led to a profitable sheep industry in the last few years. In 1976 Victoria exported 90,000 live sheep to countries in the Middle East and by 1980 the number had increased to 713,000. Large quantities of sheep meat are also being exported to the Middle East. If the good prices received on this market continue it is expected that many local producers will increase their production to cater for this market.



Sheep on freehold land near Digby

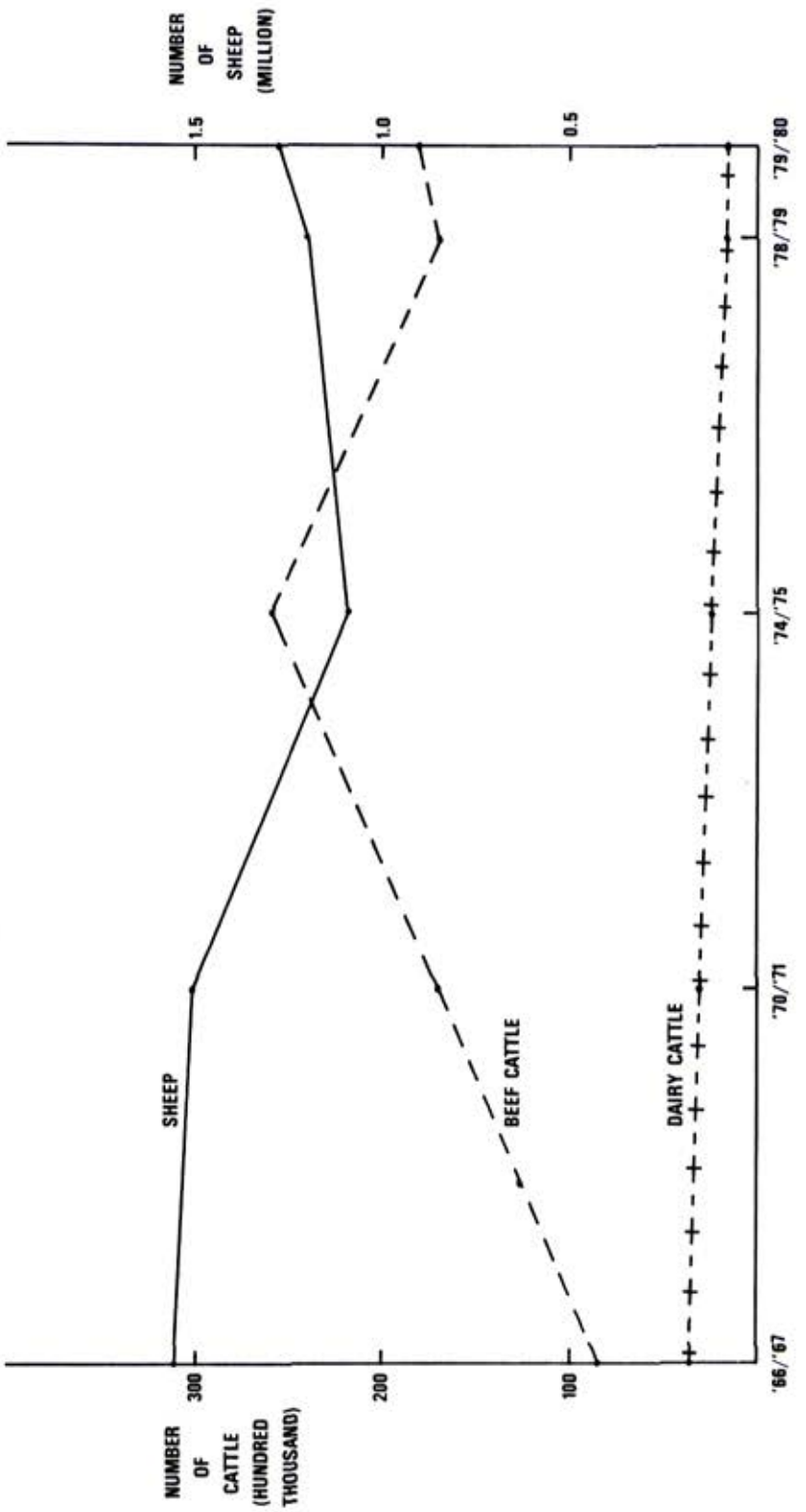


FIGURE 6 : TRENDS IN LIVESTOCK NUMBERS

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Herefords under river red gum, near Digby

In contrast, the cattle industry, which is currently booming, is expected to go into a cyclic downturn in the next few years. The large-scale slaughtering of breeding stock during the collapse of the beef market in 1974/75 had a detrimental effect on the beef industry and has led to a shortage of cattle.

Apiculture

Apiculture is a small primary industry producing honey and beeswax. Honey is used for table consumption, confectionery manufacture, and stock feeds, and in the preparation of meat, vinegar, and some pharmaceutical and cosmetic products. Beeswax has many uses, including candle, cosmetic, and polish manufacture. Table 15 gives statistics for honey production in Victoria over the last 4 years. Production fluctuates considerably from year to year depending on intensity of flowering of the best honey-producing eucalypts.

Table 15

HONEY PRODUCTION IN VICTORIA

	1975/76	1976/77	1977/78	1978/79
Number of apiarists	492	520	455	477
Number of hives	91,203	92,734	82,000	86,000
Honey production (tonnes)	3,470	1,713	3,106	2,715
Beeswax production (tonnes)	60	30	46	47

Source: Australian Bureau of Statistics

The value of a particular tree or shrub species for beekeeping depends on its flowering period and its yield of nectar and pollen. The most important for apiculture in Victoria are the eucalypts. A few other species also yield some useful amounts. Flowering periods vary, not only between species but also within species from district to district depending on local climatic conditions. Most eucalypts flower heavily every second or third year.

Because of its dependence on flowering eucalypts, beekeeping must be migratory. To maximize production, hives are moved from district to district to coincide with peak nectar flows over the summer months. Hives must be placed not only close to the nectar source, but also close to a reliable source of water.

Table 16 shows the important nectar - and pollen-producing plants used by beekeepers in the study area. The messmate, brown stringybark, and manna gum forests frequently provide some of the best breeding conditions available in Victoria. These species provide both pollen and nectar, which are required to build up hive strength, and their flowering period is such that they can be worked in conjunction with trees in other areas.

Table 16

HONEY FLORA

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	Winter	Fair	Good
Red gum	Dec--Jan	Good	Good

To operate hives on public land a beekeeper must have a licence. Licences are issued for both permanent and temporary sites and give the beekeeper the right to use a small area for his hives and equipment and the exclusive right to operate his bees within a radius of about 1.5 km. Beekeeping is also permitted in areas managed by the National Parks Service, and sites are currently being used in the Lower

Glenelg National Park. Demand for sites on public land varies considerably from year to year, but the number of sites normally ranges between 20 and 160. It is estimated that apiarists use a similar number of sites on private property.

Extensive clearing of land for agriculture has greatly reduced the value of the study area for beekeeping. River red gum, yellow gum, and pink gum are valuable for apiarists, if they occur in large enough areas to be utilized. These species used to be extensive in the study area in the past, but now only small pockets remain on public land and along roadsides. The remaining areas of public land suitable for apiculture are becoming increasingly important to apiarists, as private property is progressively cleared and as the use of insecticides in modern agricultural practices frequently makes large areas of farmland unsuitable for beekeeping.

Reference

Australian Bureau of Statistics. 'Rural Industries Season 1976--77.' (Australian Bureau of Statistics: Melbourne 1978.)

12. SOFTWOOD PRODUCTION

The first softwood plantations in the region were established in the 1880s at Mount Burr and the first regular plantings commended in 1907 - all in South Australia. In the late 1920s private companies commenced planting significant areas in both Victoria and South Australia, and in 1947 the Forests Commission of Victoria started establishing softwood plantations at Rennick.

Softwood plantations on public and private land within the study area consist almost entirely of radiata pine (*Pinus radiata*), and now total approximately 37,940 hectares. Together with approximately 77,000 ha on public and private land in the adjacent areas of south-eastern South Australia, the region supports one of the largest concentrations of softwood plantations in Australia.

This concentration has enabled a large, integrated wood-based industry to develop. Wood from softwood plantations is used to supply sawmills, preservation plants, particle-board mills, pulp and paper mills, and veneer mills.

Suitability criteria for radiata pine

Commercial production of radiata pine has the following site requirements:

* mean annual rainfall should exceed 700 mm
* soils should be acid and well drained and have moderate fertility
* more than 0.5 m of topsoil should overlie any soil layer that may impede root development or water percolation

Although radiata pine generally grows quite rapidly in the study area, variations in growth rates occur due to differing site factors. The actual or potential productivity of a site to grow radiata pine is described as its site quality. Site quality is a measure of the total volume of wood produced. It is based upon a series of indices, related to the predominant height reached by a stand at age 20 years. Site quality classes form the basis for calculating growth rates and the quantities of the various classes of wood products that will become available for industry. Table 17 sets out the productivities of the different site quality classes.

Existing Forests Commission plantations 10 years and older, as assessed in 1977, averaged site quality IV, with 72% of stands falling within the range V--III. Site quality I and II stands comprised a further 15% and site quality VI stands comprised 11%.

It is not possible to determine the quality of a particular site accurately until a plantation has actually grown on it.

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However, it is possible to predict site quality classes from the native vegetation growing there, and from soil, topographic, and climatic factors. This method is used to predict site quality classes for the areas of uncommitted land in Part IV of this report.

Table 17

PRODUCTIVITY OF RADIATA PINE

Site quality class	Site index; height at age 20 (m)	Total yield over 30-yr rotation (m^3/ha)	Average annual yield (m^3/ha/annum)
I	31.0	1,001	33
II	29.0	892	30
III	27.5	782	26
IV	26.0	666	22
V	24.4	535	18
VI	22.2	399	13
VII	19.5	268	9

Note: Volumes shown are underbark to a small-end diameter of 10 cm.

Source: Forests Commission of Victoria

Productivity of an area can be increased by improved establishment and tending techniques. These techniques include fertilizing at or shortly after planting, weed control, cultivation, and deep ripping of sites with impeding soil layers. They can lead to an increase in productivity equivalent to at least one site quality class, and their use has enabled successful establishment of softwood plantations on soils of low fertility that were previously considered marginal to unsuitable.

Softwood Plantation Areas

Most softwood plantations in the study area have been established by three organizations: the Forests Commission of Victoria, South Australian Perpetual Forests Ltd (SAPFOR Ltd), and Softwood Holdings Ltd. Table 18 lists the areas established on freehold and public land, while Map 7 shows their location. As can be seen from Map 7 and Table 18, more than one-third of the softwood plantations in the study area have been established on freehold land.

Adjoining areas of south-eastern South Australia carry about 62,000 ha of government-owned plantations and more than 15,000 ha established by private companies.

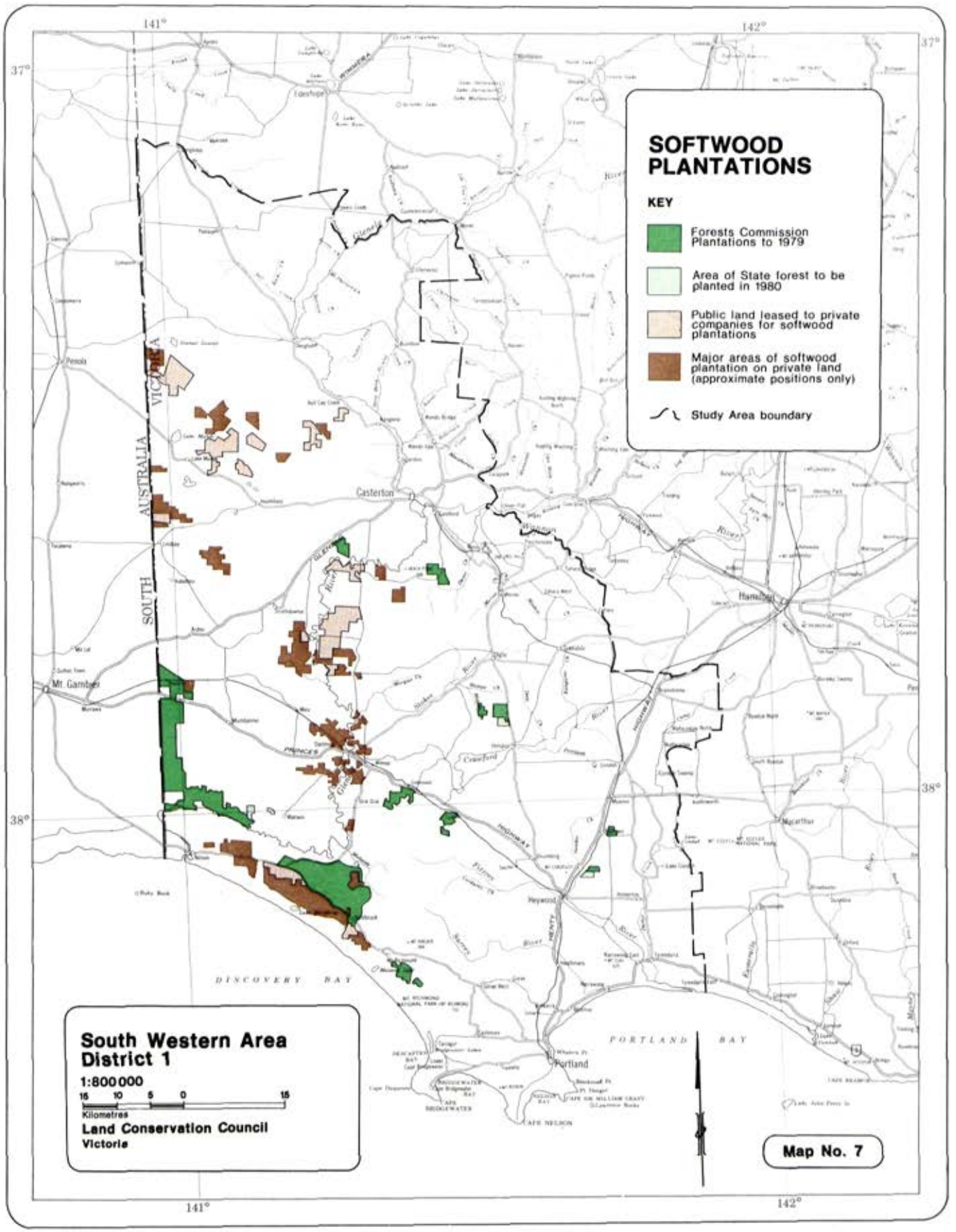
SOFTWOOD PLANTATIONS
KEY
Forests Commission Plantations to 1979
Area of State forest to be planted in 1980
Public land leased to private companies for softwood plantations
Major areas of softwood plantation on private land (approximate positions only)
Study Area boundary
South Western Area
District 1
1:800000
15 10 5 0 15
Kilometres
Land Conservation Council
Victoria
Map No. 7
141°
142°
37°
38°
SOUTH AUSTRALIA
VICTORIA
Casterton
Hamilton
Mt. Gambier
Heywood
Portland
DISCOVERY BAY
PORTLAND BAY

Table 18

NET PLANTED AREAS OF SOFTWOOD PLANTATIONS

Organization	Public land (ha)	Freehold land (ha)	Total (ha)
Forests Commission	14,840*	-	14,840
Private forestry companies	8,570	12,430	21,000
Other private owners	-	2,100	2,100
Total (ha)	23,410	14,530	37,940

* Includes 3,000 ha of purchased freehold land.

Source: Forests Commission of Victoria

Forests Commission plantations

Forests Commission plantations within Victoria have been organized into eight development zones to provide sufficient softwood resources to support large permanent wood-based industries in suitable decentralized areas. One of these zones, the Portland--Rennick Plantation Development Zone, falls within the study area.

At February 1981, the Forests Commission had established about 14,840 ha of softwood plantations within the study area, including nearly 3,000 ha on purchased freehold land. The Commission plans an annual expansion rate of 600 ha within the study area.

Plantations established by private companies

The two large private companies operating in the study area, SAPFOR Ltd and Softwood Holdings Ltd, have established plantations on both freehold and public land.

More than half of the total area of softwood plantations established by SAPFOR Ltd in the study area is on public land made available under the provisions of the *Land (Plantation Areas) Act* 1966. Planting of these lease areas has now been completed. SAPFOR Ltd has also established extensive plantations on company-owned land in Victoria and south-eastern South Australia, and Crown land held under perpetual lease in South Australia.

Softwood Holdings Ltd has established the majority of its plantations in the study area on company-owned land and a smaller area of leased public land. It also has extensive softwood plantations in South Australia, which it uses to supply its sawmills, preservation plants, and a particleboard plant at Portland.

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Other private plantations

About 2,100 ha of softwood plantations within the study area have been established by various other private interests. Some 75% of these plantings have been established by individuals assisted by the State government under its Farm Forestry Loan Scheme, in which loans to offset establishment costs are provided at favourable interest rates. Softwood Holdings Ltd supplements this scheme by offering contracts to landholders, which provide an assured outlet for the produce. Almost all of the Farm Forestry loanholders have taken advantage of this opportunity.

The Wood-based Industry

Plantation softwoods produce the raw material for a variety of end uses, including light construction, flooring, weatherboards, joinery, furniture, veneers and plywood, particleboard, paper, and fencing material. The timber is suitable for pressure treatment with preservatives, enabling it to be used in situations of high insect and fungal attack. Table 19 lists the output from State plantations in the study area in 1978/79 according to different uses.

Table 19

OUTPUT FROM SOFTWOOD PLANTATIONS FOR 1978/79

Category	Quantity	% of softwood output from Victorian State Forest
Sawlogs	40,000 m^3	15%
Roundwood fencing timbers	360,000 pieces	90%
Particle-board	26,000 m^3	59%
Veneer logs	5,000 m^3 *	N.A.

* Production of veneer logs from State plantations for a mill in South Australia commenced in 1980, with rights to 5,000 m^3 being granted for that year.

Source: Forests Commission of Victoria

The study area contains three main timber-processing plants: two integrated sawmill/timber preservation plants and a particle-board mill.

Softwoods Dartmoor Ltd operates a sawmill/preservation plant at Dartmoor, utilizing sawlogs from private plantations and Forests Commission plantations at Rennick and Kentbruck. The plant produces softwood flooring, house framings, linings, cladding, treated sawnwood and roundwood, and dressed roundwood for markets in Adelaide, Melbourne, Sydney, Perth, and country areas of Victoria.

Portland Pine Products Pty. Ltd. operates a sawmill/preservation plant at Heywood. This company also obtains sawlogs from private and State plantations to produce dressed timber, scantling, and treated posts and poles for markets in Melbourne and other outlets.

Softwood Holdings Ltd has recently built a large modern particle-board mill at Portland; it began operating in 1977. The mill uses sawmill residue and roundwood from plantation thinnings to produce particle-board, which is used for a wide variety of construction purposes. Markets are Australia-wide, with large quantities being sold in Sydney and Melbourne, and export markets are also becoming significant.

SAPFOR Ltd processes sawlogs and preservation material from its plantations at its mill at Tarpeena, S.A. Pulpwood from its plantations is sold in South Australia for the manufacture of pulp and paper products.

A number of timber-processing plants - including seven sawmills, two particle-board mills, two pulp and paper mills, veneer mills, timber-lamination plants, and timber preservation plants - are located in the south-eastern region of South Australia. Some of these plants are supplied partially by wood from Victorian plantations.

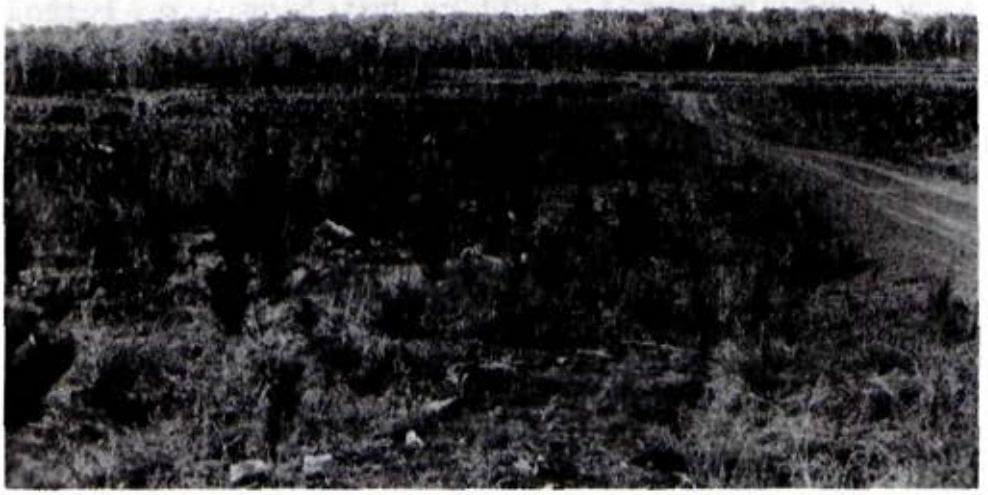
Forestry and the wood-based industries are a major source of employment in this region. In 1977 the industry directly employed about 4,200 persons in South Australia and about 560 persons in Victoria.

Future Plantation Development

Federal policy laid down in the 1960s determined that Australia should aim at self-sufficiency in forest products and that this should be achieved by establishing softwood plantations at an annual planting rate of about 30,000 ha per annum. Subsequently the *Softwood Forestry Agreement Acts* of 1967, 1972, 1976, and 1978 made Commonwealth funds available to the States for the establishment of softwood plantations.

A number of arguments both for and against an expanding softwood plantation program have been raised. These include challenges to the self-sufficiency concept, environmental concern over the clearing of native forests, and differing estimates of domestic demand and the availability of export markets. A Senate Standing Committee on Trade and Commerce is currently conducting an 'Inquiry into All Aspects of Australia's Forestry and Forest Produce Industries'. The findings of this Committee may affect future funding for softwood plantations.

The Forests Commission has pursued a policy that, wherever possible, plantation expansion will be carried out on purchased farmland. To date the Commission has purchased nearly 3,000 ha in the Portland--Rennick Development Zone and - if sufficient funds are available and suitable land is for sale at economic prices - plans to continue this policy.



Pinus radiata *plantation, Cobboboonee block*

In 1975 the State government ratified an Agreement between Softwood Holdings Ltd and the Forests Commission for the supply of minimum annual volumes of softwood timber from State Forest for use by Softwood Holdings Ltd. The Agreement assures the company of a minimum supply of 30,000 m^3 of softwood timber in 1981/82, increasing steadily to 37,000 m^3 by 1995/96. The company has also been granted an annual supply of an additional 35,000 m^3 of material for particle-board manufacture, and 16,000 m^3 of sawlogs and preservation material. The security of assured supplies from Forests Commission plantations and from company-owned plantations has enabled Softwood Holdings Ltd to make the substantial investment necessary to construct a large particle-board plant at Portland.

Rights to wood supplies from Forests Commission plantations are also held by other companies in the region. Panelboard Pty Ltd, which produces particle-board at its plant in Mount Gambier, has an agreement under which approximately 11,000 m^3 of wood is made available from Forests Commission plantations at Rennick.

Productivity of Successive Rotations

In the adjoining areas of south-eastern South Australia, significant plantation areas have been harvested at maturity and replanted. On many sites the productivity of the second crop has shown a substantial decline. The soils on these sites are coarse-textured dune sands, which are infertile and contain low levels of organic matter, and they are similar to those on which softwood plantations have been established in the study area.

Because substantial planting of radiata pine began much later in south-western Victoria than in South Australia,

only recently have small areas been replanted. Research is in progress to study the productivity of these plantations in relation to the previous rotation, but it is too early to make meaningful comparisons. However, early results from concurrent studies on matched first-and second-rotation sites show no evidence for a second-rotation decline in productivity, and suggest that retention of logging residue is important when establishing second-rotation crops. For example, early growth on unburnt second-rotation sites is markedly better than that on first-rotation sites that, in common with past practice, were burnt after clearing of the native eucalypt forest.

Logging residue was previously burnt to lower the risk of wildfire, to eliminate thickets of natural pine regeneration, and to improve access for machinery used in cultivation and planting. It is now realized that on these infertile soils this practice may be detrimental because nutrients are lost to the atmosphere by volatilization and transfer of particulate matter. Also, the practice reduces surface mulch of logging residue and litter, and may lower the level of soil organic matter. Retention of that surface mulch is important because it maintains more favourable soil moisture conditions and, as it decomposes, returns nutrients and organic matter to the soil. Some evidence also suggests that the mulch reduces the need for fertilizers and weedicides.

The Forests Commission has therefore investigated establishment techniques that do not require the burning of logging residue, and a method now being used on an operational basis consists of a tractor-drawn roller with steel blades (roller chopper). This implement reduces logging residue to a surface mulch less than 30 cm thick. Its main disadvantage is that planting is more difficult than on conventionally prepared sites.

Fertilization and weed control are also practised to improve the productivity of successive-rotation plantations. Fertilization compensates for the natural infertility of the soils, and weeds are controlled chemically to minimize competition for available soil moisture and nutrients. Current operational procedures will be progressively modified as results from research in progress become available.

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13. HARDWOOD PRODUCTION

The mixed-species eucalypt forests of the study area have been used as a source of wood since early settlement. the most important timber species - messmate and brown stringybark-produce a strong, moderately durable timber that is used for general-construction purposes. Of the two, messmate is the more important because of its superior growth rate and larger log size.

Productive timber stands cover about 27,000 hectares in the study area. These forests contain extensive stands of messmate with an average tree height in excess of 30 metres.

Early settlers logged the messmate forests selectively and removed the best trees. Many of those left behind will never be suitable for sawlog production. In the 1930s the Forests Commission commenced a program of silvicultural treatment to improve the productivity of the messmate forests. It involves the removal of defective stems and the thinning of regrowth over large areas and is responsible for much of the better-quality forests in the study area today. The Commission has continued to carry out silvicultural

Silviculturally treated 50-year-old messmate, Narrawong area

Stringybark fence posts, Annya area

treatment as funds are available and, since 1968, has treated 8,000 ha in the Heywood Forest District.

Other species - including shining peppermint, manna gum, and swamp gum - provide a limited amount of hardwood timber, although of inferior quality. Red gum and yellow gum produce a durable timber suitable for heavy construction works, sleepers, and fencing, but unfortunately only small pockets of these species remain on public land. The brown stringybark forests in the north of the study area rarely exceed 20 m in height and are not suitable for commercial sawlog production, but they supply some of the local demand for farm and domestic timbers.

Sawmilling industry

The average supply of sawlogs from the study area over the last 5 years has been about 25,000 m^3 per annum. In 1978/79 this represented about 2.5% of the total hardwood sawlog production from State Forest for that year. The Forests Commission estimates that 26,000 m^3 of sawlogs per annum could be cut from the forests of the study area on a sustained-yield basis if stand improvement works are continued, and with the existing levels of fire protection.

Currently, eight sawmills utilize sawlogs from the forests of the study area. Two are located at Gorae and one each at

Hamilton, Merino, Heathmere, Homerton, Dartmoor, and Yahl in South Australia. A small mobile mill also operates in the study area. Hardwood logging and sawmilling provide employment for approximately 70 people in the study area.

Most of the hardwood timber produced is sold locally for general-construction purposes. The forests are very important for local timber supplies as the closest hardwood forests to this region are the Grampians and the Otways. Minor forest products, including poles, fencing materials, firewood, and sleepers are obtained from the hardwood forests of the study area. They are important for servicing the local demand, but their total volume is small.

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14. MINING AND QUARRYING

Exploration

Since the mid 1960s, 13 exploration licences have been granted in the study area. Of these, the seven currently in operation cover areas from 660 km^2 to 792 km^2 and include both public and private land.

The increasing prices of imported petroleum products have led to an increase in exploration activities in all prospective areas. The Tertiary and Mesozoic sediments of the study area show a number of promising features for petroleum occurrence. At present, two petroleum exploration permits cover parts of the study area, and use both seismic techniques and drilling techniques. However, drilling to date has been confined to a site east of the study area where hydrocarbons have been intersected near Port Campbell.

Map 8 shows the known occurrences of metallic minerals and areas with potential for further discovery of minerals and petroleum products.

Minerals

Table 20 lists the minerals that are known to occur in the study area and the localities where they have been recorded.

Stone

Stone, as defined under the *Extractive Industries Act* 1966, is extracted on both private and public land throughout the study area. The material is quarried by shires, government departments, and private operators. It is used for the construction and maintenance of roads, buildings, airfields, and harbours, and also in the manufacture of cement, lime, bricks, and tiles. Table 21 shows the total output from operations in the study area.

Together the Shires of Portland and Glenelg use about 53% of the gravels extracted in the study area, principally for road construction and maintenance. The Shire of Portland uses 96,000 m^3 of gravel each year, of which 73% comes from public land, and the Shire of Glenelg uses 48,000 m^3, of which about 47% comes from public land. Gravel has a low value per unit volume and transport costs represent a significant part of the final cost. As a result, it is not economically desirable to transport gravel long distances if alternative sources are available locally.

Two of the four commercial quarries currently operating use some public land, but the bulk of the quarries in the study area are non-commercial quarries operated by shires and gov-

Table 20

OCCURRENCES OF MINERALS

Mineral	Occurrence	Comments
Black coal	Private land near Merino and Mocamboro	Currently uneconomic thin seams
Brown coal	Private and public land	Thin seams recorded from drilling
Peat	Intermittently in wetlands throughout the study area	Deposits generally small and of poor quality
Bentonite	Public and private land south-west of Greenwald	A drilling program has proved reserves of 2.5 million tonnes (10% moisture)
Diatomite	Two occurrences on private land north of Portland	Diatomite may also occur on nearby public land as it has similar geological features
Nickel	Private land near Wando Vale	This mineral occurs in serpentinite host rock, which contains 0.14 to 0.38% nickel
Chromite	Private land near Wando Vale	Occurs in a belt of Cambrian rocks through Mount Stanley
Silver and lead	Private land south-east of Dergholm	These deposits were mined late last century
Heavy minerals	Private and public land	Traces occur in sand sheets and ridges of dune sandstone

Source: Department of Minerals and Energy

ernment departments. The location of quarries and pits in the study area is shown on Map 8.

Basalt

There is a large basalt quarry operated by the Portland Harbour Trust Commissioners at Cape Sir William Grant. In the past this quarry was used to supply blocks of basalt to construct the Portland Harbour breakwater and it is now used

Table 21

QUANTITY OF STONE EXTRACTED, 1977/78

Material	Quantity (tonnes)	Land status of extraction sites
Crushed and broken basalt	31,560	Vested in Portland Harbour Trust
Granite	2	Public
Limestone	1,754	Private
Sand	41,616	Private and public
Gravel (includes shires, government departments)	273,000	Private and public
Total	347,932	

Source: Department of Minerals and Energy

to supply crushed basalt for road-making and concrete aggregate.

The construction of the Alcoa aluminium smelter at Portland will require 90,000 tonnes of crushed rock for aggregate and 50,000 tonnes of rock for fill over 2 years. Investigations are currently being carried out to locate suitable rock on uncommitted land at Bolwarra, on private land at Tyrendarra, and at the Cape Sir William Grant quarry to meet the construction needs of the smelter and the expected building in Portland associated with the construction.

Scoria and tuff

Scoria quarries are located on private land at Mount Rouse, Mount Eccles, and Mount Napier east of the study area. Within the study area, deposits of scoria and tuff at Mounts Eckersley, Vandyke, and Deception have been used in the past to supply local demands, but these reserves are generally more deeply weathered than those to the east.

Granite

Granitic rocks outcrop at a number of places in valleys dissected in the Dundas Tablelands and the Dergholm Platform. The coarse-grained red and green to greenish pink granite west and north-west of Dergholm is highly sought after as an ornamental veneer for buildings.

Pink granite is currently quarried north of Baileys Rocks and has been quarried in the past near Boiler Swamp and Wando Vale (the 'St Elmo' granite). Other outcrops in the

study area are deeply weathered and sites suitable for quarrying are limited. Granitic sand for road-making is also supplied from private land near Baileys Rocks.

Mesozoic sandstone

Small quantities of feldspathic sandstone have been quarried for building stone near Coleraine, but it is not of high quality.

Buckshot gravels

Buckshot gravels used by the shires and the Forests Commission for unsealed-road construction are derived from lateritic soils of Tertiary age that cap remnants of the original surfaces of the Dundas Tablelands and Merino Dissected Tablelands. Numerous shallow borrow pits occur on public land, and buckshot gravels have been worked extensively on private land near Merino and Casterton.

Limestone

Four groups of limestones are quarried in the study area. In order of age from oldest to youngest, they are mid Tertiary, Whalers Bluff Formation, dune, and fresh-water limestone.

Mid Tertiary limestone

Extensive deposits of high-quality Tertiary limestone containing 80 to 90% calcium carbonate occur on private land north-east of Portland. This limestone is used as agricultural lime and for cement-making. Smaller deposits exist throughout the study area, mainly on private land, but these are of minor importance. It is estimated that the Alcoa aluminium smelter will require 18,000 tonnes of cement over the 2-year construction period. However, it is expected that most of it will come from Geelong and interstate.

Whalers Bluff Formation limestone

This formation consists mainly of carbonate sand (chiefly shell grit), which is cemented to varying degrees by calcium carbonate. It is a good base-course material for road construction due to the natural cementing properties of the calcium carbonate. Quarries have been established where zones of moderately cemented limestone are associated with weakly cemented sands to allow earth-moving equipment to excavate the formation. Extraction of this material is currently taking place on private land near Wilkin and on public land at Dartmoor.

Dune limestones (Bridgewater Formation)

These limestones resemble those of the Whalers Bluff Formation but, as a result of wind sorting, are more uniform in grain size. The composition and hardness of the rock varies in different locations according to the amount of calcium

carbonate present, which normally ranges from 70 to 98%. This material was used as a building stone in early settlement days and large quantities are now used for road-making. Quarries are located on public land at Jones Ridge, in the Kentbruck Plantation, and at Mount Richmond, and on private land at Lake Mundi, Trewalla, and west of Dartmoor. The Gallpens quarry west of Portland also provides some limestone suitable for use as agricultural lime.

Fresh-water limestones

Fresh-water limestones occur at the base of some swamps and as deposits adjacent to springs in the Glenelg Valley. They have been used to a limited extent for road construction and as a source of agricultural lime in the past.

Calcareous sands

The extensive mobile dune system fringing Discovery Bay and Bridgewater Bay contains very large quantities of calcareous sands. These contain 60 to 95% calcium carbonate, which can be used for agricultural lime, glass manufacture, and other uses. Approximately 40,000 tonnes are extracted annually from pits located mainly on public land adjacent to the Portland--Cape Nelson road.

Quartz sand

Extensive deposits of medium- to fine-grained siliceous sand cover much of the public land in the study area. These deposits are extracted from several pits and are used for filling and construction purposes, and as concrete sand.

It is estimated that 45,000 tonnes of concrete sand will be required over 2 years for the construction of the Alcoa al-

Rehabilitation of sand quarry

uminium smelter at Portland. Large quantities of fine sand are available near Portland, and coarse sand is currently obtained from alluvial deposits at Coleraine, outside the study area. However, there is likely to be a shortage of coarse sand due to the increased demand. Alternative sources are currently being investigated - the nearest known deposit being on uncommitted land at Wanwin.

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15. WATER UTILIZATION

The study area does not contain any major water supply storages. However, small regulatory structures have been built on many lakes, swamps, and waterholes to maintain their levels so that the water can be used for urban supply and irrigation. In addition, the Konong Wootong Reservoir, east of Casterton and just outside the study area, provides water for Casterton, Sandford, and Coleraine.

Water resources utilized for town supplies are managed by four locally constituted authorities under the *Water Act*. The State Rivers and Water Supply Commission oversees the financial and technical activities of these Waterworks Trusts, who are responsible for the construction and maintenance of waterworks within their defined districts.

Groundwater is used to supplement surface water supplies for the towns of Portland, Heywood, Merino, and Casterton and for industrial purposes at Portland. The Alcoa aluminium smelter will utilize 0.5 ML of groundwater per day. It is expected that this demand can be adequately supplied from existing groundwater supply facilities at Portland.

Groundwater is also used for agricultural purposes and a total of 221 groundwater licences have been issued for bores in the study area. These bores supply in excess of 15,000 ML of water, used for irrigating 2,605 ha of farmland. Groundwater is important for irrigation, as the salinity of most of the streams in the study area increases significantly during the drier months, making them unsuitable for irrigation. There are also numerous unlicensed shallow bores used for domestic and stock purposes throughout the study area.

The study area contains two River Improvement Trusts: the Strathdownie Drainage Trust and the Glenelg River Improvement Trust. The former has carried out a comprehensive program of drainage of freehold land in the Strathdownie area and the latter has been responsible for a program of stream conservation works along the Glenelg River.

Appendix I lists the authorized diversions of surface water for farming and industrial purposes, Appendix II the water supply and consumption for the major towns, and Appendix III the authorized annual extractions from groundwater resources within the study area.

16. HAZARDS

Hazards are here defined as biological and physical processes that threaten the integrity of land and lower its productivity. To retain the productivity of land it is important that actual and potential sources of environmental degredation are identified and controlled.

Soil Deterioration

Three main types of soil erosion occur in the study area: wind and water erosion and mass movement of soil.

Wind erosion is mainly a hazard on the calcareous dunes of Discovery Bay and Bridgewater Bay. For these dunes, stability depends on maintaining the vegetative cover; they become subject to wind erosion when grazing, uncontrolled recreational use, fire and other processes damage or destroy the vegetation. Management practices protecting the vegetation reduce this hazard.

Water erosion - the removal of soil by running water - occurs in the form of sheet, gully, stream bank, and tunnel erosion in the study area. All cause turbidity in streams; moreover silt, which includes the most fertile fraction of the soil, may be carried downstream and lost.

Sheet erosion and gully erosion are common on the undulating country with duplex soils derived from Tertiary sediments. Some of the worst examples are on private land in the Branxholme--Chetwynd area and near Casterton, where gullies may reach 10 metres deep. Stream-bank erosion occurs along many streams, particularly as streams cut and widen their courses in the alluvium of the lower slopes and flats, and may result in severe stream siltation (for example, in the lower reaches of the Wando and Chetwynd Rivers). Tunnel erosion is found in a few places on private land near the edge of the Dundas Tablelands.

Mass movement involves the movement of large volumes of soil as a whole rather than individual particles. It is common on soils derived from Mesozoic sediments on the private land throughout the Merino Tablelands.

Erosion of beaches and foreshores by the sea has occurred on the Dutton Way and the Henty Bay Estate. This process has been accentuated by the lack of any natural influx of sand other than locally derived sand. Basalt blocks have been placed along the foreshore to absorb the wave energy - thus preventing further erosion taking place. Sections of the limestone cliffs around Nelson Bay have also been eroded by marine undercutting, causing large sections to collapse. Collapses may produce channels that permit waves to attack the cliffs more directly.

Soil salting causes localized problems in parts of the study area. The build-up of soluble salts in the upper soil horizons not only limits plant growth but may also lead to increased salinity in streams. Salting is not a widespread problem, but extensive clearing of native forest vegetation in certain areas could result in severe stream salting.

Wildfire

The study area has a high risk of wildfires during summer due to a combination of hot dry weather and the highly flammable nature of the vegetation. The heaths and the brown stringybark forests with heathy understories are particularly flammable and pose a fire risk to life and property on both public and private land.

Fire history

Little is known about the prevalence of fire prior to European settlement. However, the frequency and severity of

Table 22

MAJOR FIRES IN THE STUDY AREA

Year	Locality	Area of public land burnt (ha)
1942	Lower Glenelg River, Moleside Creek	3,800
1942	Wilkin, Weecurra, Hotspur	11,800
1943	Kentbruck	3,900
1952	Tooloy, Drajurk	39,100
1952	Annya	4,900
1955	Bogalara, Dergholm	20,000
1959	Roseneath	3,200
1959	Lower Glenelg River, Palpara	6,100*
1962	Cobboboonee	5,300
1967	Kentbruck	5,700
1967	Cobboboonee	3,200
1967	Hotspur	3,300
1967	Roseneath	8,500
1976	Cobboboonee	3,400
1977	Roseneath	7,800
1979	Lower Glenelg River, Nelson	2,700*

* Large areas in South Australia were burnt before these fires crossed into Victoria.

Source: Forests Commission of Victoria

fires increased when the settlers used fires to clear land, burn old growth, and encourage new shoots on grazing runs. Often these fires escaped and continued to burn uncontrolled through thousands of hectares of bush.

The disastrous fires that swept Victoria in 1939 burnt much of the study area, including a large area in the Portland--Stokes River region. Since then 16 major fires have occurred on the public land, the largest of which burnt out 39,100 ha between Dergholm and the Glenelg Highway in 1952.

Table 22 lists the major fires that have occurred on public land in the study area since 1939 and Table 23 shows the known or suspected causes.

Table 23

CAUSES OF WILDFIRES ON THE PUBLIC LAND
(1971/72 to 1978/79

Cause	Total number of fires over 8-year period	Percentage of total
Deliberate lightings (arson)	41	21
Escapes from burning operations on private property	33	17
Vehicles and engines	18	9
Licencees, forest workers	14	7
Recreationists	14	7
Miscellaneous known (including lightning)	48	25
unknown	26	14
Total	194	100

Source: Forests Commission of Victoria

Fire and land management

Repeated severe wildfires adversely affect timber production in hardwood forests. Although the trees frequently survive the fires, significant losses occur due to timber degrade and decreased growth. The growth rate in older larger trees recovers in a few years, with rapid development of new foliage from dormant buds. However, younger trees - with their lower crowns and thin bark - are very susceptible to fire damage and fires frequently kill the upper stem, causing serious tree malformation. It is often preferable to remove the affected stems of these trees rather than allow them to grow into mature trees with only short merchantable boles. Significant wood degrade may occur following a high-

intensity fire due to the formation of gum (kino) veins or to insect or fungal attack.

Fuel-reduction burns to reduce the extent and intensity of wildfires are concentrated in strategically important areas, and their frequency depends on fuel build-up. In most forest types in the study area they are planned every 5--7 years. The substantial investment made in the establishment and maintenance of softwood plantations requires that a high priority be given to their protection from wildfires. Eucalypt forest in strategic areas around softwood plantations is fuel-reduced at regular intervals, and other protection measures in softwood plantations include the slashing and ploughing of strips around external plantation boundaries and internal firebreaks, as well as pruning of lower pine branches in strategic areas.

Biological Hazards

Noxious weeds

In Victoria, 103 plants have been proclaimed as noxious weeds under the provisions of the *Vermin and Noxious Weeds Act* 1958 and 44 of these are found within the study area. In general, their distribution is limited to semi-improved agricultural land, undeveloped land, or land that has been disturbed. Many of them are found only in isolated patches or have very limited distribution.

African feather grass is one of the most important problem weeds in the study area. In addition to dense infestations along the Glenelg River and other waterways, it is found along road reserves, on agricultural land, and in some areas of native bushland. Control is difficult to achieve but new control methods have been successful in many places. Further spread along the Glenelg River south of Dartmoor is being prevented.

A noxious weed causing some concern in the study area is one-leaf cape tulip. Dense infestations are found on both public and freehold land near Digby. This plant is poisonous to stock and can replace desirable plants on grazing land.

Other noxious weeds causing localized problems with differing degrees of significance within the survey area include Bathurst burr, blackberry bramble, boneseed, boxthorn, cape broom, furze, horehound, Paterson's curse, stinkwort, serrated tussock, spiny rush, and sweet briar. Thistles are also widespread. In general, control measures are preventing these and other noxious weeds from further spread.

Pest animals

The rabbit population throughout is reasonably low, but numbers can rapidly increase under favourable breeding conditions. Areas where control measures are difficult to implement - for example, the stony rises between Lake Condah

Stabilization of coastal dunes with marram grass

and Tyrendarra - support large numbers of rabbits. Another problem area is the coastal sand dune zone, where rabbits can cause serious damage to marram grass plantings and regenerating native vegetation.

Foxes and feral cats are common, although population levels fluctuate widely. In contrast, wild dogs are rarely found; but domestic dogs, especially when roaming in packs, can cause local problems.

Farmland adjacent to areas of bushland is particularly susceptible to damage from kangaroos and wallabies. These animals shelter in the bushland during the day, and move out to feed on crops and pastures in the early mornings and evenings. They cause damage to fences, flatten crops, and directly compete with stock for feed. Permits may be obtained from the Fisheries and Wildlife Division to destroy these animals, although normally they are protected.

Fungi

The root rot fungus *Phytophthora cinnamomi* has been recorded in about 20 places in the Cobboboonee forest between Digby and Mount Richmond. This fungus infects the soil and attacks the fine roots of trees, causing dieback. Sites especially vulnerable to the disease are characterized by soils that readily become waterlogged - because of poor structure or the presence of a soil horizon that impedes the movement of soil moisture.

The sites where *P. cinnamomi* as been recorded here only cover a small total area (approximately 50 ha in 1974). The major eucalypt species that it affects are messmate and brown stringybark; peppermint and the gum-barked eucalypts appear to be tolerant.

Dieback caused by a native root-rot fungus - *Armillaria* sp. (possibly A. *luteobubalina*) was recently recorded in three locations in the messmate forests of the study area. The amount of damage is negligible, but the occurrence is being monitored.

Softwood Plantations

Softwood plantations impose a major change on the environment. Hazards associated with large-scale softwood plantations include the destruction of wildlife habitat, the removal of nutrients and organic matter from the soil, pollution of streams and groundwater by chemicals used in plantations, and a reduction in the landscape values of the area due to the regular and regimented format of plantations.

There is a lack of detailed long-term studies on the effects that plantation development has on environmental values; however, the many studies currently under way will progressively redress this situation. Current management practices include the breaking up of continuous plantation units with large areas of native forest, the retention of strips of native vegetation along streams and in blocks within the plantation complex, improved establishment and silvicultural techniques, and avoidance of planting on areas of high landscape value. Together these reduce the hazards associated with softwood plantations.

PART IV
BLOCK DESCRIPTIONS

BLOCK DESCRIPTIONS

The original descriptive report by the Land Conservation Council on the South-western Area, District 1, divided the study area into 18 blocks to facilitate a detailed description and assessment of natural resources. In this review the 18 blocks have been amalgamated into seven groups that have broadly similar climate, soils, topography, and vegetation. The block names used in the original report have been retained for continuity.

Map 9 shows the location of the 18 descriptive blocks and the boundaries of the seven groups into which they have been amalgamated.

The present tenure, nature of the land, capability for various uses, and likely land use hazards are described for each group. A consistent format of headings and subheadings has been used to enable the reader to compare specific data for various blocks. The information on land uses in this section of the report refers to the public land except where explicit reference is made to the private land. Within each block the discussion is concentrated on the resources and potential uses of the uncommitted land.

Capability

This term refers to the value of the land for the particular use to which it may be put. Present levels of use are described, where possible, to give some indication of capability. Capability for some uses, such as nature conservation, is based primarily on the land's inherent characteristics. For others it also depends on inputs (such as fertilizer application) that raise the productivity.

Capabilities are assessed in general terms only, because the amount of information available varies from block to block and because some values are difficult to quantify. In assessing capabilities, comparisons have been made with other blocks and with other parts of the State.

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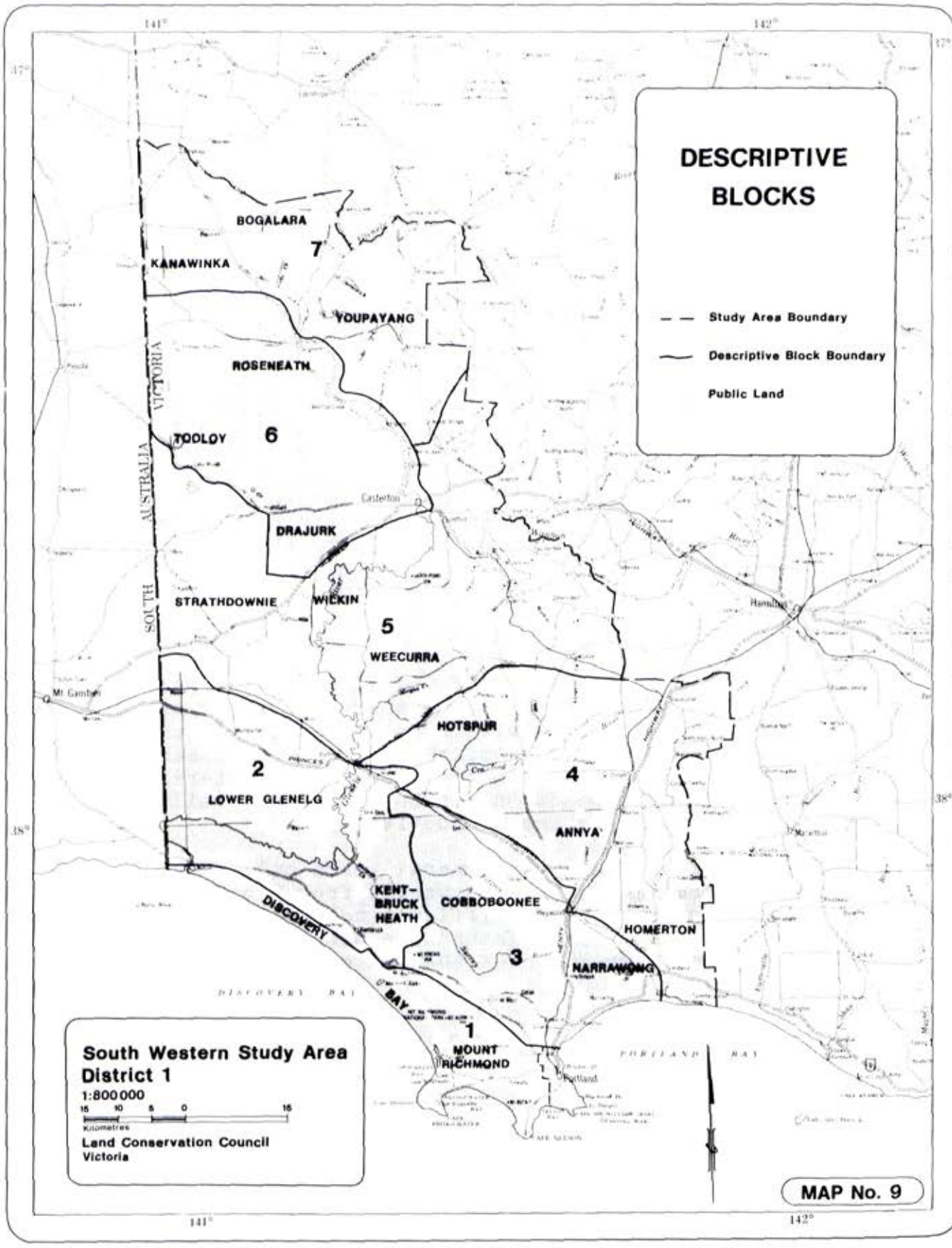

DESCRIPTIVE BLOCKS
Study Area Boundary
Descriptive Block Boundary
Public Land
BOGALARA
7
KANAWINKA
YOUPAYANG
ROSENEATH
TOOLOY
6
DRAJURK
STRATHDOWNIE
WILKIN
5
WEECURRA
HOTSPUR
2
LOWER GLENELG
4
ANNYA
KENT-BRUCK HEATH
COBBOBOONEE
HOMERTON
DISCOVERY BAY
3
NARRAWONG
1
MOUNT RICHMOND
Portland
Mt Gambier
Casterton
Hamilton
SOUTH AUSTRALIA
VICTORIA
141°
142°
37°
38°
South Western Study Area
District 1
1:800000
15 10 5 0 15
Kilometres
Land Conservation Council
Victoria
MAP No. 9

1. DISCOVERY BAY--MOUNT RICHMOND

A. Tenure and Nature of the Land

1. Present tenure

Public land totals around 13,500 ha, of which 8,530 ha is within the Discovery Bay Coastal Park. Other conservation reserves include Mount Richmond National Park (1,707 ha), Cape Nelson State Park (210 ha), Bats Ridge Wildlife Reserve (290 ha), and a flora reserve at Johnstone's Creek (40 ha). On the Forests Commission's Mount Richmond plantation within these blocks, a net total of 560 ha of softwood plantations have been established. Public land also occurs along the coastal reserve stretching from Cape Bridgewater to Portland.

The largest piece of uncommitted land consists of 1,460 ha adjoining Bridgewater Bay. Other areas of uncommitted land include approximately 150 ha south of Mount Richmond National Park, and several small isolated blocks west of Portland.

2. Climate

Average annual rainfall ranges from 760 mm near Nelson to around 860 mm at Cape Bridgewater. At Portland it is 850 mm, with a marked winter incidence. Temperatures are generally mild along the coast; the mean monthly maximum at Portland ranges from 20.7°C in January to 13.0°C in July. Due to its proximity to the coast, the area is subject to strong salt-laden onshore winds.

3. Geology and geomorphology

The shores of Discovery Bay and Bridgewater Bay consist of long sandy beaches interrupted by cliffs of Pleistocene dune limestone. Behind the beach, steep unconsolidated calcareous dunes overlie a series of consolidated dune limestone ridges. Caves have developed in the dune limestone at Bats Ridge and at Tarragal. In some places the dunes are mobile and are advancing inland under the influence of onshore winds. Behind the Discovery Bay dunes, a chain of shallow swamps occupies a swale in the dune limestone. Around Cape Bridgewater and Cape Nelson cliffs of limestone covered with basalts from Mount Richmond and other volcanoes occur.

Mount Richmond block consists of Miocene limestone that has been buried by basalt flows from Mount Richmond itself and other volcanoes on Cape Bridgewater and Cape Nelson. Dunes and sheets of white siliceous sand and Pleistocene limestone overlie the basalt. Mount Richmond is a tuff and scoria cone that is now partially covered with sand. The underlying basalt is exposed in a few places at Mount Richmond and at Johnstone's Creek.

4. Soils

Undifferentiated yellow-brown calcareous sands occur over most of the public land adjoining the coast. In areas where the dunes have been stabilized over a long period, dark brown sandy soils occur and friable peats have developed in swampy areas. Small areas of red and black sandy loams have developed where the limestone dunes are exposed. The Mount Richmond block contains areas of variable leached acidic sands, and the volcanic rocks are exposed in a small area of red gradational soils on Mount Richmond.

5. Vegetation

The mobile calcareous dunes of Discovery Bay are largely unvegetated except in areas where introduced marram grass *(Ammophila arenaria)* has been planted to stabilize them. Further inland on the landward side, the dunes carry a complex dominated by coast wattle and coast beard-heath. A coastal swamp complex - dominated by woolly tea-tree and scented paperback and including many species of sedges and rushes - occurs behind the dunes.

The predominant vegetation of Mount Richmond National Park is an open forest of brown stringybark. Open forests of manna gum occur on the more fertile sandy soils and small areas of swamp gum are found on the volcanic soils. The deep heavily leached sands carry substantial areas of floristically diverse heath and an area of closed scrub dominated by shining peppermint with a heathy understorey.

The large block of uncommitted land adjoining Bridgewater Bay supports a similar vegetation to that of the dunes of Discovery Bay, except that it lacks the swamps and associated vegetation behind the dunes. The block of uncommitted land south of Mount Richmond National Park supports open forests of brown stringybark and a small area of closed scrub dominated by brown stringybark and shining peppermint.

6. Fauna

The fauna of the Discovery Bay Coastal Park includes nine species of mammals and more than 140 species of birds. The park provides significant habitat for coastal and estuarine wetland fauna as well as for species that utilize the sand dune complex. Significant bird species that have been recorded in the park include the ground parrot, orange-bellied parrot, beautiful firetail, and rufous bristle-bird. The wetlands behind the mobile dunes provide good habitat for waterfowl, and Long Swamp is used as a breeding area by chestnut teal and other waterfowl.

Mound Richmond National Park, although small in size, supports about 10 species of mammals and 100 species of birds, including the rufous bristlebird, southern emu-wren, beautiful firetail, swamp antechinus, and potoroo. The park contains many mature trees, which provide hollows for arboreal animals.

The fauna of the uncommitted land adjoining Bridgewater Bay has not been studied in detail. However, this land would support a similar range of species to those found in the Discovery Bay Coastal Park, except for those associated with the park's Long Swamp complex.

B. Present Uses and Capabilities

1. Nature conservation

Public land in these blocks has a high capability for nature conservation. It includes three parks - Mount Richmond National Park, Cape Nelson State Park, and Discovery Bay Coastal Park - all of which are important for this purpose. The conservation values associated with each one are discussed in Chapter 8.

Other areas of importance for nature conservation include: the large block of uncommitted land adjoining Bridgewater Bay, which contains good examples of relatively undisturbed coastal vegetation; the coastal reserve stretching from Portland to Cape Bridgewater, which includes the 'Petrified Forest' caused by wind and water erosion of the old scrub root system at Cape Bridgewater; and the Bats Ridge Wildlife Reserve, which includes limestone caves used by several bat species.

The 'Petrified Forest', Cape Bridgewater.

Cape Bridgewater

2. Recreation

Due to their proximity to Portland and major tourist roads, the three parks are all well used for outdoor recreation. Together they provide opportunities for a wide range of recreational activities, including picnicking, nature study, bushwalking, and, in the case of the Discovery Bay Coastal Park, dune buggying and surf fishing. The outdoor recreational use of these parks is described in Chapter 9.

Many visitors are attracted to the coastal reserve at Cape Bridgewater by the spectacular views of the cliffs and the blowholes and the 'Petrified Forest'. The coastal reserve is also used to provide access to the beach at various locations for swimming, surfing, fishing, and a variety of boating activities. The large block of uncommitted land adjoining Bridgewater Bay is not currently used to any great extent for outdoor recreation, as access into this area is not well developed.

3. Agriculture and apiculture

Sand dunes cover much of the public land and are not suitable for agriculture.

These blocks have a moderate capability for apiculture. Coast beard-heath, one of the dominants in the dune vegetation, and some of the heath plants provide useful supplies of pollen and nectar, which are used for winter hive maintenance. However, the lack of access limits the use for apiculture.

4. Softwood production

The Forests Commission has established a total of 560 ha of softwood plantations in its Mount Richmond plantation. The

only area of uncommitted land with potential for commercial softwood plantations is one south of Mount Richmond National Park, where site quality is estimated as SQIV. The dune sands of the uncommitted land adjoining Bridgewater Bay are unsuitable.

5. Hardwood production

The dunes of Discovery Bay and Bridgewater Bay are not suitable for hardwood production. The forests in the Mount Richmond block contain small trees with poor form that have a very low potential for hardwood production.

6. Mining and quarrying

Large dunes in the uncommitted land adjoining Bridgewater Bay contain large quantities of fine sand that would be cheap to extract and is suitable for uses such as agricultural lime, glass manufacture, and as a base course for road construction. Limestone and buckshot gravel are currently extracted from several pits on both public and private land, for road construction purposes.

7. Hazards and conflicts

The most serious hazard in these blocks is wind erosion of the dunes adjoining Discovery Bay and Bridgewater Bay. Blow-outs have always been a natural feature of these mobile dunes, but sand extraction and uncontrolled grazing by stock and rabbits have destroyed the vegetation and resulted in blow-outs occurring much more frequently. Complete stabilization of the dunes would be extremely difficult and is unnecessary, as the dunes are only moving inland in a few places where large blow-outs have developed. Marram grass has been planted in such areas, and these plantings have enabled native vegetation to recolonize previously unstable areas. Maintenance of the dune vegetation requires the exclusion of cattle and sheep, rabbit control, fire protection, and rehabilitation of areas where sand has been extracted.

2. LOWER GLENELG--KENTBRUCK

A. Tenure and Nature of the Land

1. Present tenure

The public land totals approximately 51,000 ha, of which the Lower Glenelg National Park occupies more than half (27,300 ha). Lower Glenelg block includes the Palpara Settlement Scheme, which covers 2,800 ha of public land currently being made available for agriculture.

Softwood plantations have been established on a significant proportion of the public land in both these blocks. The Forests Commission has established 11,740 ha net in the Rennick and Kentbruck plantations, and Softwood Holdings Ltd. has established plantations that cover a net total of 1,110 ha on two areas of leased public land.

The largest piece of uncommitted land - of approximately 6,800 ha - adjoins the Forests Commission's Rennick Plantation. The only other uncommitted land consists of several small isolated areas south and west of Dartmoor, the largest of which is approximately 300 ha, and two areas on the Portland to Nelson road near Kentbruck.

2. Climate

Average annual rainfall ranges from 800 mm at Rennick to around 910 mm in the vicinity of the Kentbruck Heath, which is one of the wettest places in the study area. The close proximity to the coast keeps the temperatures fairly mild throughout the year, with the mean monthly maximum at Rennick ranging from 25.2°C in January to 13.3°C in July.

3. Geology and geomorphology

Most of the public land in these blocks is covered by low dunes and sheets of orange siliceous sands, which overlie consolidated dune ridges of Pleistocene limestone. The basement rocks consist of Miocene limestone. In the eastern half of Kentbruck block the Miocene limestone is partially buried by Pleistocene basalt, which in turn is overlain by sheets of white acidic wind-blown sand. These sheets of sand also cover most of the uncommitted land in Lower Glenelg block.

The Glenelg River is the only major stream in the area and drains most of the land in the Lower Glenelg National Park. The topography of the Kentbruck Heath is flat and the drainage network is poorly developed. The only major streams in this area are Moleside and Little Moleside Creeks, which flow west into the Glenelg River. North of Lower Glenelg National Park the surface drainage pattern is again poorly

developed and most of the surface water percolates through swamps into the groundwater.

4. Soils

These blocks contain extensive areas of deep, leached, acid, sandy soils with low natural fertility and organic matter content. They usually have a layer of buckshot gravel at a variable depth in the profile. In places where the crests of the limestone dunes are exposed, shallow red and black sandy loam soils occur (terra rossa and rendzina soils).

5. Vegetation

On the large areas of leached sands, brown stringybark is the major vegetation community present. The wetter more fertile soils in the east of Kentbruck block carry brown stringybark as an open forest II, often in association with manna gum. The poorer sites, of strongly leached sands, carry the species as an open forest I, sometimes in association with shining peppermint and swamp gum. Areas of open forest II of messmate occur on the fertile basaltic soils, and small areas of river red gum also occur along the length of the Glenelg River Gorge.

Heaths cover a large area. The Kentbruck Heath is one of the largest continuous tracts of inland heath in Victoria and includes more than 60 species at the western limit of their range. It is botanically very diverse and is dominated by prickly tea-tree, scrub she-oak, silver banksia, and beaked hakea.

The large parcel of uncommitted land in Lower Glenelg block carries mainly woodlands and open forests of brown stringybark. It also has small areas of open forests of manna gum, and open forests of swamp gum - frequently with shining peppermint co-dominant or sub-dominant in the canopy. Along its eastern margins, it carries a band of dense heath--wet scrub, dominated by prickly tea-tree and silver banksia.

6. Fauna

Because of its wide range of habitats, the Lower Glenelg National Park supports a very diverse fauna, including 34 species of mammals and more than 160 species of birds. Significant mammal species known to occur here include the swamp antechinus, whose Victorian distribution is restricted to coastal heaths and sedgelands west of Sunday Island, great pipistrelle, which reaches the westernmost limit of its distribution in the park, yellow-bellied glider, wombat, and heath rat. The diverse range of birds includes the peregrine falcon, rufous bristle-bird, and red-tailed black cockatoo. The limestone caves in the park are used for shelter and breeding by two species of bats.

Uncommitted land in Lower Glenelg block contains one of the largest continuous areas of wet scrub habitat remaining in the study area. The importance of this habitat for small

mammals was indicated during recent surveys, which recorded the short-nosed bandicoot, swamp antechinus, bush rat, and swamp rat present in high densities. In addition, small flocks of red-tailed black cockatoos, which in Victoria now only occur in the south-west of the State, appear to be resident in this uncommitted land.

B. Present Uses and Capabilities

(1) Nature conservation

Lower Glenelg National Park has a very high capability for nature conservation, as it covers an extensive area and includes a diverse range of vegetation communities. Its conservation features are described in Chapter 8.

The large area of uncommitted land in Lower Glenelg block has a lower capability than the park. However, it is significant for nature conservation, as it contains substantial areas of wet scrub habitat that is particularly important for small mammals, and also because much of the adjoining land has been converted to softwood plantations.

(2) Recreation

Lower Glenelg National Park is one of the most popular places for outdoor recreation in the study area. Most of the recreational activities are centred on the Glenelg River, which is used for boating, canoeing, water-skiing, and fishing. Other popular activities include picnicking at the numerous picnic areas along the river, bushwalking, nature study, pleasure driving, and viewing the wildflower displays of the Kentbruck Heath and other parts of the park. The Princess Margaret Rose Caves also attract large numbers

Sandy Waterholes, Lower Glenelg National Park

of visitors, some of whom travel to the caves by boat from Nelson. The uncommitted land in Lower Glenelg block has low recreational use, as it lacks the outdoor recreational attractions of the park. Picnic facilities have also been developed close to the Princes Highway in the Rennick Plantation at Pinaster Park, Palpara Park, and Bullant Ridge.

(3) Agriculture and apiculture

Public land here generally has a low capability for agriculture, particularly the areas covered in deep sands. The heaths and shallow sands have a higher capability, but development costs would be high.

A total of around 2,800 ha of public land in the Palpara Settlement Scheme has been cleared and pasture established. This land is currently being made available for agriculture by the Rural Finance and Settlement Commission.

The brown stringbark forests of these blocks are useful for apiarists as a source of pollen to build up their hives over the winter period. The understorey species, such as silver banksia and sweet bursaria, also provide good sources of pollen and honey for breeding purposes.

(4) Softwood production

Much of the public land has a high capability for softwood production. A net total of 12,800 ha already established on the public land includes 6,190 ha net in Rennick Plantation and 5,500 ha net in the Kentbruck Plantation, established by the Forests Commission, and 1,110 ha net established by Softwood Holdings Ltd on two leased areas. In addition, Softwood Holdings Ltd has established extensive softwood plantations on company-owned land in this area.

The uncommitted land in Lower Glenelg block that supports brown stringybark and manna gum open forest I is estimated to be capable of supporting SQIII--SQIV stands on the better sites. Excessively and poorly drained leached sands previously considered marginal to unsuitable for radiata pine can, with improved establishment techniques, be successfully planted. Site qualities are estimated at SQIV to SQVI.

(5) Hardwood production

These blocks generally have a low potential for hardwood production. The small areas of open forest II of brown stringybark have a moderate potential, but the growth rates there would be well below those of the messmate forests in the Cobboboonee block to the east.

(6) Mining and quarrying

Large quantities of dune limestone are extracted from pits, mainly located within the softwood plantations, for road construction. The small block of uncommitted land at Wanwin contains reserves of coarse sand suitable for use as conc-

crete sand, which will be in great demand during the construction of the Alcoa aluminium smelter at Portland. These reserves are the nearest known deposit on public land.

(7) Hazards and conflicts

The main hazard in these blocks is wildfire, particularly near the Glenelg River. This hazard is increased by the large number of people who visit and camp along the river in summer. Control of fires in this area is difficult, as fires can readily cross the river, but the only bridges to carry firefighters across are at Nelson and Dartmoor. Controlled burning is carried out to reduce this hazard.

Concentration of visitors in popular areas can have an adverse effect on the environment. Large numbers of people in a small area can cause the destruction of vegetation, soil erosion, and littering; moreover, they require the construction of expensive facilities such as roads, toilets, and picnic areas.

3. COBBOBOONEE-NARRAWONG

A. Tenure and Nature of the Land

1. Present tenure

Public land in these blocks covers approximately 38,000 ha, of which totals of 26,700 ha in Cobboboonee block and 1,720 ha in Narrawong block are currently managed for hardwood production. Cobboboonee block also contains a net 880 ha of softwood plantations established by the Forests Commission at Glenaulin and Lyons, and three wildlife reserves: Grassy Flats (220 ha), Tremaine Swamp (110 ha), and Sinclair Lake (15 ha).

The two largest parcels of uncommitted land - 2,250 ha in Narrawong block and 1,170 ha in Cobboboonee block - both adjoin large areas of forest managed for hardwood production. There are also several small isolated parcels, the largest of which are south of Tyrendarra and at Bolwarra.

2. Climate

This is the wettest part of the study area, with an average annual rainfall of around 910 mm in the Cobboboonee forest. Temperatures are fairly mild throughout the year, with the mean monthly maximum ranging from around 24°C in January to 13°C in July.

3. Geology and geomorphology

The blocks are covered by flat to undulating plains of mildly dissected basalt overlying Miocene limestones. Strong weathering of the basalt has resulted in the formation of a residual layer of nodular ironstone and a fine mottled red clay. Sheets and low dunes of wind-blown sands have been deposited across parts of the basalt surface, including most of the uncommitted land in Narrawong block.

The drainage pattern is not well developed and most of the streams are dry in summer. Surface water in these blocks is drained via short creeks into the Fitzroy, Surry, and Glenelg Rivers, although some percolates through the swamps into the groundwater.

4. Soils

Weakly bleached gradational soils formed on the weathered basalts and tuffs cover most of the public land. These soils consist of a red-brown clay loam merging into mottled red-brown clay, with buckshot gravel abundant throughout the profile. The uncommitted land in Narrawong block consists mainly of grey to yellow leached sands of variable depth, with clay and buckshot gravel often within a metre of the

surface. Brownish gleyed waterlogged soils and peaty soils are found in the heaths and swamps.

5. Vegetation

Open forest II of messmate predominates on the fertile basalt soils, largely in pure stands although in some places the species occurs in a mixed open forest with shining peppermint, swamp gum, and brown stringybark. Open forests of brown stringybark and heaths occur on areas covered with sandy soils.

The parcel of uncommitted land in Narrawong block contains a large area of open forest II of brown stringybark as well as mixed open forests of shining peppermint and messmate. A closed heath dominated by scented paper-bark, prickly tea-tree, and austral grass-tree occupies a large part of the parcel. Within this heath the rare blue-tinsel lily is locally common. The small block of uncommitted land at the junction of the Fitzroy River and Darlots Creek supports open forest II of manna gum growing on basaltic soils. The uncommitted land in Cobboboonee block supports open forest II of shining peppermint with areas of mixed open forest of brown stringybark, messmate, and swamp gum.

6. Fauna

The open forests of messmate support a diverse and abundant range of birds and mammals. As this habitat only occurs in the wetter southern portions of the study area and is well separated from its occurrences elsewhere, it has a high value for fauna conservation. The open forests of brown stringy-bark, heaths, and swamps add further diversity to the native animal population found here.

Species known to occur in the open forests include the yellow-bellied glider and tiger quoll; the dusky antechinus and potoroo inhabit the dense shrub understorey. The heath rat and potoroo have also been recorded in the heaths that occur on the uncommitted land in the Narrawong block.

B. Present Uses and Capabilities

(1) Nature conservation

These blocks have a high capability for nature conservation, as they contain large continuous areas of messmate forests as well as other vegetation communities that provide a diverse range of hatitats for native fauna. The messmate forests of Cobboboonee block are the most westerly occurr-ence of consolidated areas of this forest type in Victoria, and many species of plants and animals reach the western limits of their distribution there.

(2) Recreation

Being close to Portland and to major tourist roads, these blocks receive a high recreational use. Picnic facilities

have been developed at Sawpit Gully in Narrawong block and at Bullockys Wells, Jackass Fern Gully, Pipeclay Swamp, and Surry Ridge in Cobboboonee block. Major recreational activities are picnicking, recreational driving, nature study, and duck-shooting on the swamps during the open season.

(3) Agriculture and apiculture

A combination of high rainfall and fertile soils gives much of the public land a high capability for agriculture. However, development costs would be high, largely because of the expense of clearing the existing forest.

The messmate forests are very important for apiarists as they flower during December and January - 1--2 months earlier than in other parts of the State. Although used largely to provide pollen to revitalize hives, they also produce valuable flows of honey.

(4) Softwood production

On the 2,064 ha of land that the Land Conservation Council previously allocated for softwood production in Cobboboonee block, some 880 ha of softwood plantations have been established, with the balance yet to be planted.

The uncommitted land in the south of Cobboboonee block, which carries open forest II of shining peppermint, is estimated to be able to produce SQIV stands. In Narrawong block, the heavily leached sands on the uncommitted land are unsuitable, but the eastern part, which carries mixed open forest II of messmate and shining peppermint, would support softwood plantations with estimated site qualities of SQIII to SQIV.

Grassy Flats Wildlife Reserve

Sand extraction, Narrawong block

(5) Hardwood production

Messmate forests have a high potential, and much of the public land in these blocks is currently managed for hardwood production. The capacity of these messmate forests to produce timber has been increased by a program of removal of defective stems and the thinning of regrowth over large areas.

(6) Mining and quarrying

Buckshot gravel is extracted from pits on the uncommitted land in Narrawong block and from pits in the Cobboboonee forest. Coloured sand for use in concrete is also extracted from pits on the uncommitted land in the Narrawong block, but the supplies have now virtually been exhausted. Large areas of basalt occur on public land in these blocks, but it is generally too weathered to be suitable for use as aggregate.

(7) Hazards and conflicts

Wildfire poses a serious hazard in summer. The Cobboboonee forests are among the most fire-prone parts of the study area and major fires in 1943, 1962, 1967, and 1976 burnt out large areas of the public land. A program of fuel-reduction burning is carried out to reduce this hazard.

The root rot fungus *Phytophthora cinnamomi* has been recorded in poorly drained soils in about 20 places in the Cobboboonee forest. Although the total area infected is small, the occurrence is being closely monitored as this fungus has the potential to kill large areas of forest.

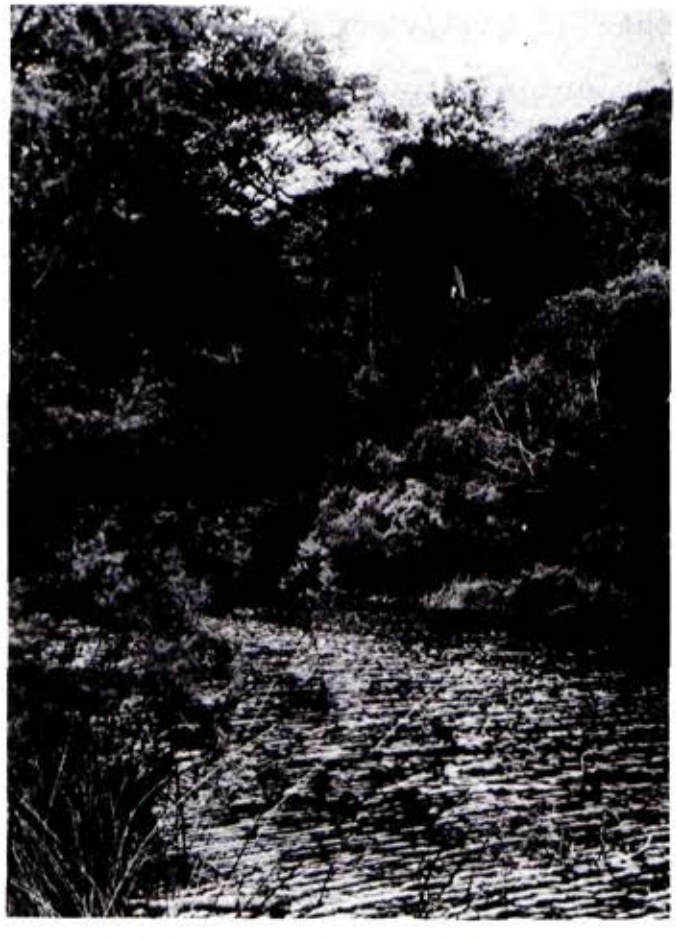
4. HOTSPUR--ANNYA--HOMERTON

A. Tenure and Nature of the Land

1. Present tenure

Public land in these blocks totals approximately 25,500 ha, of which the Forests Commission currently manages around 20,100 ha for hardwood production. Since the Land Conservation Council's final recommendations for this area were published, in April 1973, the Commission has purchased two areas of land at Milltown and some land adjoining the Annya and Hotspur forests. The Commission has established a net total of 1,050 ha of softwood plantations on this purchased land, and the remainder is currently being managed for hardwood production.

Hotspur block includes the Crawford River Forest Park (1,900 ha) and the Crawford Lake Wildlife Reserve (80 ha). The Lake Condah Wildlife Reserve is located in the east of the block and adjoins 'The Stones' Faunal Reserve, which extends into adjoining public land in the South-western Area, District 2.



The Crawford River - Crawford River Forest Park

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These three blocks contain very little uncommitted land. The two largest areas - about 1,500 ha in Annya block and some 240 ha in Hotspur - both adjoin large areas of hardwood production forest. There are three parcels of uncommitted land south of Milltown, two of which adjoin existing Forests Commission plantations. The remaining uncommitted land consists of small isolated areas surrounded by freehold land.

2. Climate

Average annual rainfall ranges from 900 mm in Hotspur block to around 710 mm at Branxholme; Heywood has an average of 860 mm. The mean monthly maximum temperatures at Heywood range from 23.4°C in January to 13.8°C in July.

3. Geology and gemorphology

Hotspur block consists of an extensive plateau of fossil laterite overlying lower Cretaceous Otway Group sediments. The plateau has been mildly dissected by the Stokes River and the Crawford River, leaving the public land as a table-land remnant between the two streams. In the western section, the laterite surface is covered by sheets of wind-blown sands.

Annya block contains flat to undulating plains of mildly dissected basalt sheets that overlie thick layers of Tertiary sediments. On the north-west margin, the Crawford River has cut a gorge exposing the underlying Tertiary sediments. All of these features are covered in parts by thin sheets of siliceous wind-blown sands.

In Homerton block, a flat to gently undulating coastal plain of Quaternary alluvium and thin sheets of siliceous wind-blown sand overlie Tertiary limestones. In the east, stony rises have developed on a young lava flow.

Surface drainage is generally well developed, with surface water draining into the tributaries of the Crawford, Stokes, and Fitzroy Rivers. Drainage of parts of Homerton block by the Fitzroy River and Darlots Creek is less efficient, and much of the surface water percolates into the groundwater through swamps.

4. Soils

Three main soil types occur in these blocks. The most common is a weakly bleached gradational soil consisting of a layer of red-brown clay loam overlying a mottled red-brown clay, with layers of buckshot gravel throughout the profile. Small areas of strongly leached sands, often with a layer of buckshot gravel within 1.5 m of the surface, occur on the sandy rises. Where the sand layer is thin, duplex soils occur with a thin layer of sand overlying a gravelly clay subsoil. Both the gradational soils and the duplex soils are fertile, with good water-holding capacity; in contrast, the strongly leached sands have low fertility and poor water-holding capacity.

Tiger quoll; Homerton block contains a remnant population of this animal.

5. Vegetation

The fertile basaltic soils that cover much of the public land support an open forest II of messmate. On the less fertile sandy soils, the most common vegetation community is an open forest of brown stringybark. Open forests of manna gum, swamp gum, and shining peppermint, often growing as mixed communities with messmate or brown stringybark, also occur. Heaths dominated by prickly tea-tree, small grass-tree, and scrub she-oak occupy only a small area.

The uncommitted land in the west of Annya block supports a mixed open forest of manna gum, shining peppermint, and swamp gum, as well as small areas of messmate open forest and heath. The uncommitted land in Hotspur block supports open forests of brown stringybark with small areas of shining peppermint and swamp gum. The three small parcels of uncommitted land south of Milltown in Homerton block contain open forests of messmate, shining peppermint, and swamp gum.

6. Fauna

The substantial areas of messmate open forest provide important habitat for a wide range of species, including the swamp antechinus, yellow-bellied glider, and heath rat. In addition, the eastern portion of Homerton block adjoins 'The Stones' Faunal Reserve, which contains a population of tiger quolls.

B. Present Uses and Capabilities

(1) Nature conservation

Because of their diverse range of vegetation communities, the blocks have a high value for conservation - particularly as these occur in large consolidated areas.

(2) Recreation

The Crawford River Forest Park attracts many visitors. A scenic drive follows the floor of the Crawford River valley and picnic facilities have been developed at a number of locations beside the river. Picnic facilities have also been developed at the Annya Camp in the Annya State Forest, on the Crawford River at Hotspur, and on the coastal reserve at the mouth of the Fitzroy River. Other recreational activities on public land include pleasure driving, nature study, and duck-hunting.

(3) Agriculture and apiculture

High rainfall and fertile soils give these blocks a high capability for agriculture, as can be seen by the agricultural industries that have been developed on adjoining freehold land. However, the cost of clearing and developing large areas of public land would be high.

The messmate and brown stringybark forests are very important to apiarists, as they provide pollen used to build up depleted hives over the winter. They also produce moderate quantities of honey and occasionally provide excellent flows of high-quality honey.

(4) Softwood production

The Forests Commission has established a net total of 1,050 ha of softwood plantations on two areas at Milltown and on land north of Hotspur. All of these plantations have been established on land purchased by the Commission for the purpose.

The small parcels of uncommitted land have a high capability for softwood production. Uncommitted land in Annya block is estimated to be capable of producing SQIV plantations on sites that carry open forest II of shining peppermint, swamp gum, and manna gum. The three small parcels in Homerton block south of Milltown are estimated to be capable of supporting SQIII plantations on sites carrying messmate open forest II. Uncommitted land in Hotspur block - carrying predominantly brown stringybark open forest II - has a lower potential and is estimated to be capable of supporting SQV plantations.

Areas of public land in the blocks that are currently being managed for hardwood production are also well suited to growing radiata pine. It is estimated that plantations of SQIII can be grown on sites carrying messmate open forest II, SQIV on sites carrying manna gum, shining peppermint, swamp gum open forest II, and SQV on brown stringybark open forest II sites.

(5) Hardwood production

The messmate and brown stringybark open forest II has a high potential, and most of the public land in these blocks is

currently managed for hardwood timber production. A program of cull-removal and thinning of regrowth stands over large areas has been carried out for a number of years to increase the productivity of these forests.

(6) Mining and quarrying

Large resources of buckshot gravel occur throughout the public land. Buckshot gravel is currently extracted from several pits on public land, including one pit on the uncommitted land north of Heywood.

(7) Hazards and conflicts

Extensive clearing of native vegetation on the steep sides of the Crawford River valley and on the slopes of the Weecurra escarpment could cause serious soil erosion. Spectacular and serious examples of gully erosion and landslips have occurred on the steep valley sides of adjacent cleared private lands.

Wildfire is also a hazard in summer. This hazard is reduced by fuel-reduction burning and other preventive measures.

5. STRATHDOWNIE--WILKIN--WEECURRA

A. Tenure and Nature of the Land

1. Present tenure

The public land covers a total area of around 26,000 ha. It includes the proposed Wilkin Park (3,600 ha), which is currently unreserved Crown land pending possible future incorporation into the parks system, and approximately 1,500 ha of land west of Merino managed to safeguard the groundwater used to supply the township of Merino. The blocks contain six wildlife reserves: Kerrs Swamp (230 ha), Kaladbro Swamp (120 ha), Church Swamp (70 ha), Red Hill Swamp (50 ha), Burgess Swamp (50 ha), and Pieracle Swamp (130 ha). Four other small blocks of public land, which together total around 800 ha, are managed for hardwood production.

Softwood plantations occupy a significant proportion of the public land. The Forests Commission has planted a net total of 660 ha in the Bahgallah and Mocamboro Plantations south of Casterton, and SAPFOR Ltd has established a total of 3,930 ha net on five blocks of leased public land in the Myaring area.

Weecurra block contains a large parcel of uncommitted land west of Digby that covers approximately 12,500 ha. In addition, several small isolated areas of public land in Wilkin and Strathdownie blocks total about 1,500 ha.

2. Climate

Average annual rainfall ranges from 660 mm at Strathdownie to 860 mm in Weecurra block. Mean monthly maximum temperatures range from around 27°C in January to 13°C in July.

3. Geology and geomorphology

To the west of the escarpment in Weecurra block and in the Strathdownie and Wilkin blocks, white, acidic, siliceous sands resting on consolidated Pleistocene calcareous sands and limestones of the Whalers Bluff Formation cover most of the public land. These sand sheets are up to 30 m deep and overlie Tertiary sands and silts.

The east of Weecurra block consists of sheets and low dunes of siliceous sand that lightly cover the Merino Tablelands. The Tablelands, which are not deeply dissected, consist of thin layers of Pliocene sands capping Tertiary sand and silt deposits. The Tertiary deposits thin rapidly to the east of the escarpment and overlie Mesozoic Otway Group sediments.

Surface drainage west of the escarpment is very restricted and swamps and waterlogged heaths are common. Some surface

drainage of Wilkin block takes place via short streams leading into the Glenelg River, but the regional drainage of most of this land, particularly in the Strathdownie area, is poorly developed. East of the escarpment, although massive sand deposits occasionally impede local drainage, the regional drainage is good, with surface water flowing into tributaries of the Glenelg River to the south and those of the Wannon River to the north.

4. Soils

Heavily leached sands which are extremely acid and grossly deficient in nutrients and have a very low water-holding capacity cover most of the uncommitted land. These sheets of medium fine sands are generally loose and structureless, although an impeding layer of buckshot gravel is often present within the first 1.5 m. Where the sand sheet is very thin, duplex soils occur - with a subsoil of a dark mottled clay - mainly in Strathdownie block. Brownish gleyed soils are also found in swampy areas.

5. Vegetation

Brown stringybark is the dominant vegetation community in Weecurra block and covers about 80% of the uncommitted land. In the north it occurs as an open forest I but in the wetter south it grows as open forest II with tree heights in excess of 30 m. The understorey is usually dominated by tall shrubs such as prickly tea-tree, heath tea-tree, small grass-tree, and bracken, with black wattle and blackwood up to 10 m tall a sporadic component of the tree layer.

On the southern margin of Weecurra block, messmate open forest II occurs along a tributary of the Stokes River. In this riparian environment the understorey consists of a tall shrub layer of blackwood and sweet bursaria overlying a well-developed ground layer that includes many ferns.

Heath communities dominated by scented paper-bark, prickly tea-tree, button grass, small grass-tree, and scrub she-oak grow on sandy soils with restricted drainage. Around the margins of the heaths and along drainage lines are found woodlands of swamp gum and also small isolated pockets of river red gum woodlands.

Public land in Wilkin block that has not been converted to softwood plantations supports similar vegetation to that in Weecurra block. The brown stringybark open forests within the proposed Wilkin Park have a high species diversity and more than 50 species of orchids have been recorded including the rare naked sun orchid. Wilkin block also contains areas of swamps, some of which are surrounded by river red gum and swamp gum woodlands and heaths.

6. Fauna

The heaths and open forests of brown stringybark provide habitat for a variety of species, including the red-tailed

black cockatoo, which was recorded during recent surveys in Wilkin and Weecurra blocks.

Uncommitted land in Wilkin and Weecurra blocks supports a diverse range of mammals, including the short-nosed bandicoot, heath rat (not previously known to occur in the area), and swamp antechinus, which had not previously been recorded so far inland. The uncommitted land in Weecurra block is particularly significant, as it contains one of the most extensive stretches of habitat for the heath rat and swamp antechinus in the study area.

B. Present Uses and Capabilities

(1) Nature conservation

Public land in Wilkin and Weecurra blocks has a high capability for nature conservation, particularly as much of the adjoining land has been cleared for agriculture or softwood plantations. The range of vegetation communities present provides habitat for many birds and mammals and is an important refuge area for native fauna. In many places the understorey is well developed and the area is rich in orchids.

In Strathdownie block nearly all of the land has been cleared for agriculture or converted to softwood plantations; thus, the remaining areas of public land supporting native vegetation are also important for nature conservation. In particular, the wetlands are used by many species of waterfowl, brolgas, and other migratory and resident birds.

(2) Recreation

These blocks have a moderate potential for recreation. Access is provided by major roads such as the Glenelg Highway, and the Wilkin and Weecurra blocks are close to Casterton. The main recreational activities are nature study, picnicking, and other forms of passive recreation plus duck-hunting on the swamps during the open season. Picnic facilities have been developed at Mill Swamp in the Wilkin Park close to the Glenelg Highway.

(3) Agriculture and apiculture

Nearly all of the land suitable for agriculture has already been alienated and no large blocks of public land suitable for agricultural development remain.

These blocks have a moderate potential for apiculture, but the irregularity of flowering by brown stringybark can lead to wide seasonal fluctuations.

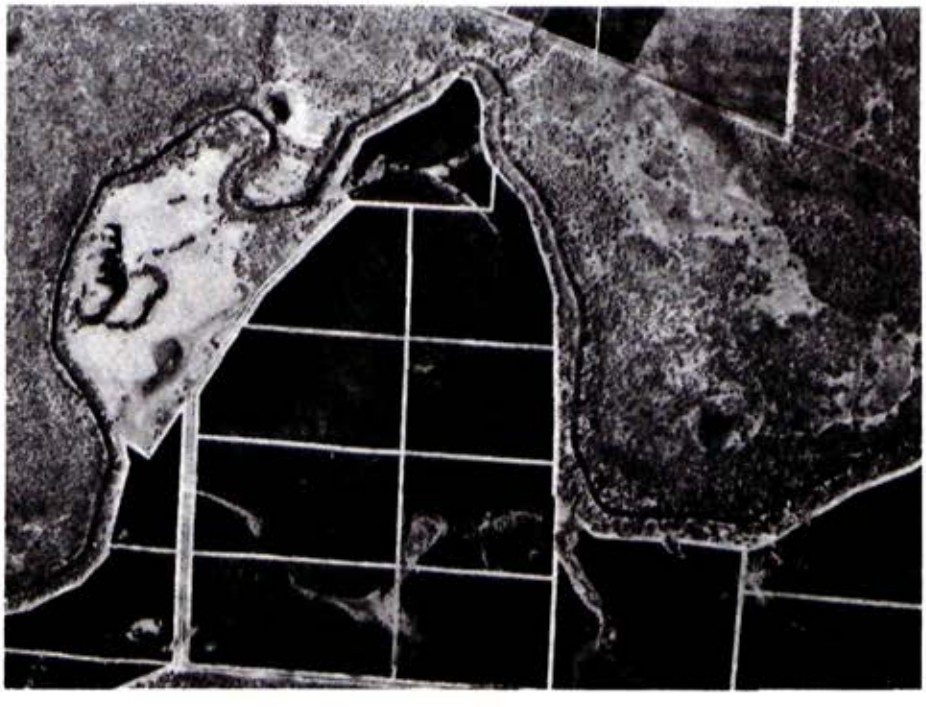
(4) Softwood production

Existing softwood plantations on public land include 660 ha net established by the Forests Commission in the Bahgallah and Mocamboro Plantations and 3,930 ha net established by SAPFOR Ltd on five blocks of leased public land in the

Myaring area. There are also substantial areas of softwood plantations on freehold land, nearly all of which have been established by Softwood Holdings Ltd or SAPFOR Ltd.

The large piece of uncommitted land in Weecurra block has a moderate capability for softwood production. On deep pale leached sands carrying brown stringybark open forest I, the estimated site quality is SQV to VI. Sites carrying brown--orange leached sands are estimated to be capable of supporting SQIV stands.

The small areas of uncommitted land in Strathdownie block are unsuitable to marginal. The uncommitted land adjoining the Bahgallah plantation in Wilkin block carries brown stringybark open forest I and heath, and varies from unsuitable to marginal for softwood production.



Aerial view of softwood plantations adjacent to the Glenelg River, Wilkin area. Note the native vegetation buffers

(5) Hardwood production

These blocks have a low potential for hardwood production. Parts of Weecurra block where the brown stringybark forests approach 20 m in height have a higher potential, but these stands are scattered through stands of low, heavily branched trees. However, these forests do supply some of the local demand for firewood and farming timbers.

(6) Mining and quarrying

Buckshot gravel is extracted for road-making purposes from public land in Wilkin block. There are also several limestone quarries on private land in these blocks and limestone has been quarried in the past from public land in Wilkin block.

(7) Hazards and conflicts

Part of Weecurra block is used to supply groundwater to the town of Merino. Clearing of native vegetation in the vicinity of the aquifers' intake areas could lead to a deterioration in the quality and quantity of the shallow groundwater supplies.

In Strathdownie block, many of the shallow wetlands on freehold land have been drained for agriculture. Drainage of the remaining wetlands on private and public land could pose a hazard to wildlife conservation particularly as the shallow swamps in this area are important breeding areas for brolgas.

Wildfire is an annual hazard, particularly in the brown stringybark forest and heaths. Fuel-reduction burning is carried out over broad areas and in small strips to remove localized hazards.

6. ROSENEATH--TOOLOY--DRAJURK

A. Tenure and Nature of the Land

1. Present tenure

Public land covers a total area of around 43,500 ha, most of which is uncommitted land. The Tooloy--Lake Mundi Wildlife Reserve occupies approximately 4,200 ha, and a further 2,000 ha of public land west of Casterton is used to protect the groundwater supply for Casterton. Other conservation reserves include the Roseneath Reference Area (2,100 ha), the Tooloy Flora Reserve (410 ha), and the Roseneath Flora Reserve (340 ha). Also, a small area of approximately 250 ha north of Lake Mundi is used for hardwood production. SAPFOR Ltd has established a net total of 3,530 ha of softwood plantations on seven blocks of leased public land.

Uncommitted land in these blocks totals about 29,500 ha, and is nearly all contained in one large parcel stretching from the Casterton--Mount Gambier road to west of Dergholm.

2. Climate

Average annual rainfall of these northerly blocks decreases to around 660 mm, with Casterton having an average of 680 mm. Mean monthly maximum temperature at Casterton ranges from 27.2°C in January to 13.2°C in July.

3. Geology and geomorphology

The area south-west of the Kanawinka Fault consists of gentle dunes and sheets of white acidic siliceous sands of variable thickness resting on Pleistocene calcareous sands and limestones of the Whalers Bluff Formation. The thickness of these sand sheets varies, but in places they may be up to 30 metres deep.

To the north-east of the Kanawinka Fault, sheets and dunes of white acidic siliceous sands cover the Dergholm platform. The sand layer over the Dergholm platform is relatively shallow and varies from less than 0.5 m to around 10 m deep in places. A late Tertiary sea retreating in stages is responsible for the basic north-west--south-east trend of low dune and sandstone ridges separated by corridors of lower-lying alluvial material.

Surface drainage on the public land is poorly developed. The area south-west of the Kanawinka Fault has no streams and in winter water collects in the swamps and lakes and then infiltrates into the siliceous sands and underlying Whalers Bluff Formation. Several short streams drain the Dergholm platform and flow either east to the Glenelg River or west to the line of swamps at the base of the escarpment.

4. Soils

Thick sheets of heavily leached acidic soils with low water-holding capacity cover most of the uncommitted land. The depth of the sand layer is variable, but a layer of buckshot gravel is usually encountered within 1.5 m of the surface. In general, the sands of Tooloy block are not as strongly leached as similar soils in the other northern blocks, and this has enabled softwood plantations to be successfully established on public land there.

The gum woodlands are developed on fertile duplex soils where the sand layer is reduced to a thin layer that often has a high loam content and overlies a heavy clay subsoil. The numerous swamps and poorly drained areas, which occur particularly in Roseneath block, are developed on dark heavy gleyed soils.

5. Vegetation

Woodlands and open forests of brown stringybark occupy about 70% of the uncommitted land. The understorey is usually dominated by shrubs such as small grass-tree, austral grass-tree, prickly tea-tree, desert banksia, and beaked hakea. In areas that have been frequently burnt, bracken is often found.

Substantial areas of heath dominated by scented paper-bark, austral grass-tree, scrub she-oak, and desert banksia also occur. Along the base of the Kanawinka escarpment, numerous swamps and poorly drained areas support sedgelands of water ribbons and sword sedge up to 1 metre tall, with jointed rush common in the perenial swamps. A fairly extensive area of shining peppermint woodland occurs in Drajurk block, with an understorey of prickly tea-tree, wattles, beaked hakea, and silver banksia.

In the north of Roseneath block and along the margin of Drajurk block, mixed woodlands of river red gum, yellow gum, manna gum, and swamp gum occur. Pink gum, a species with a very restricted distribution in Victoria, forms part of these mixed woodlands in some areas. Some small areas carry river red gum woodlands growing as pure stands with a grassy understorey. Together these comprise one of the largest areas of gum woodlands remaining on public land in the study area.

Softwood plantations have been established on much of the public land in Tooloy block. However, substantial areas of brown stringybark, heath, and swamp communities remain in the Tooloy--Lake Mundi Wildlife Reserve. There is also an area of manna gum woodland with an understorey of silver banksia up to 2 metres tall in the Tooloy Flora Reserve.

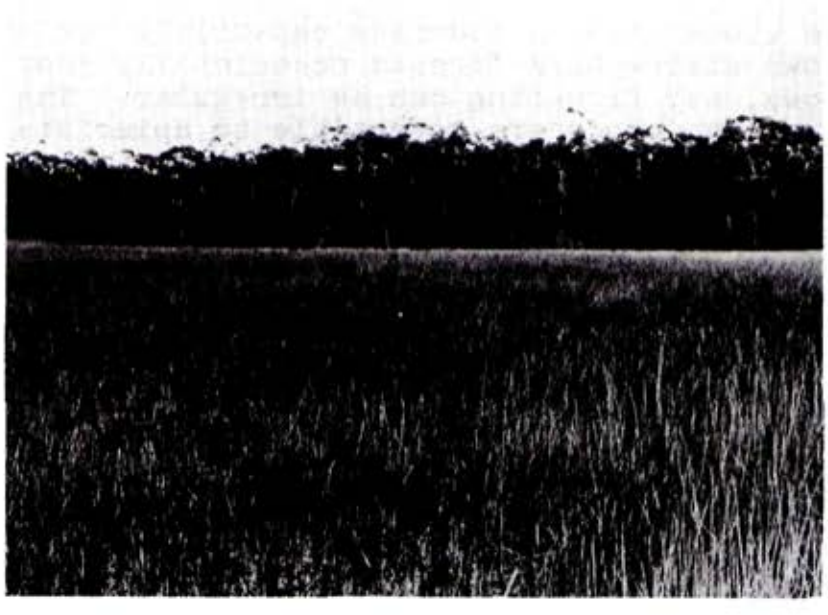
6. Fauna

As most of the public land is consolidated in one large area it is important for fauna conservation. Uncommon species

that were recorded in recent surveys include the red-tailed black cockatoo, southern emu-wren, heath rat, and swamp antechinus.

The small areas of gum woodlands occurring in these blocks provide habitat for many birds and mammals. In conjunction with the other woodlands to the north, they are the stronghold in the study area for several species of honeyeaters and lorikeets. Activities and numbers of these bird species peak between August and October when the pink gum and yellow gum are flowering. Mammals found in the gum woodlands include the sugar glider, brush-tailed possum, and yellow-footed antechinus.

The swamps are important for the conservation of many water birds. They provide feeding and breeding areas for many species, including breeding areas for the blue-billed duck, a rare bird that needs heavily vegetated swamps for nesting.



Typical fresh-water swamp, Drajurk area

B. Present Uses and Capabilities

1. Nature conservation

One of the important botanical features here is the extensive area of relatively undisturbed heath dominated by saw banksia north of Tullich Swamp in Roseneath block. A number of interesting species recorded in this heath during recent surveys include the blue-tinsel lily, which is restricted to sandy heaths in western and south-western Victoria, and porcupine grass, which is common on the sand hills of the Little and Big Deserts but has a restricted distribution in the study area.

The mixed gum woodlands that occur particularly in Roseneath block are important for nature conservation, as they are good examples of a land type that has been extensively cleared for agriculture. Pink gum is present in some of these woodlands and, as the Victorian distribution of pink

gum is confined to a small area in western Victoria, its occurrence is of considerable importance.

2. Recreation

Current recreational use of public land in these blocks is low. The major recreational activities are nature study, some picnicking, and duck-hunting in the swamps during the open season. Picnic facilities have been developed by the Forests Commission at Long Lead Flat, south of the Casterton--Penola road.

3. Agriculture and apiculture

Land in these blocks has only low agricultural capability, and no large areas of public land suitable for alienation for farming remain. The small areas of gum woodland have a higher capability, but do not occur in large parcels, so development would be difficult.

The blocks have a moderate capability for apiculture. The brown stringybark forests occasionally provide large honey flows, but flowering can be irregular. The gum woodlands in Roseneath block are accessible to apiarists and produce very good honey flows.

4. Softwood production

SAPFOR Ltd has established a net total of 3,530 ha of softwood plantations on leased public land, and has also established extensive plantations on freehold land in this area. The Forests Commission does not have any softwood plantations here.

The uncommitted land has low potential for softwood production, because of the low rainfall and predominance of deep, heavily leached, infertile, sandy soils. The better sites carrying brown stringybark open forest I could support SQV to SQVI plantations.

5. Hardwood production

Potential for hardwood production is low. The small areas of gum woodlands are capable of producing limited amounts of durable sleepers and posts, and those of brown stringybark produce firewood and posts to meet some of the local demand.

6. Mining and quarrying

Buckshot gravel for road-making purposes is extracted from several pits on public and private land in these blocks. Red Dergholm granite has been quarried in the past near Boiler Swamp in Roseneath block.

7. Hazards and conflicts

Development of the area immediately surrounding the Casterton water-supply bores for either softwood production or

agriculture could pose a hazard to the groundwater supplies. It is important that the native vegetation is retained in the area to maintain the quality and quantity of the groundwater.

Wildfire is a serious hazard in the brown stringybark forests and heaths, as these blocks comprise one of the most frequently burnt parts of the study area. Major fires in 1952, 1959, 1967, and 1977 burnt extensive areas of the public land. This hazard is reduced by a program of fuel-reduction burning.

7. KANAWINKA--BOGALARA--YOUPAYANG

A. Tenure and Nature of the Land

1. Present tenure

Public land covers about 24,000 ha, most of it uncommitted land. The only existing conservation reserves here are the Bailey's Rocks Scenic and Recreation Reserve (510 ha), the Beniagh Swamp Wildlife Reserve (215 ha), and two bushland reserves, one north of Chetwynd and the other north of Poolaijelo.

Youpayang block contains a large area of uncommitted land covering approximately 13,000 ha. Bogalara block contains two parcels, which together total around 7,200 ha, and Kanawinka block contains an area of approximately 2,300 ha of uncommitted land.

2. Climate

Average annual rainfall in these northerly blocks decreases to around 660 mm. Dergholm lies within a small pocket of higher rainfall and has an annual average of 711 mm. Mean monthly maximum temperatures range from 27°C in January to 13°C in July.

3. Geology and geomorphology

Sheets and low dunes of white siliceous sand cover most of the public land. Diversity in land form and vegetation is primarily determined by the thickness of these sand sheets, which overlie Tertiary sand deposits and fossil laterite. A plain of Miocene limestone with a veneer of Quaternary swamp and lagoon deposits, which occupies extensive areas of the Wimmera Plains to the north of the study area, occupies a portion of the land in these blocks.

Surface drainage is poor and the Kanawinka and Youpayang blocks contain large circular swamps. Intermittent streams occur around the margins of Bogalara and Youpayang blocks and eventually drain into the Glenelg and Chetwynd Rivers.

4. Soils

Thick sheets of heavily leached sands - highly acidic and very infertile, with a very low water-holding capacity - cover most of the uncommitted land. A layer of buckshot gravel is frequently encountered within the first metre of the profile. Small areas of gum woodlands on the margins of the blocks are developed on fertile duplex soils that consist of shallow sands with a significant loam content overlying a heavy grey mottled clay with buckshot gravel. These soils are often waterlogged during winter.

5. Vegetation

Woodland and open forests of brown stringybark occupy about 70% of the uncommitted land. The understorey is dominated by shrubs such as small grass-tree, austral grass-tree, prickly tea-tree, silver banksia, and beaked hakea. Bracken is widespread and is frequently the dominant understorey species.

Heaths are common, particularly in Bogalara and Youpayang blocks. They occur on sandy soils with restricted drainage and are dominated by scented paper-bark, prickly tea-tree, she-oak, and silver banksia. In Bogalara block, an extensive area of heath contains a mosaic of heath alliances whose distribution is mainly determined by soil type.

Woodlands of river red gum, yellow gum, pink gum, and manna gum occur on the more fertile soils on the margins of the public land. They occur as both pure and mixed stands and although they occupy less than 10% of the total area of the blocks, form one of the largest zones of gum woodlands left on public land in the study area.

Small occurrences of woodlands and open forests of swamp gum are found in poorly drained positions and around the margins of the heaths. Silver banksia up to 4 metres tall is emergent in the understorey in some places, and yellow gum may be co-dominant or sub-dominant in the tree layer.

A rosetting mallee form of pink gum in Kanawinka block.

6. Fauna

These blocks support a varied animal population, the open forests of brown stringybark being interspersed with heaths, swamps, and small areas of gum woodlands. As most of the

Large granite tors at Baileys Rocks

public land occurs in a few large tracts, this is an important area for the conservation of native fauna.

The red-tailed black cockatoo lives in the brown stringybark forests and the southern emu-wren reaches the northern-most limits of its Victorian distribution here and in the heaths of the Grampians to the east of the study area. The blue-faced honeyeater has been occasionally recorded in the gum woodlands on the margins of these blocks.

Mammal species that occur here include the silky grey mouse and the wombat. The silky grey mouse was recently trapped in nine localities in Bogalara and Kanawinka blocks, representing the southern limit of its range in Victoria. Its occurrence with species typical of the Bassian faunal region to the south is unique and is of considerable zoogeographic interest. There are also small isolated populations of wombats in Bogalara block - mainly on private land, although some evidence suggests that wombats occur or recently occurred on public land at Baileys Rocks.

B. Present Uses and Capabilities

(1) Nature conservation

The large areas of public land that occur in these blocks have a moderate capability for nature conservation The range of vegetation communities present includes two comm-

unities of special interest: in Bogalara block an extensive area of relatively undisturbed heath contains a mosaic of heath alliances; also of note are the woodlands of pink gum. Pink gum has a very restricted distribution in Victoria and is confined to the northern parts of the study area and similar country to the north.

(2) Recreation

Being remote from major population centres, this area has low recreational use. The large granite tors at Baileys Rocks provide the major recreational attraction. Picnic areas have been developed at Baileys Rocks and at Wando Bridge on the Casterton--Edenhope road. Other recreational activities on the public land are generally confined to nature study and duck-hunting on the swamps during the open season.

(3) Agriculture and apiculture

No large areas of the public land are suitable for development for agriculture. The small areas of gum woodlands and heaths have a moderate capability, but they are distributed in small pockets, which makes development difficult.

In contrast, these blocks have a high capability for apiculture. The diverse heath and eucalypt species provide pollen for over-wintering as well as favouring spring and summer production.

(4) Softwood production

No softwood plantations occupy public land in these blocks. Most of the uncommitted land is unsuitable for softwood production, but the better sites of brown stringybark open forest I in Youpayang block could support SQV to SQVI plantations.

(5) Hardwood production

Potential for hardwood production is low. The gum woodlands are capable of producing durable timbers for posts and sleepers, but these stands only cover a small area. The potential of the brown stringybark forests is low, although they do meet some of the local demand for farm and domestic timbers.

(6) Mining and quarrying

Buckshot gravel and granitic sand are extracted from pits in Bogalara block for road-construction purposes. In the past the granite outcrops near Baileys Rocks have been quarried for use as a veneer on buildings.

Land in the Youpayang area has potential for the discovery of metallic minerals, and occurrences of gold, silver, arsenic, lead, and zinc have been recorded on private land in this area.

(7) Hazards and conflicts

At present, few physical hazards threaten to cause land deterioration. Extensive clearing of native vegetation would increase the salinity levels of the tributaries of the Glenelg River, and wildfire is a hazard in the summer. Extensive quarrying of the granite outcrops in the vicinity of Baileys Rocks could also conflict with the recreation and conservation values of the area.

APPENDICES

Appendix I

AUTHORIZED DIVERSIONS FROM SURFACE WATER RESOURCES

Stream system (1)	No. of permits issued: Irrigation	Domestic & stock	Industrial (2)	Area irrigated for pasture, lucerne, annual crops, and others (ha)	Annual volume, irrigation (ML)
Fitzroy River	3	-	-	15.2	91.0
Condah Main Drain	4	2	-	53.5	325.4
Darlots Creek	4	2	-	34.6	211.4
Scotts Creek	2	2	1	9.5	66.2
Glenelg River	4	3	-	39.3	244.8
Crawford River	2	2	-	14.5	91.4
Surry River	2	-	-	12.5	75.0
Badger Creek	1	-	-	6.0	18.0
Glenavlin Creek	1	-	-	4.0	24.0
Stokes River	-	1	-	-	2.2
Tea Tree Creek	1	-	-	12.3	37.0
Wando River	1	-	-	4.2	25.0
Total	25	12	1	205.6	1,211.4

Source: State Rivers and Water Supply Commission

Notes : (1) None of the stream systems listed is regulated

(2) Annual permits authorizing diversion for various industrial purposes

Appendix II

TOWN WATER SUPPLIES AND CONSUMPTION

Authority	Source of supply	Population served	Consumption (ML) Av. daily	Max. daily	Annual	Remarks
Coleraine/Casterton Waterworks Trust - serves Casterton within study area	Konong Wootong Reservoir and bores	2,336 (Casterton)	1.23	3.08	450	Maximum daily assumed to be 2.5 x average daily
Shire of Glenelg Waterworks Trust - serves Sandford	Purchase of bulk water from Coleraine/ Casterton	200	0.065	0.162	24	
Merino	Bores	300	0.098	0.245	36	
Heywood Waterworks Trust	Bores	1,300	0.438	1.10	160	
Portland Waterworks Trust	Bores	8,900	8.220	20.55	3,000	

Source: State Rivers and Water Supply Commission

Appendix III

AUTHORIZED ANNUAL EXTRACTIONS FROM GROUNDWATER RESOURCES

Parish	No. of licences	Total area irrigated (ha)	Total authorized extraction (ML)
Annya	1	0	3
Ardno	64	731.0	2,241.0
Audley	1	0	2
Bessiebelle	1	0	4
Bolwarra	11	43.6	222.0
Branxholme	1	1.6	14.0
Byambynee	8	6.1	53.0
Casterton	1	0	4.0
Drajurk	1	0	2.0
Drumborg	3	0	14.0
Glenelg	1	0	5.0
Gorae	13	42.4	286.0
Greenhills	1	0	3.0
Heywood	26	215.0	1,595.0
Homerton	7	16.0	113.2
Kaladbro	63	967.9	4,738.0
Killara	3	8.9	62.0
Malanganee	1	5.7	18.0
Merino	2	0	45.0
Mouzie	1	0	4.0
Myamyn	11	0	38.2
Nangeela	2	0	199.0
Narrawong	24	67.0	461.0
Portland	6	22.0	2,685.0
Tarragal	3	100.0	602.0
Trewalla	11	106.8	643.0
Tyrendarra	14	35.4	234.0
Werrikoo	25	215.1	727.0
Wilkin	1	20.0	120.0
Winyayung	1	0	4.0
Total	221	2,604.7	15,141.4

Source: State Rivers and Water Supply Commission
Note : Parishes within the area, but not tabulated, indicate no authorized groundwater use

Appendix IV

PLANT NAMES IN REPORT

Common name	Scientific name
Austral cord-rush	*Restio australis*
Austral grass-tree	*Xanthorrhoea australis*
Australian indigo	*Indigofera australis*
Austral king-fern	*Todea barbara*
Beaked hakea	*Hakea rostrata*
Black bristle-rush	*Chorizandra enodis*
Black wattle	*Acacia mearnsii*
Blackwood	*Acacia melanoxylon*
Blue tinsel-lily	*Calectasia cyanea*
Bracken	*Pteridium esculentum*
Brown stringybark	*Eucalyptus baxteri*
Bullrushes	*Typha* spp.
Button grass	*Gynoschoenus sphaerocephalus*
Cherry ballart	*Exocarpus cupressiformis*
Coast beard heath	*Leucopogon parviflorus*
Common heath	*Epacris impressa*
Common maidenhair	*Adiantum aethiopicum*
Common reed	*Phragmites communis*
Cranberry heath	*Astroloma humifusum*
Daisy bush	*Olearia axillaris*
Desert banksia	*Banksia ornata*
Drooping she-oak	*Casuarina stricta*
Fishbone water fern	*Blechnum nudum*
Fringed hare-orchid	*Leptoceras fimbriatum*
Golden tip	*Goodia lotifolia*
Guinea flower	*Hibbertia stricta*
Hairy spinifex	*Spinifex hirsutus*
Heath honey myrtle	*Melaleuca squarrosa*
Heath tea-tree	*Leptospermum myrsinoides*
Honey pots	*Acrotriche serrulata*
Hop goodenia	*Goodenia ovata*
Manna gum	*Eucalyptus viminalis*
Maroon leek orchid	*Prasophyllum hartii*
Marram grass	*Ammophila arenaria*
Marsh-flowers	*Villarsia* spp.
Messmate	*Eucalyptus obliqua*
Moonah	*Melaleuca lanceolata*

Common name	Scientific name
Parson's bands	*Eriochilus cucullatus*
Pink gum	*Eucalyptus fasciculosa*
Pithy sword-sedge	*Lepidosperma longitudinale*
Porcupine grass	*Triodia irritans*
Prickly moses	*Acacia verticillata*
Prickly tea-tree	*Leptospermum juniperinum*
Radiata pine	*Pinus radiata*
Red-beaks	*Lyperanthus nigricans*
Red gum	*Eucalyptus camaldulensis*
Sallow wattle	*Acacia longifolia*
Saw sedge	*Gahnia radula*
Scent bark	*Eucalyptus aromaphloia*
Scent paperbark	*Melaleuca squarrosa*
Scrambling coral fern	*Gleichenia microphylla*
Scrub she-oak	*Casuarina stricta*
Shining peppermint	*Eucalyptus nitida*
Silver banksia	*Banksia marginata*
Slaty helmet orchid	*Corybas diemenicus*
Slender twine-rush	*Leptocarpus tenax*
Small grass-tree	*Xanthorrhoea minor*
Small helmet orchid	*Corybas unguiculatus*
Snow gum	*Eucalyptus pauciflora*
Soap mallee	*Eucalyptus diversifolia*
Swamp gum	*Eucalyptus ovata*
Swamp greenhood	*Pterostylis tenuissima*
Sweet bursaria	*Bursaria spinosa*
Tall spike-rush	*Eleocharis sphacelata*
Tussock grass	*Poa australis*
Twiggy daisy bush	*Olearia ramulosa*
Water milfoil	*Myriophyllum propinquum*
Water ribbons	*Triglochin procera*
Woolly tea-tree	*Leptospermum lanigerum*
Yellow gum	*Eucalyptus leucoxylon*

Appendix V

BIRD NAMES IN REPORT

Common name	Scientific name
Barking owl	*Ninox connivens*
Barn owl	*Tyto alba*
Beautiful firetail	*Emblema bella*
Blue-billed duck	*Oxyura australis*
Blue-faced honeyeater	*Entomyzon cyanotis*
Boobook owl	*Ninox novaeseelandiae*
Brolga	*Grus rubicundra*
Bush thick-knee	*Burchinus magnirostris*
Chestnut-rumped hylacola	*Sericornis pyrrhopygius*
Chestnut teal	*Anas castanea*
Crimson rosella	*Platycercus elegans*
Gang-gang cockatoo	*Callocephalon timbriatum*
Grey butcherbird	*Craticus torquatus*
Grey-crowned babbler	*Pomatostomus temporalis*
Ground parrot	*Pezoporus wallicus*
Laughing kookaburra	*Dacelo novaeguineae*
Little lorikeet	*Glossopsitta pusilla*
Masked owl	*Tyto novaehollandiae*
Musk lorikeet	*Glossopsitta concinna*
Orange-bellied parrot	*Neophema chrysogaster*
Peregrine falcon	*Falco pereginus*
Pied currawong	*Strepera graculina*
Pink robin	*Petroica rodinogaster*
Powerful owl	*Ninox strenua*
Purple-crowned lorikeet	*Glossopsitta porphgrocephala*
Rainbow lorikeet	*Trichoglossus haematodus*
Red-tailed black cockatoo	*Calyptorhynchus magnificus*
Rose robin	*Petroica rosea*
Rufous bristlebird	*Dasyornis broadbenti*
Rufous fantail	*Rhipidura rufifrons*
Sacred kingfisher	*Halcyon sancta*
Satin flycatcher	*Myiagra cyanoleuca*
Southern emu-wren	*Stipiturus malechurus*
Sulphur crested cockatoo	*Cacatua galerita*
White-throated tree creeper	*Climacteris affinis*
Yellow-tailed black cockatoo	*Calyptorhynchus funereus*

Appendix VI

MAMMAL NAMES IN REPORT

Common name	Scientific name
Brown antechinus	*Antechinus stuartii*
Brush-tailed possum	*Trichosurus vulpecula*
Bush rat	*Rattus fuscipes*
Chocolate wattled-bat	*Chalinolubus morio*
Dusky antechinus	*Antechinus swainsonii*
Eastern pygmy-possum	*Cercartetus nanus*
Eastern quoll	*Dasyurus viverrinus*
Fat-tailed dunnart	*Sminthopsis crassicaudata*
Feathertail glider	*Acrobates pygmaeus*
Gould's wattled-bat	*Chalinolobus gouldii*
Great pipistrelle	*Pipistrellus tasmaniensis*
Heath rat	*Pseudomys shortridgei*
Koala	*Phascolarctos cinereus*
Lesser long-eared bat	*Nyctophilus geoffroyi*
Little brown bat	*Eptesicus pumilus*
Potoroo	*Potorous* spp.
Silky grey mouse	*Pseudomys apodemoides*
Short-nosed bandicoot	*Isodon obesulus*
Sugar glider	*Petaurus breviceps*
Swamp antechinus	*Antechinus minimus*
Swamp rat	*Rattus lutreolus*
Tiger quoll	*Dasyurus maculatus*
Tuan	*Phascogale tapoatafa*
White-footed dunnart	*Sminthopsis leucopus*
White-footed tree-rat	*Conilurus albipes*
Wombat	*Vombatis ursinus*
Yellow-bellied glider	*Petaurus australis*
Yellow-footed antechinus	*Antechinus flavipes*

MAP NO. 2 PUBLIC LAND USE

LEGEND

NATIONAL PARKS	A1 *Lower Glenelg* A2 *Mt. Richmond*	
FOREST PARKS	A3 *Crawford River*	
COASTAL PARKS	A5 *Discovery Bay*	
OTHER PARKS	A4 *Wilkin*	
REFERENCE AREAS	B1 *Keegans Bend* B2 *Kentbruck Heath*	B3 *Cobboboonee* B4 *Roseneath*
WILDLIFE RESERVES	C1 *Lawrence Rocks* C2 *Bats Ridge* C3 *The Stones* C4 *Crawford Lake* C5 *Red Hill Swamp* C6 *Kerr's Swamp* C7 *Kaladbro Swamp* C8 *Church Swamp*	C9 *Beniagh Swamp* C10 *Lake Condah* C11 *Sinclair Lake* C12 *Tremaine Swamp* C13 *Grassy Flats* C14 *Burgess Swamp* C15 *Tooloy–Lake Mundi*
FLORA RESERVES	J2 *Johnstone's Creek* J3 *Tooloy*	J4 *Roseneath*
WATER PRODUCTION	G1 *Drajurk* G2 *Weecurra*	
HARDWOOD PRODUCTION	D1 *Cobboboonee* D2 *Annya* D3 *Homerton*	D4 *Narrawong* D5 *Hotspur* D6 *Strathdownie*
SOFTWOOD PRODUCTION	E1 *Rennick* E2 *Kentbruck* E3 *Mt. Richmond* E4 *Cobboboonee* E5 *Weecurra*	E6 *Wilkin* E7 *Weecurra* E8 *Tooloy* E9 *Roseneath* E10 *Other Plantations (Public Land Only)*
BUSHLAND RESERVES	J7 *Various*	
RECREATION RESERVES	J1 *Bailey's Rocks*	
SCENIC RESERVES	J5 *Hedditch Hill*	
STREAMSIDE AND COASTAL FRONTAGES	J6 *Various*	Note: Some of these reserves were not shown on the L.C.C. final recommendations map published in April 1973 .
AGRICULTURE Alienation	F1 *Palpara* F2 *Various*	
NO PRIMARY USE	I1 *Narrawong* I2 *Stokes River*	I3 *Drajurk–Roseneath–Bogalara* I4 *Various*

Notes (1) This map also shows two areas that have been purchased and reserved for conservation since the L.C.C. final recommendations were published in April 1973:

1. Cape Nelson State Park, indicated by: **CNSP**
2. Pieracle Swamp Wildlife Reserve, indicated by: **PSWR**

(2) The land shown on this map as allocated for softwood production includes some small areas that have not yet been planted (refer to text for their location).

(3) See text regarding land in the No Primary Use category.

Study Area Boundary

City or Borough Boundary

PUBLIC LAND USE

South Western Area District 1

1:250 000

0 5 10 20 Kilometres

Land Conservation Council
Victoria

Numbers shown thus 80 indicate grid values at 10,000 metre intervals on the Australian Map Grid, zone 54. Grid values are shown in full only at the south-west corner of the map.

MAP NO. 2

MAP No.6 LAND ZONES AND LAND SYSTEMS

LEGEND

Land Zone		Land System	Landform and Geology	Soils	Vegetation
Nelson	1a	Discovery Bay	Coastal dunes of Pleistocene and Recent calcareous sands.	Undifferentiated yellow – brown calcareous sands. (Uc 1.11)	Large areas unvegetated Pioneering grasslands of marram grass and hairy spinifex, open scrub and some heaths.
	1b	Long Swamp	Coastal swamp and dune complex of Recent calcareous sands.	Friable peat (O soils) dark grey–brown sand overlying yellow–brown sand (Uc 1.11)	Sedgeland of reeds and rushes fringed by wet heath and open scrub.
	1c	Nelson	Consolidated dune ridges of Pleistocene limestone and sand sheets of orange siliceous sand.	Shallow red and black sandy loams (terra–rossa) (Uc 6.13) and rendzina (Um 6.1) over limestone;leached sands elsewhere. (Uc 2.2)	Woodlands including *E. viminalis*, *E. ovata*, *E. baxteri* and *E. nitida*, with heath and scrub understorey
Heywood	2a	Strathdownie	Broad coastal plain of Pleistocene and Recent lagoon deposits developed between low dune ridges.	Grey–brown coarse sandy loam overlying mottled heavy clay. (Dy 5)	Open woodlands of *E. camaldulensis* and woodlands of *E. ovata* with heathy understorey; *E. viminalis* on drier sites.
	2b	Heywood	Flat to undulating coastal plain of Tertiary limestone and Quanternary alluvium.	Dark grey–brown sandy loam merging to olive brown sandy clay (Dy 5)Other duplex and gradational soils, including red–brown loam overlying clay loam on limestone.	Forest and woodland formations of *E. viminalis*, *E. obliqua* and *E. ovata* with heathy understorey.
Kanawinka	3a	Follett	Gentle dunes and sheets of acidic siliceous Malanganee sands with inter–dune Pleistocene lagoon deposits.	Leached dark grey to white acidic sand sometimes overlying buckshot gravel. Sand may be up to 30m. deep.(Uc 2.33, 2.2)	Woodland of *E. baxteri* with heath understorey very widespread; some heath plains with *Leptospermum juniperinum* and *Banksia marginata*.
	3b	Kanawinka	Gentle dunes and sheets of acidic siliceous Malanganee sands overlying Tertiary sandy deposits and fossil laterite.	As above, but sand generally not as deep. Buckshot gravel often present.	As for Follett
Dundas	4a	Dundas	Extensive flat plateau of fossil laterite with some areas of shallow dissection.	Brown sandy loam overlying gravelly loam and mottled orange heavy clay. (Dy 3.61) grey clays in shallow depressions.	Open woodland of *E. camaldulensis*, *E. ovata* and *E. viminalis*, with small areas of *E. nitida*, *E. obliqua* and *E. paucifloria*.
	4b	Glenelg	Deeply dissected valleys cut below the tablelands exposing Palaeozoic sedimentary, igneous and metamorphic rocks.	Brown–grey coarse sandy loam over yellow–grey coarse sand and mottled yellow–brown heavy clay. Weathered bedrock at shallow depth. Sandy alluvium and clays on valley floor. (Dy. 3.61, 3.81)	Woodland formation of *E.camaldulensis* and *E. viminalis* with *Casuarina stricta* on drier sites.
Casterton	5	Casterton	Broad dissected valleys and steeply rolling hills cut below the level of the Dundas Tablelands exposing Mesozoic sediments and Permian glacial deposits.	Dark brown to black clay loam overlying dark brown clay, well structured and cracking throughout.(Ug 5.1, Gn 3.4)	Tussock grasslands on upper slopes. Open woodland of *E. camaldulensis* with grassy understorey along creeklines.
Hamilton	6a	Hamilton	Generally flat to broadly undulating Plio–Pleistocene basaltic plains.	Grey–brown silty loam over gravelly loam and mottled brown clay. (Dr 2 and Dy 3)	Woodlands of *E. ovata* and *E.viminalis* with shrub understorey.
	6b	Branxholme	Broad open valleys and undulating to rolling hills below the general level of the volcanic plains exposing underlying Tertiary limestone and marl.	Brown sandy loam and gritty sandy loam overlying a mottled red, brown and grey sandy clay. (Dy 3)	As for Hamilton.
	6c	Ecctes	Stony rises of moderately vesicular blocky basalt of Holocene age.	Shallow and stony red–brown organic loam.(Um 6.4)	Woodland of *E. viminalis* with understorey of bracken and grasses, mainly *Poa australis*.
	6d	Condah Swamp	Recent swamp deposits formed upstream of impounding valley lava flow and some Holocene basalt.	Mainly peats peaty clays (O soils)	Closed scrub of woolly tea–tree *Leptospermum lanigerum* fringed by tussock grasses.
Portland	7a	Cobboboonee	Flat to undulating plains of mildly dissected basalt sheets of Plio–Pleistocene lava flows.	Red–brown clay loam merging into mottled red–brown clay. Also gravelly loam and grey–brown gravelly clay loam merging to a yellow and mottled red clay becoming more massive at depth. (Dy 3.61)	Forest or tall woodland of *E. obliqua* with *E. nitida* and *E. viminalis*; some areas of *E. baxteri* with heaths and swamps.
	7b	Drumborg	Complex of cinder cones and associated lavas and tuffs of Plio–Pleistocene age.	Red–brown clay loam merging into mottled reddish–brown clay. (Dy 3.61)	Forest or tall woodland of *E. viminalis*, *E. nitida* and *E. ovata*; *Casuarina stricta* in dry places.
	7c	Greenwald	Valleys dissected below the level of the Cobboboonee basalt sheets exposing Tertiary sediments.	Grey–brown loam and clay loam over yellow–brown light clay merging to mottled brown and orange clay. (Dy 3)	Forest or tall woodland of *E. nitida* and *E. viminalis* with some *E. ovata* and *E. obliqua*.
Lowan	8	Lowan	Regionally flat plain of Miocene limestone with a veneer of Quaternary swamp and lagoon deposits.	Fine brown sandy loam and fine grey–brown sand overlying mottled orange–brown to red clay. (Dr 3.42, 3.43)	Open woodland of *E. camaldulensis* with small areas of *E. leucoxylon* and *E.fasciculosa*.

Public Land

Study Area boundary.

City or Borough boundary.

LAND ZONES AND LAND SYSTEMS

South Western Area District 1

1:250 000

0 5 10 20 Kilometres

Land Conservation Council Victoria

Compiled from Land Systems and Land Units in the Counties of Follett, Normanby and parts of Dundas and Villiers, Victoria by F. R. Gibbons and R. G. Downes, Soil Conservation Authority, 1964.

Numbers shown thus, e.g. 80 indicate grid values at 10,000 metre intervals on the Australian Map Grid, zone 54. Grid values are shown in full only at the south–west corner of the map.

MAP No.6

MAP No.8 MINING AND QUARRYING

MINING AND QUARRYING

South Western Area District 1

1:250 000

0 5 10 20 Kilometres

Land Conservation Council
Victoria

LEGEND

METALLIC and NON-METALLIC MINERALS

Occurrences

- Au Gold
- Ag Silver
- As Arsenic
- B Bentonite
- Bm Base metals
- D Diatomite
- Fe Iron
- Ni Nickel
- Pb Lead
- Zn Zinc

Area with metallic mineral potential.

Area with potential for discovery of oil and gas, brown coal, black coal and other non-metallic minerals.

STONE

- ×B Basalt quarry
- ×G Granite quarry
- ×g Gravel pit, generally <2m deep.
- ×L Limestone quarry
- ×s Sand pit
- ×(d) Disused quarry

Public land

Study Area boundary.

City or Borough boundary.

Numbers shown thus, e.g. 70 indicate grid values at 10,000 metre intervals on the Australian Map Grid, zone 54.
Grid values are shown in full only at the south-west corner of the map.

MAP No.8