Land Conservation Council Victoria

Murray Valley Area

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REPORT

on the

MURRAY VALLEY AREA

Land Conservation Council, Victoria

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CONTENTS

Foreword (vi)
Land Conservation Act - Extract (vii)
Acknowledgements (xi)

PART I - INTRODUCTION

1. Aims and Methods 1
2. Conservation Principles 3
3. The Study Area 6
4. Aboriginal Associations 13
   - Traditional Aboriginal Perspective 13
   - Aboriginal Perspective since European Contact 21
5. European Settlement 29
   - Exploration 30
   - The Overlanders 31
   - Squatting Era 31
   - Rivers and Transport 32
   - Land Selection 35
   - Irrigation Development 38

PART II - NATURE OF THE LAND

6. Geology and Geomorphology 41
   - Geological History and Geomorphic Evolution 41
   - Geomorphology 43
   - Stratigraphy 46
   - Glossary 52
7. Climate 56
8. Water Resources 64
   - Surface Water 64
   - Groundwater 70
9. Soils 74
   - Uniform Soils 76
   - Gradational Soils 77
   - Duplex Soils 79
10. Vegetation 82
    - Importance of Vegetation 82
    - Classification 83
    - Vegetation Units 83
11. Fauna 103
    - Habitat 104
    - Changes in Distribution 110
    - Water Birds 112
    - Fish 113
    - Significant and Notable Species 115
    - New South Wales Crown Lands 124
12. Land Systems 126

PART III - LAND USE

13. Hazards 135
    - Land Salinization 135
    - Soil Erosion 139
    - Floods 141
    - Floods and the River Red Gum Ecosystem 143
    - Fire 145
    - Biological Hazards 152

14. Conservation 159
Use of Conservation Areas 159
Viability 164
Types of Reserve 165
15. Recreation 166
Environments 167
Main Public Land Recreation Resources 169
Recreational Activities 177
Future Demand 186
16. Timber Production 188
History 188
Current Timber Production 194
17. Agriculture 203
Dryland Agriculture 203
Irrigated Agriculture 204
Farm Enterprises 204
Agricultural Research Stations and Colleges 209
Grazing on Public Land 212
18. Apiculture 217
Important Plant Species 218
Licensed Bee-keeping on Public Land 220
19. Mineral and Stone Production 221
Minerals 221
Stone 225
20. Water Utilization 229
Historical Development 229
Irrigation 232
Current Utilization 236
Future Utilization 239
River Improvement 240
21. Utilities 242
22. Land Use Relations 245

PART IV - BLOCK DESCRIPTIONS

Block Descriptions 251

1. Gunbower 252
2. Patho 261
3. Goulburn 268
4. Barmah 276
5. Yarrawonga 285
6. Hume 293

APPENDICES

1. Distribution of Species of Conservation Significance 301
2. Fauna Habitat, Murray Valley Area 309
3. Distribution of Fauna by Descriptive Blocks 318
4. Supplementary Bird List 332
5. Recorded Noxious Weeds of the Murray Valley Area 338
6. Local Water Authorities Constituted under the *Water Act* 340
7. Local Sewerage Authorities Constituted under the *Sewerage Districts Act* 348

TABLES

1. Demography 8
2. Employment by Industry 10
3. Monthly and Average Annual Rainfall 57
4. Mean Monthly and Annual Maximum and Minimum Temperatures 59
5. Average Mean Daily Sunshine Duration at Tatura 60
6. Estimated Eo and Measured Average Ep at Tatura 61
7. Surface Water Resources 64
8. Water Storage of Local Significance 66

9. Stream Characteristics 68
10. Water Quality Limits 69
11. Groundwater Characteristics 71
12. Main Soil Groups of the Murray Valley Area 75
13. Structural Forms of Vegetation 84
14. Vegetation Units Facing Page 84
15. Land Systems 126
16. Summary of Fire Origin; Cause and Area Burnt 146
17. Fires in the Study Area: Classification by Size and Area Burnt 148
18. Average Annual Output of Wood Products from Victorian State Forest 196
19. Tenements Issued by the Department of Minerals and Energy on Public Land, Murray Valley Area 222
20. Summary of Stone Extraction from Public Land by Shires 227
21. Water Delivered in Irrigation Areas 236
22. Authorized Annual Water Use Outside Irrigation Areas 237

FIGURES

1. Simplified Geological History 42
2. Goulburn River Flow Pattern 67

MAPS

1. Locality Plan 6
2. Public Land and Descriptive Blocks *
3. Municipalities 10
4. Geology, Mineral and Stone Production *
5. Geomorphology 42
6. Rainfall, Water Resources, Water Utilization, and Topography *
7. Groundwater Resources *
8. Vegetation *
9. Land Systems *
10. Recreation *
11. Timber Production 192
12. Primary Production *
13. Mineral Exploration Licences 224
14. Coal Production 224
15. Licenced Groundwater Usage 238
16. River Improvement Districts 240

* These maps are contained in the pocket inside the back cover.

FOREWORD

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

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

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

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

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

Submissions received by the Council will be available for inspection at the Council's offices 10 days after the closure of the submission period.

S.G.McL. DIMMICK
Chairman

Land Conservation Council
464 St. Kilda Road
MELBOURNE 3004

LAND CONSERVATION ACT 1970

EXTRACT

Public land

Section 2.

(1) "Public land" means -

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

(i) unalienated land of the Crown including land permanently or temporarily reserved under section 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 recommendation to -

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

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

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

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

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

Government departments and authorities to give effect to recommendations.

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

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

Section 11.

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

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

ACKNOWLEDGEMENTS

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

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

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

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

Forestry Commission of New South Wales, Kerang Historical Society, Port of Echuca, Victorian Archaeological Survey, Mr W. Atkinson, Mr G. Fink, Mr D. Frood, Mr A. Jackomos, Mr P. Robertson.

PART I

INTRODUCTION

1. AIMS AND METHODS

This report brings together information that is relevent to making decisions on the future use of public land in the study area.

It describes the physical nature of the land, examines the existing and likely forms of land use, and assesses the hazards associated with these uses. The report does not contain recommendations, but aims at providing a factual basis on which land use recommendations can be formulated.

Existing information collected from published reports, government departments, public authorities, private organizations, and individuals has been supplemented by short-term surveys of plants and animals.

Although public land has been emphasized, the report considers relevant aspects of all land in the study area to place the public land in perspective.

Also the management and use of Crown land that abuts the Murray River in New South Wales and its relation to the management and use of public land in the study area has been considered in this report.

The text is divided into four main sections. Part 1, an introductory section, sets out the aims of the study, and defines and briefly describes the study area, the Aborigines' association with it, and the history of European settlement.

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

Part III deals with the main forms of land use that are likely to make demands on public land and examines the present levels of activity. Hazards associated with these land uses, such as soil deterioration and fire, are also discussed. Maps in this section indicate the areas used for the various forms of primary production, mineral and stone production, recreation, and timber production.

Part IV provides more detailed information and, for convenience, the study area has been divided into six descriptive blocks. The information for each block is set out in a consistent format of headings, so that specific information can be readily found and compared with its counterparts in other blocks or areas.

A number of appendices, including lists of flora and fauna, complete the report.

2. CONSERVATION PRINCIPLES

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

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

Natural Resources

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

Non-renewable resources

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

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

Renewable recources

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

Conservation of renewable resources requires a thorough understanding of ecological principles and development of sound management techniques based on those principles. An ecosystem typically contains many interrelated components. A change in any one of these will have effects elsewhere in the system.

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In general, an ecosystem with a diverse range of species will be better able to adapt and absorb the impact of sudden change - such as that caused by fire, disease, or man's activities - than a simple ecosystem with few species.

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

Relations Between Resource Uses

Many uses of a resource are compatible. Also one form of resource usage may increase opportunities for another form of use or make possible new uses. They may also be competitive, as is the case when an increase in one leads to a decrease in other.

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

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

The Principles of Land Use

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

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

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

The intangible values of recreation, aesthetics, and preservation associated with natural areas need to be recognized and the impact of other land uses upon them considered.

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

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

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

3. THE STUDY AREA

The Murray Valley area contains approximately 15,600 sq.km of land, bounded by the Victoria--New South Wales State border along the River Murray in the north, the Hume Highway in the east, the Shire boundaries of Euroa, Rodney, Deakin, Rochester, and Gordon in the south, and the Loddon River in the west, as indicated on Maps 1 and 2.

The position of this State border was determined by the New South Wales Constitution (*Imperial Acts* 18 and 19 *Victoriae* c.54 of 16 July, 1855), which decreed that the whole watercourse of the Murray, from its source to the eastern boundary of the colony of South Australia, was thereafter to be within the Territory of New South Wales. This fixed the left (southern) bank as the boundary between that State and Victoria.

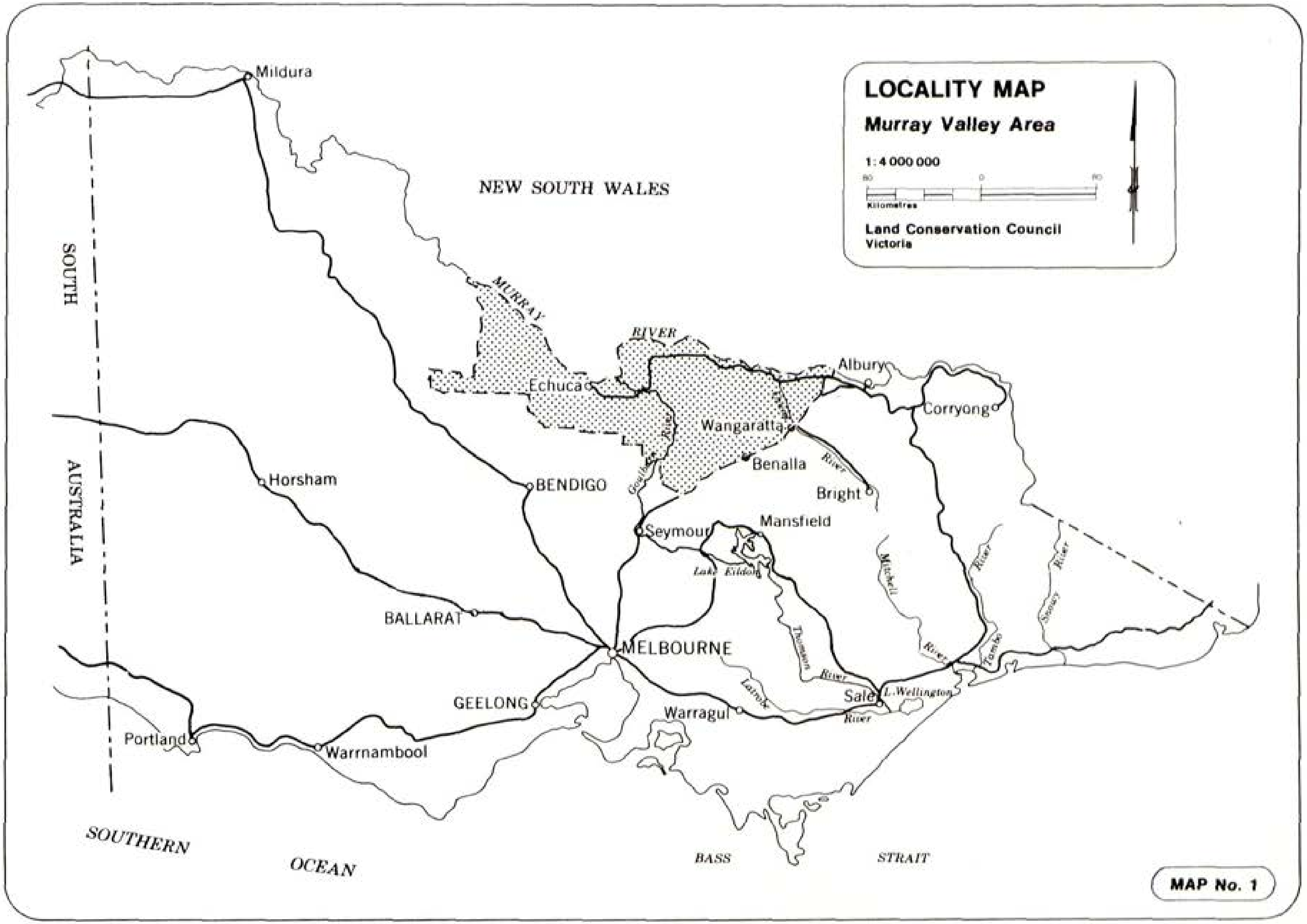
In May, 1980, the High Court of Australia clarified the situation further by ruling that the northern boundary of Victoria followed the top of the southern bank of the river, all territory to the north being within New South Wales.

Covering nearly 7% of the State, the area includes the Shires of Cobram, Cohuna, Deakin, Nathalia, Numurkah, Rochester, Rodney, Rutherglen, Shepparton, Tungamah, and Yarrawonga, and parts of the Shires of Benalla, Euroa, Gordon, Kerang, Violet Town, and Wangaratta. Municipal, county, and parish boundaries are shown on Map 3.

Within or abutting the study area lie the cities of Benalla, Echuca, Shepparton, and Wangaratta, the town of Kyabram, and the borough of Kerang, which together cover some 130 sq. km. Crown land within these urban areas is not public land (as defined in the *Land Conservation Act* 1970) and is therefore not subject to recommendations by the Land Conservation Council. However, Crown land within the urban boundaries of Shepparton and Kerang does abut public land in places.

Description

The Murray Valley area comprises the broad flat alluvial plains of the Murray River, with isolated bedrock outcrops rising above the plains. The lower reaches of the Ovens, Broken, Goulburn, Campaspe, and Loddon Rivers traverse the area. These streams are characterized by considerable variation in stream flow


LOCALITY MAP
Murray Valley Area
1:4 000 000
Kilometres
Land Conservation Council
Victoria
NEW SOUTH WALES
SOUTH
AUSTRALIA
Mildura
MURRAY
RIVER
Albury
Echuca
Corryong
Wangaratta
Benalla
River
Bright
Horsham
BENDIGO
Seymour
Mansfield
Lake Eildon
Mitchell
River
River
Snowy
BALLARAT
MELBOURNE
Thomson
River
Tambo
Latrobe
GEELONG
Sale
L.Wellington
Warragul
River
Portland
Warrnambool
SOUTHERN
OCEAN
BASS
STRAIT
MAP No. 1

throughout the year and, over time, this has led to the development of extensive riverine plains relieved by features such as lakes, billabongs, swamps, and river terraces. These alluvial plains form a major physiographic subdivision of the extensive Murray Basin plains and cover most of the study area.

It has flat and undulating topography, generally ranging in elevation from 70 to 200 m, the major exception being the Warby Range (200--500 m) and Mount Major (379 m). In addition, a number of higher isolated peaks (bedrock outliers) such as Mount Terrick Terrick, Mount Hope, and Pyramid Hill rise above the plains. The low average annual rainfall, varying from 700 down to 350 mm, decreases from south-east to north-west across the study area.

Public land

The public land occupies approximately 1,344 sq. km (nearly 9% of the study area) and, apart from the Warby Range, Mount Major, and Mount Terrick Terrick, mainly borders the major rivers and streams.

Most of it - nearly 67% - is reserved forest. The remainder comprises the Warby Range State Park (about 2%), land owned or controlled by the State Rivers and Water Supply Commission for water supply and drainage purposes (about 11%, excluding channels), agricultural colleges and research stations (3%), game and wildlife reserves (less than 1%), and various Crown land reserves and unreserved Crown land (nearly 16%).

Public lands in the area serve many purposes, including hardwood production, recreation, protection of flora and fauna habitat, grazing, flood mitigation, water supply and drainage, agricultural research and education, and apiculture, and they produce sawlogs, posts, piles, sleepers, firewood, gravel, forage, game, and honey.

Most of the public land supports stands of native vegetation, which consists mainly of river red gum forests and woodlands, box--ironbark forests and woodlands, *Callitris* forests and woodlands, and grasslands. Little of this remains on the freehold land, however, since its development for agriculture.

River red gum, *Eucalyptus camaldulensis*, is the most widely distributed eucalypt in Australia and its best development as a forest species occurs on the Murray River flood plains - particularly in the Barmah and Gunbower Island State Forests.

Similar stands of river red gum in New South Wales, opposite these Victorian forests, have been designated as New South Wales State Forests.

Smaller but nonetheless important areas of river red gum are to be found elsewhere along the Murray and along the

Table 1

DEMOGRAPHY

Local government area	Area (sq.km)	Population 1971[A]	1976[B]	1981[C]
Cobram (Shire)	433	5,520	5,765	6,206
Cohuna (Shire)	494	4,768	4,607	4,505
Deakin (Shire)	933	5,666	5,503	5,789
Nathalia (Shire)	1,255	3,206	3,182	3,167
Numurkah (Shire)	728	5,801	5,647	5,840
Rochester (Shire)	1,919	7,587	7,157	7,152
Rodney (Shire)	1,014	12,406	13,402	14,116
Rutherglen (Shire)	526	2,473	2,612	2,774
Shepparton (Shire)	917	6,477	6,282	7,228
Tungamah (Shire)	1,128	3,147	2,958	2,813
Yarrawonga (Shire)	609	3,755	4,072	4,437
Part of Benalla (Shire)[D]	1,039	1,892	2,126	2,629
Part of Euroa (Shire)[D]	625	1,904	1,919	1,842
Part of Gordon (Shire)[D]	2,023	3,124	2,944	2,873
Part of Kerang (Shire)[D]	1,084	2,864	2,702	2,598
Part of Violet Town (Shire)[D]	556	869	913	927
Part of Wangaratta (Shire)[D]	565	928	1,104	1,317
Total (actual study area)	15,848	72,384	72,895	76,213

* Not part of the study area

Table 1

Local government area	Area (sq.km)	Population		
		1971[A]	1976[B]	1981[C]
Benalla (city) *	16	8,255	8,300	8,151
Echuca (city) *	19	7,505	7,873	7,943
Shepparton (city) *	27	19,410	21,238	23,579
Wangaratta (city) *	27	15,586	16,157	16,202
Kyabram (town) *	21	5,081	5,122	5,414
Kerang (borough) *	18	4,103	4,022	4,049
Total (urban areas)	128	59,940	62,712	65,338
Total (including urban areas)	15,976	132,324	135,607	141,551

Notes: A Census 1971
B Census 1976
C Census 1981
D Compiled from Collector District data

Source: Australian Bureau of Statistics

lower reaches of the Ovens and Goulburn Rivers.

Population

At the time of the 1981 census, the Murray Valley area had a population of 141,551 persons, representing 3.6% of Victoria's total. Approximately 46% of the population is concentrated in the urban centres of Benalla, Echuca, Shepparton, Wangaratta, Kyabram, and Kerang. Demographic patterns also reflect the main agricultural pursuits of the area; irrigation areas are more populous than areas of dryland farming (see Table 1).

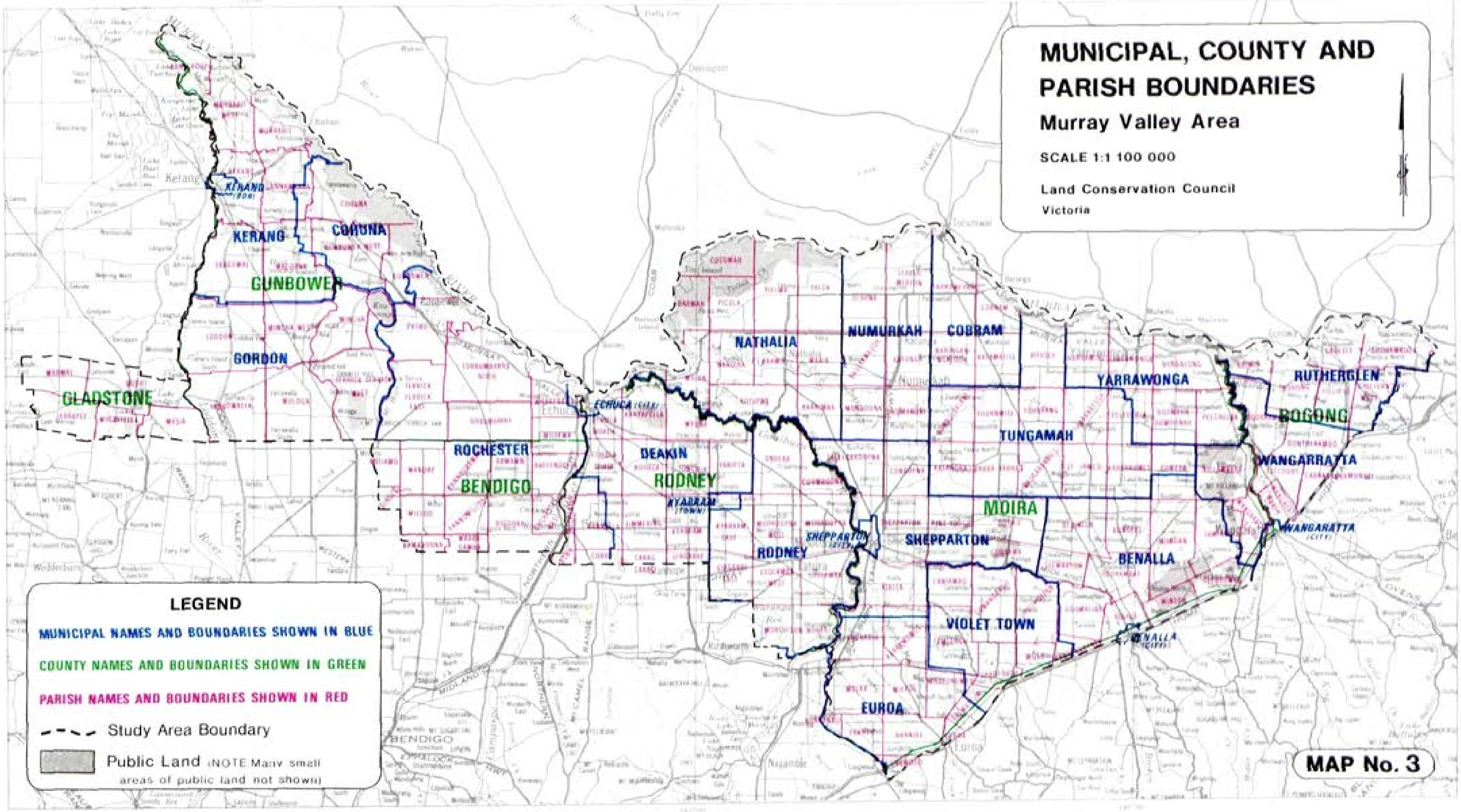
During the 10-year period 1971--81, this population has grown by 6.9%, with growth mostly occurring in Shepparton,

Table 2

EMPLOYMENT BY INDUSTRY
(as at June 30, 1981)

Industry	Total	Percentage of total
Agriculture: agriculture, agriculture services, other	12,902	22.4
Forestry, fishing, hunting	160	0.3
Mining	97	0.2
Manufacturing: textiles, food, drink, clothing, metal products, machinery, other	7,275	12.6
Manufacturing: wood furniture	485	0.8
Electricity, gas, water	1,234	2.1
Construction	3,199	5.6
Wholesale and retail trade	9,579	16.7
Transport, storage: road, rail, water and air transport; storage	1,944	3.4
Communication	909	1.6
Finance, insurance, real estate, business	2,536	4.4
Public administration, defence	2,064	3.6
Community services: health, education	7,754	13.5
Recreation, personal services: entertainment, restaurants, hotels, clubs, recreation services	2,558	4.4
Other (undefined)	4,806	8.4

Source: Australian Bureau of Statistics, compiled from 1981 Census.


MUNICIPAL, COUNTY AND PARISH BOUNDARIES
Murray Valley Area
SCALE 1:1 100 000
Land Conservation Council
Victoria
LEGEND
MUNICIPAL NAMES AND BOUNDARIES SHOWN IN BLUE
COUNTY NAMES AND BOUNDARIES SHOWN IN GREEN
PARISH NAMES AND BOUNDARIES SHOWN IN RED
Study Area Boundary
Public Land (NOTE Many small areas of public land not shown)
MAP No. 3
KERANG
CORUNA
GUNBOWER
GORDON
GLADSTONE
ROCHESTER
BENDIGO
DEAKIN
RODNEY
NATHALIA
NUMURKAH
COBRAM
YARRAWONGA
RUTHERGLEN
BOGONG
TUNGAMAH
WANGARATTA
MOIRA
SHEPPARTON
BENALLA
VIOLET TOWN
EUROA

Wangaratta, and the local government areas that contain irrigation districts. Including the main urban centres, the Murray Valley has a population density of some nine persons per square kilometre.

Economic activity

Since settlement, the major form of economic activity in the area has been agriculture. Pursuits include dairying, cropping, and raising sheep, beef, fruit, grapevines, vegetables, and pigs. The value of this agricultural production has national significance, especially that of the fruit and dairy products based on irrigation. The manufacturing, retailing, and service industries, usually located in the major urban centres, are also economically important for the area (see Table 2).

The forests of the area have supported a viable timber industry since the earliest days of settlement. Despite declining production, this industry retains economic importance locally.

Recreation and tourism are also important economic activities here. The area contains many features, especially the Murray River, that attract tourists and other people seeking recreation. The fact that the city of Echuca, over the period 1975/76 to 1980/81, has recorded an increase of 55% in the number of bed spaces in hotels and motels indicates the local growth of tourism. Over the period 1979/80 to 1981/82, the city's caravan parks recorded a 23% increase in site occupations.

The people within the Murray Valley area have an adequate infrastructure of community services, which have been built up over the years in conjunction with irrigation development.

Capital investment in the area over the past 90 years has been substantial, in both the private and public sectors. Employment growth, although not dynamic, has always been soundly based on a continuing increase in light industries and businesses that provide support for the agricultural sector.

New South Wales Crown Land

The Murray Valley area abuts significant parcels of New South Wales Crown land (see Map 2), mainly associated with the Murray River. Their tenure is mostly State Forest with some smaller areas being Crown Land Reserves. No national parks are located there, nor have any substantial portions been reserved specifically for the maintenance of flora or fauna values.

This Crown land serves many purposes, including timber production, recreation, protection of flora and fauna habitat, grazing, flood mitigation, and apiculture; it produces sawlogs, posts, piles, sleepers, firewood, gravel, forage, game, and honey. Its largest areas carry State forests located directly opposite the Victorian Gunbower Island and Barmah State Forests.

Public lands abutting the Murray River in the two States have very similar floristics, fauna, tenure, and usage and they are susceptible to the same hazards and management problems.

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4. ABORIGINAL ASSOCIATIONS

This chapter summarizes a report commissioned and prepared for the Land Conservation Council describing the Aborigines' association with the Murray Valley area. It was prepared by Mr. W. Atkinson (a descendant of the Yorta Yorta tribe) assisted by Ms. A. Berryman (a postgraduate archaeological student at La Trobe University). They used archaeology, anthropology, written history, and oral evidence to compile the report. Oral evidence - information passed on by word of mouth - is of value for defining the historical Aboriginal perspective.

Mr Atkinson also consulted various local Aboriginal organizations located at Echuca, Mooroopna, Shepparton, and Cummeragunga and the Aborigines Advancement League in Melbourne.

Aboriginal people have been associated with the south-east of Australia for 40,000 years. It is highly likely that they have occupied the Murray Valley for an equally long period, although the earliest scientific dates available at present, for Kow Swamp, indicate approximately 13,000 years.

Present-day Aboriginal descendants in the area claim that elements of their Aboriginality have survived from the period before European contact to the present. Aboriginality refers to their origins, philosophy, and culture, and to the views that they have of their cultural heritage - whether it be tangible, such as a burial site, or intangible, a religious belief, say. An expression of their Aboriginality is the special relationship or affinity that exists between them and their ancestral lands.

There is now a consistent Aboriginal and academic view that sees the Aboriginal perception of the land in terms of a special relationship with the country. In this context, land use may not have the same meaning for Aborigines as it does for Europeans.

Traditional Aboriginal Perspective

Environment

The changing geomorphology of the Murray Valley flood plain has been a feature of the area for many thousands of years. It is extremely likely that the local climate, fauna, and flora have altered also, over this time span. This changing environment would have had implications for hunting and gathering peoples

Archaeological dig at Kow Swamp - Sydney University students

living in such close association with the land and its resources.

Over the last 10,000 years - since the stabilization of the present river system and the development of a climate similar to that of the present - the woodland plains, treeless plains, and seasonally flooded forests were regional features, as they remain today. Living zones over this period would have been similar to those existing at the time of early European contact.

As a general principle, the Aboriginal people ranged over different living zones to maximize their chances in the quest for food. Such living zones were: the rivers, particularly the river edges with their tall river red gums; the wetlands, including swamps, billabongs, streams, and anabranches; and the grassy plains interspersed with patches of scrub.

They moved across these zones to satisfy a variety of dietary needs at different times of the year, and used different technologies for obtaining the various foods. Not all movement across these living zones concerned the quest for food. Intertribal gatherings, quests for non-food items like ochre and stone, and the relaying of messages required extensive territorial range.

Fire has been a feature of Aboriginal life, and early historical accounts of the area speak of its frequent use for clearing tracks through reed-beds, for hunting, and for dissuading Europeans from venturing into tribal territory.

Tribal boundaries and populations

The main tribes who occupied territory within the area - using the boundaries given in Tindale (1947) - are the Bangerang, Joti Jota, and Kwat Kwat tribes. Present-day Aboriginal descendants refer to the Joti Jota as Yorta Yorta rather than using the anthropological spelling.

Other neighbouring tribes with territories overlapping the area are the Baraparapa and Wemba Wemba to the north-east and the Jaara Ngurelban and Taungerong of central Victoria. The last two tribes formed part of a larger confederacy that Howitt, an early anthropologist in Victoria, called the 'Kulin Nation'.

Reed-beds, Barmah forest - an important source of raw material to the Murray River tribes in making spears, ornamentation, hunting and trade.

Traditional boundaries were marked by natural and totemic features; each tribe occupied a recognized area and spoke a common language.

The traditional boundaries of the Baraparapa, Wemba Wemba, and Yorta Yorta extended into New South Wales, north of Deniliquin. The Murray was obviously not a political boundary to these tribes - who occupied large tracts of country on both sides, encompassing the range of living zones previously mentioned.

Estimates of Aboriginal population levels as reported by the earlier explorers and squatters are usually treated with caution. Indications are that introduced diseases such as smallpox (carried here from Port Jackson via the Murrumbidgee) and frontier violence had already severely reduced local population levels prior to the large-scale European settlement of the area.

Drawing on historical accounts and literature dealing with the known effects of smallpox epidemics, a figure for the pre-contact Aboriginal population in the study area can be put somewhere between 2,400 and 4,800 people.

Social organization

The tribe comprised two kinds of social groups. One was the local patrilineal descent group, whose members trace their descent through the father to a common ancestral being. The local descent group identified itself with a particular area and was related to a number of sacred ceremonial sites, for which it was responsible.

The other was the band or horde, whose members were drawn from different local descent groups through inter-marriage. This was the group that lived together and co-operated in food-gathering, hunting, and fishing. A tribe, then, was made up of a number of bands or hordes.

Another social division that operated was the moiety (meaning half). Moiety

Barmah Lake: an important place for intertribal meetings and food gathering

was a system of classifying everybody in the tribe, as well as natural phenomena, in two distinct divisions. In this region the moieties were named eagle (Bunjil) and crow (Waang). Members of a local descent group all belonged to the same moiety.

These social divisions governed marriage and certain ceremonial functions.

Intertribal relations

Tribal and intertribal meetings were held for corroborees and initiation ceremonies, and to arrange marriages, settle disputes, celebrate the arrival of a particular food species, or trade goods. Meetings were arranged by highly respected people who could speak the surrounding tribal dialects (like modern-day diplomats), whom early European observers called 'postmen'.

Meetings usually occurred in the spring and summer when food was readily available and could support large gatherings for extended periods of time. Meeting-places were recorded at the intersection of tribal boundaries and other important points. Kow Swamp (an intersection of five tribal boundaries) was a traditional meeting-place. The Moira and Barmah Lakes area, 'the stronghold of the Yorta Yorta and Bangerang tribes', were similarly important and significant.

Gunbower station and Tallygaroopna station were also meeting places for up to

500 people from local and neighbouring tribes.

Religion

Few early observers documented the religious concepts and practises of the Murray Valley Aborigines. Inferences, suggesting complex religious notions, can be drawn from the written sources, from archaeological data on burial customs etc., and from the broad understanding of a common pattern of religious life for all Aboriginal Australia.

Before the arrival of Europeans and Christianity, the Aboriginal people had their own world view, which embraced the belief that ancestral supernatural beings established the foundations of human life.

These ancestral beings created the physical features of the tribal land - rivers, plains, rocks, and sand hills. Sun, moon, and stars came into being through them, and man and other living species took on their particular physical characteristics, and were shown the rules of behaviour they should follow.

All of this knowledge was handed down from generation to generation through such media as mythology, rituals, and oral traditions. The Aborigines believed that, by acting in accordance with the rules laid down by these ancestors, they could keep in touch with them or their power and thus help to perpetuate a stable food-producing environment and a harmonious social order. This period is otherwise known as 'the dreaming'.

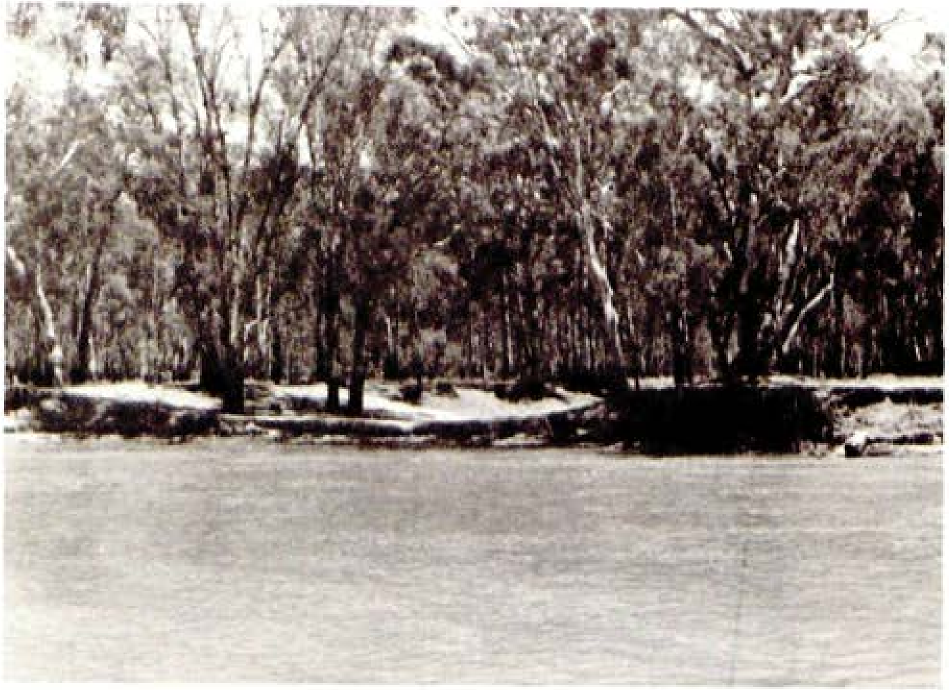
In religious terms, the Aboriginal people saw their world in a completely different perspective from that of European man.

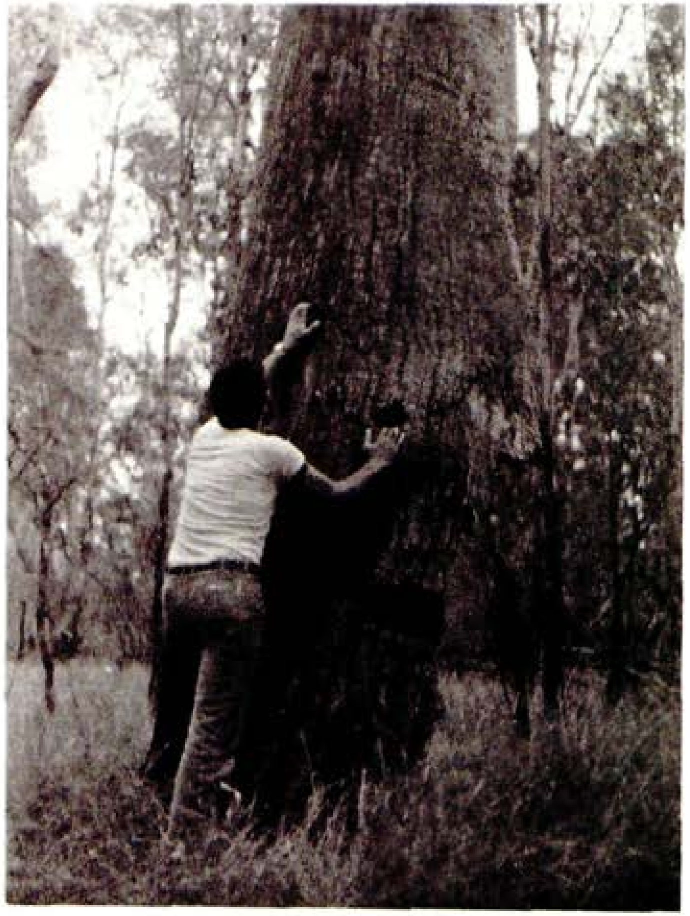
The landscape's features were monuments to the activities of specific ancestral beings and, like European religious monuments, were 'sacred sites'. Aborigines did not seek to alter these features, as to do so would bring disaster. The local descent group had the responsibility of caring for the land and its sacred sites, which included spirit centres.

Natural species of animals were linked to Aboriginal people through totemic relationships and were classified with people into moieties. The Aborigines tried to ensure food supplies through supernatural increase ceremonies, and through the practical system of food taboos. Consequently the Aborigines' actions were found not on the need for change but rather on the need to perpetuate their natural cycles.

Economy

The general hunter-gatherer pattern - group dispersal during times of food scarcity and group congregation in times of plenty - applies in the Murray Valley area. Nevertheless, the relative abundance of food allowed the local tribes to





In a fish weir (above), a depression was blocked off with sticks when flooded, to create a fish trap when the waters receded. Notches in the scarred tree (right) indicate skill involved in climbing trees in pursuit of game such as possums.

avoid the extremes of this pattern because it could support a comparatively larger and more sedentary population.

Evidence suggests that food foraging was scheduled in accordance with seasons, with groups following a cyclic course in its pursuit. The warm months on the rivers were the most productive, while the colder months encouraged dispersal, in smaller groups, to areas away from the main water bodies.

Generally speaking, the main economic activity was based around the water bodies and the use of technologies, such as fish weirs, emphasizes this.

All manner of techniques, artefacts, and knowledge about plant and animal behaviour were used in the procurement and preparation of food. The Aborigines foraged for fish, water birds, yabbies, mussels, turtles, frogs, birds, possums, kangaroos, wallabies, emus, rats, dingos, lizards, snakes, insects, grubs, cumbungi reeds, and waterlilies.

Common artefacts and technologies that they employed in food-foraging included canoes, nets, fish weirs, stone tools, spears and throwing sticks, mussel shells, oven mounds, and carry bags.

Canoes were highly efficient and valued, and were cut from the bark of river red gums with stone hatchets, shaped over a fire, seasoned in the sun, and end-blocked with clay. The Aborigines used them in great numbers for travel, for foraging, and as points from which to take fish with both spear and line.

Nets, made from fibre such as masticated cumbungi, were a feature of the area. Different forms of hooped nets were used for crayfish, yabbies, and fish, while larger, cross-line nets were strung low above the water for catching driven ducks or under the water in some permanent stream to catch schools of fish. Similar line nets were used for emu and kangaroo drives: a number of strategically placed people along a natural run could herd the prey towards the net.

Fish weirs, constructed from closely spaced stakes driven vertically into the mouths of receding flood-water channels, were spoken of as yielding bountiful harvests for a 5- to 6-week period.

Early historical accounts do not give much detail about stone tools, save for the hafted, edge-ground axe used in possum-hunting and canoe-building. Some evidence indicates that the Goulburn people imported greenstone (diabase) axes from the Mount William area, in exchange for reed spears. What little stone has been found, other than the axes, shows that quartz, quartzite, silcrete, and chert were the materials used for flakes, scrapers, hammerstones, and grinding stones.

Spears - used for hunting and for fighting - included spears with hafted bone

Smooth grooves in rock outcrops produced by Aborigines grinding their stone axes

Bark cut from the tree trunk to form a canoe left a scar on the tree

or hardened wood points, spears with carved barbs, and some with stone pieces set into the head. Some were designed for large marsupial game and others for water-based hunts.

Fresh-water mussel shells formed intruments for fibre and skin preparation.

Ovens were used to bake large catches of game and large volumes of vegetable like typha or cumbungi root. Calcined or burned clay, in the absence of natural stone, served as heat retainers for underground cooking pits. Accumulated clay and organic debris contributed to form the mounds seen today in the area.

Woven fibre and skin bags, used by men and women, were important items for transporting goods in times of major movement as well as in day-to-day foraging activities such as collecting yabbies. Skin bags were also used for transporting water, especially on trips to the dry country.

Culture and cultural heritage

Material culture is often thought of as physical artefacts, such as spears and baskets, but it also includes the ideas embodied in the artefacts: ideas that come from people's interaction with their physical, intellectual, and religious environment.

A spear from the Murray Valley area provides an obvious example of the material culture. A less straightforward example is specific corpse preparation to ensure an unobstructed course in the spirit world. An even more complex example could be some natural feature that is significant because of the religious associations it holds.

The two aspects of material culture studies - objects and associated ideas - have not been well developed for the area, for two reasons.

Firstly, no comprehensive collections of artefacts and details about their contexts are available for the Murray Valley. The rapid destabilization of traditional Aboriginal life at contact time plus a lack of interest in making systematic collections, and observations, have contributed to the paucity of information.

Secondly, because the total extent of material culture studies has not been consistently pursued, information still remains locked in the few fragmentary collections and details about traditional life that are available.

Accounts of material culture by the early settlers are weighted heavily in favour of economic artefacts such as the hatchets, spears, fish weirs, stone tools, nets, canoes, and oven mounds mentioned in the previous section. Other artefacts that have been recorded or are held in museums are dress and ornamentation items such as feathered aprons, crayfish-antennae necklaces, shields, possum-skin cloaks, armlets, and bags.

It is highly probable that many more material culture sites and objects remain to be located in the area. The geological nature of the Murray Valley has been responsible for obscuring many of the expected older sites, either by altering living zones significantly, and thereby changing centres of human activity, or by depositing flood soils over the older material.

Since European contact, such things as settlement, clearing, rabbits, grazing animals, and irrigation schemes may have reduced the visibility of sites, in some cases destroying them altogether. Other areas - like the Mount Hope rock outcrop in the predominantly flat landscape - may, if archaeologically investigated, suggest a ceremonial significance consistent with similar features found elsewhere in Aboriginal Australia.

Aboriginal Perspective Since European Contact

Post-European contact saw massive reductions in the populations of the Aboriginal tribes who occupied the Murray Valley area. Introduced diseases were the main causes, but frontier conflicts and poison were also important.

Further, the advent of European settlement saw the Aborigines forcibly removed from their ancestral land, and their traditional associations with the land were severely affected by the invasion of European pastoralists and their stock.

This process of forced removal was further accelerated in the mid nineteenth century by the colonial government's policy of protection, which resulted in the establishment of stations where remaining tribes could be relocated. The protectorate station at Murchison was used to relocate some of the Murray Valley tribes.

After a very brief history - 1838--49 - the protectorate system was abolished, but no alternative system was introduced. During this time the Goulburn and Murray tribes experienced further dispossession of their land. However, some pastoralists came to a joint arrangement with Aborigines over use of the land. One such pastoralist was Mr Lewes of Moira Station, who permitted Aborigines to hunt on their grounds in his occupation.

During 1849, a Select Committee Inquiry recommended Aboriginal Reserves along the Murray: near Barmah, Benalla, Wangaratta, and Ulupna. A later Inquiry, in 1958/59, made similar recommendations for reserve sites, but no reserves were established in the Murray Valley.

The 1858/59 Inquiry saw the emergence of the Aboriginal Protection Board, which assumed responsibility for Aborigines in Victoria. The Board established a system of central stations run by managers, where the State's Aborigines could be relocated, but again none of these were set up in the Murray Valley area.

Instead a number of ration depots were established, at Echuca, Gunbower, Durham Ox, Wyuna, Ulupna, Toolamba, Cobram, and Goulburn (Murchison). Local honorary guardians were appointed to issue supplies and rations to Aborigines in the area and to use their powers to protect them from encroachments by whites.

A small reserve was later established at Lake Moodemere, near Corowa, for remaining tribes who occupied the upper reaches of the Murray.

To enable the Aborigines Protection Board to gather Aborigines onto central stations, an Inspector, John Green, was appointed in 1861 to superintend the welfare of Aborigines in the colony and to implement its relocation program.

In an 1862 visit to the Murray between Cobram, Echuca, and Gunbower, he gathered the names of more than 500 Aborigines. The main reason for Green's visit was to gather children who were regarded as orphaned or neglected, and others who were willingly surrendered by their parents, and relocate them at Coranderrk Station - a new reserve established by the Board in 1863 near Healesville for remaining Kulin tribes. Coranderrk be-

On anabranch creek, Aborigines gathered to catch and eat fish, shellfish, turtles, and crayfish; over the years the refuse created this mound in Barmah Forest

came a refuge for many of the Murray Valley people in the absence of a reserve in that area between 1863 and 1874.

To assist the Board in carrying out its relocation program more effectively, a special *Aborigines Act* was passed in 1869, which gave the Governor, on the advice of the Board, power to prescribe where an Aborigine or Aboriginal tribe should live. It also gave special powers to control the daily activities of Aborigines on and off reserves.

Most importantly, it gave authority to take charge of Aboriginal children who were considered orphaned or neglected. During the 1870s the Board engaged in a concerted attempt to gather children from the Murray Valley and place them in the dormitories at Coranderrk. Although most of the young were transferred to Coranderrk during this time, the people about Echuca were especially reluctant to leave their tribal homelands and fled across the Murray whenever the Victorian Board tried to collect the children.

Concerned about the plight of remaining tribes in the Murray Valley, Green recommended that the Board set up reserves in the area. However, these recommendations again fell on deaf ears and not until 1874 - through the efforts of a *concerned missionary, Daniel Mathews* - was a refuge provided for remaining Murray Valley tribes.

In that year Mathews established the Maloga Mission Station a short distance from Barmah on the New South Wales side of the Murray. The station was on private land owned jointly by William and Daniel Mathews, and was once a great gathering place and corroboree ground for local and neighbouring tribes. Aboriginal people who settled at Maloga came from the Yorta Yorta, Bangerang, and Goulburn Valley tribes as well as tribes from the upper and lower reaches of the Murray.

With the inception of the New South Wales Aborigines Protection Board in 1883, a new site of 1,800 acres adjoining the Mathews property was gazetted and the Maloga residents and buildings were removed to what, officially, became Cummeragunga in 1889. Cummeragunga - meaning 'my home' - was later extended to its final size of 2,695 acres after the 1900s.

Like the Victorian system, the Board assumed the responsibility for Aborigines in New South Wales and modelled its administration on the same lines. Stations were run by managers and special legislation was introduced for their control. In 1909 the *New South Wales Aborigines Act* was introduced, giving special powers to the Board to control the lives and movements of Aboriginal *people living on and off stations.* This in fact duplicated the Victorian 1869 *Act*. In 1898, many of the Wemba Wemba and Baraparapa people were relocated to Moonacullah, the State Aboriginal station, near Deniliquin, N.S.W.

The major population movements from Cummeragunga began after the subsequent 1915--18 amendments to the 1909 *Act*, which gave further powers to the Board to remove children for apprenticeship as servants and enforced the removal of part-Aboriginal youngsters. Prior to these movements, Cummeragunga held 394 people in 1908, but by 1921 the population had been halved, entirely as a result of emmigration after these further powers were introduced.

In 1924 a visitor counted 147 residents on the reserve and another 118 camped in bag huts on the Barmah side.

Another major movement from Cummeragunga took place in 1939, when residents resolved to go on strike over a number of issues, including poor living conditions, the leasing of 2,000 acres of the reserve to a white farmer, inadequate rations, and an antagonistic manager. An Aboriginal descendant who was there during the strike remarks, 'they crossed the river and settled in tent camps on the Victorian side'.

The mass migration across the river in February 1939 brought unprecedented

'Cummeragunga Remembered' - church service at Cummeragunga Mission about 1915

press attention and debate in the New South Wales, Victorian, and Commonwealth Parliaments. Public concern hastened the reconstruction and change of the New South Wales Protection Baord to the Aborigines Welfare Baord under an amended *Act* in 1940.

The new Welfare Board changed its policy from protection to assisting people to assimilate into the general community. This assistance, however, only applied to those who were living in New South Wales, and those who moved across the river and refused to go back were left to their own means. The Victorian government ignored the plight of this Victorian camp in the belief that it no longer had any Aboriginal problem, and its only responsibility was to the residents of Lake Tyers station in Gippsland.

Eventually some families returned to Cummeragunga, but most remained in Victoria. Some moved to Shepparton and Mooroopna to seek work in the fruit industry, and others moved to Echuca and Moama. Later, many families moved to other surrounding towns such as Nathalia. Tongala, Kyabram, Benalla, Wangaratta, and Cobram.

The bulk of the movement, however, focused on Mooroopna, where families recongregated on the bend of the Goulburn River and erected tin huts. This became known as the 'Flat'. When the periodic floods inundated the 'Flat', families had to move their camps across to higher ground to a place called 'Dashes Paddock'. They would then move back after the floods receded.

In 1957 the Victorian government established its Welfare Board on the recommendations of the McLean Report, emphasizing the policy of assisting Aboriginal people to take their place in the general community as equal citizens. The Board established a transitional housing estate at Rumbalara near Mooroopna in 1958, for families who had migrated from Cummeragunga to the Flat.

Families were subsequently housed in Commission homes in Shepparton and Mooroopna.

Cummeragunga was closed in 1953 but continued as an unsupervised reserve. Despite this closure and the assimilation policies of the time, the population of Cummeragunga actually climbed from 46 to 95 persons by 1961.

In 1969 the Cummeragunga Company, formed by Aboriginal residents, obtained a capital loan from the Commonwealth to develop a farming program. Thus, after 134 years as recipients of forced changes through government decisions, Aboriginal descendants of Murray Valley tribes were finally given an opportunity to make their own decisions.

Many of the Moonacullah people, descendents of the Baraparapa and Wemba Wemba tribes, remained in New South Wales and some migrated to Victorian towns in the Murray Valley.

Present-day associations

Cummeragunga has been continuously occupied by Aboriginal descendants since its inception in 1889. Its significance to former Aboriginal residents and their descendants is highlighted frequently when families return for social and recreational activities. Family reunions, community meetings, historical visits by interested groups, and 'Back to Cummera' celebrations are a feature of these activities. Today it provides a focal point for the maintenance of social and cultural links with the area.

The region around Cummeragunga, in particular the Barmah and Moira Forests, also have special significance to present-day Aboriginal descendants, who see it as embodying living aspects of their cultural heritage and a special part of their ancestral homelands. Barwick (1974) demonstrates this significance in her studies, remarking: 'Most Aboriginals have a strong attachment to a specific home place: the region surrounding the reserves where their forebears were settled last century, which was usually part of their ancestral territory'.

This strong attachment is constantly reinforced by Aboriginal communities and organizations through cultural programs focused on the Aboriginal aspect of the forest and the history of Cummeragunga and Maloga.

Local educational excursions and cultural camps are run by Aboriginal groups, with the aim of creating an awareness, particularly among the younger Aboriginal people, of the immense history and cultural heritage associated with the area. Visits to special places of historical and cultural significance are conducted by Aboriginal descendants who retain valuable knowledge of the nature of these places from oral history passed on by their forebears.

These programs are also aimed at teaching the general community about Aboriginal history and cultural heritage from

River-bank erosion has revealed the presence of a shell midden the Aboriginal viewpoint. In conjunction with them, the Shepparton Aboriginal Keeping Place provides a focal point for Aboriginal cultural heritage in the Murray Valley area. Visits by schools, lectures on local history, and organized excursions to the Barmah and Moira forests are an integral part of their activities. Barwick's statement, quoted above, holds very true for this area.

Many Aboriginal people who have moved away to towns and cities re-visit the area regularly for camping, fishing, or hunting, to visit sites, and most importantly to maintain kinship associations with relatives. Aboriginal people, when they visit these ancestral homelands, often say that it gives them a sense of belonging and reaffirms their Aboriginality and cultural associations with the region.

Aboriginal people today feel strongly the need to maintain this attachment and ensure the continuity of their cultural heritage so that it can be passed on and appreciated by all Australians.

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Only two references are given in this chapter which is based on a report prepared by Mr. W. Atkinson and Ms. A. Berryman entitled 'Aboriginal Association with the Murray Valley Area.'

Other references are cited in the report held at the office of the Land Conservation Council.

5. EUROPEAN SETTLEMENT

As a result of European occupation, the Murray Valley area has been subjected to intensive development - mainly agricultural - and the natural ecosystems have altered extensively - mainly in terms of hydrology. This development and alteration has realized many economic and social benefits, to both the area and Australia; the agricultural produce is of national significance.

The history of the area is closely associated with the history of settlement and agricultural development, which shows a general trend from large to small holdings and the rise of irrigation farming.

After the explorers and overlanders had reported that its extensive, grassy, treeless plains and open woodlands were suitable for grazing, squatters quickly moved in and took up large runs, which soon covered the bulk of the Murray Valley. This early settlement was strongly influenced by the location of permanent water and the settlement pressures being exerted in adjoining districts.

River transport along the Murray and the discovery of gold ensured economic prosperity for the squatters. The river offered a cheap and effective means of transport and communication, while the goldfields provided a ready, close, and lucrative market for agricultural produce.

The rail link from Melbourne to Echuca in 1864 ensured further economic prosperity and enabled Echuca to become a major port. Rail and river transport together facilitated the increased harvesting of the local river red gum forests. These were harvested to meet the growing demand in Victoria and overseas for durable construction timber and rail sleepers.

Development of the two forms of transport facilitated further land settlement there when the various *Land Acts* were implemented after the gold rush had declined. This brought more settlers, who took up farms following the subdivision of the large squatters' runs and engaged in dryland farming, sheep-raising, and wheat-growing.

The gold rush only directly encroached into the Murray Valley around Rutherglen. Some alluvial gold was mined

Pumping plant on River Murray to provide Kerang with domestic water, 1902

there, but after the initial rush of 1860 most miners found further recovery of gold beyond their means, as the large amounts of water they encountered within the shallow leads required pumping.

They turned to growing grape-vines and producing red wines, forming the foundation of Rutherglen's reputation as a wine-producing area. Despite various economic slumps and the ravages of phylloxera, wine-making remains important there today.

It had long been recognized by the early settlers that the flat fertile plains of the Murray Valley were ideal for irrigation. After the devastating drought of 1877 to 1880, which ruined many local farmers, the Victorian government set up Irrigation Trusts to foster irrigation schemes. Many of these Trusts failed and not until many years later did irrigation management and water supply become organized enough to allow for the dramatic increase in the extent and importance of irrigation.

Development expanded further under the various closer settlement and soldier settlement schemes implemented during the first half of this century, and was most pronounced in the irrigation areas.

Since the late 1950s and early 1960s agriculatural development there has slowed, and land and water salinization problems are now causing general community concern.

Exploration

The first European explorers who ventured near the study area were Hume and Hovell during their expedition to Corio Bay in 1824/25. During their journey they passed to the south of it, but on their return they passed through it in the vicinity of the present-day Hume Highway between Euroa and Benalla.

The next explorer to venture near was Major Thomas Mitchell on his journey through 'Australia Felix' in 1836. This was actually a detour: Mitchell had planned to follow the Murray upstream to test the theory that Sturt's Murray was the same river that Hume and Hovell had named the Hume in 1824.

Nearing Kow Swamp on his journey up the river, Mitchell encountered hills for the first time in several hundred miles, and from Mount Hope he saw country to the south that he felt too inviting to be left unexplored. Passing Pyramid Hill and crossing the Loddon near Jarklin, he left the Murray Valley and proceeded on to Portland Bay.

On his return trip, Mitchell passed through the south-east of the study area in the vicinity of Seymour, Benalla, and Wangaratta.

The Overlanders

In 1838 Joseph Hawdon set off from Seymour to drive cattle to Adelaide by following the Goulburn and Murray Rivers. Hawdon encountered Mitchell's tracks near Kow Swamp and stayed with these as far as the Loddon River. He then went north beside that river until he met the Murray, which he followed to South Australia.

Also in 1838, E.J. Eyre attempted to overland cattle to Adelaide by taking a direct route from the Goulburn to the Loddon. He encountered Hawdon's tracks, but turned westward, following Mitchell's path. Unable to penetrate the mallee scrub, however, Eyre retraced his steps to the Loddon and took Hawdon's route to Adelaide.

In the same year Charles Sturt overlanded cattle to Adelaide - along the Murray from Albury to the Barmah Forest, where he crossed the river, proceeded along the south bank, and then followed Hawdon and Eyre to Adelaide.

By the end of the year the explorers and overlanders had explored the perimeter and centre of the Murray Valley area, but it was left to the squatters to explore the remainder and settle it.

Squatting Era, 1839--1865

The 'Major's Line' (Thomas Mitchell's homeward route from Australia Felix) was the path used by pastoralists who overlanded from New South Wales to the new Port Phillip district in the late 1830s. It lay on the south-eastern fringe of the study area, and provided a route for squatters who took up adjoining country. From this line pastoral occupation proceeded in leap-frog fashion - from the most accessible and well-watered lands, westwards towards the drier and more remote grasslands of the mid Murray.

Prior to 1840 most squatters were situated east of the Ovens River but in the next two years outlying stations were established along the Goulburn River down to its junction with the Murray. Pastoralists reached Torrumbarry in 1842, and by 1846 had claimed most of the country between the Goulburn and Loddon Rivers.

Thereafter, squatter numbers and interests within the region could expand only through subdivision of runs, acquisition of established stations, and heavier stocking of the native pastures. Land use was regulated by annual licences, which gave the squatters no security of tenure and prohibited the disturbance of soil except to supply their own needs.

Between 1845 and 1865 the number of runs in the region increased by 35% - from 50 to 68. But at the same time runs were often aggregated, and the number of registered graziers increased only marginally - from 43 to 46. While subdivision offered the opportunity to intensify squatting occupation, its main effect was to facilitate adjustments to boundaries through agglomeration of smaller units. The total number of enterprises remained static.

Stocking of each station was highly variable: the number of sheep or cattle grazed fluctuated from year to year, and even from month to month. Flocks or herds were often required to stock new runs in neighbouring regions, and graziers with runs in other regions often moved their stock about according to seasons and market conditions. Some runs were valued for fattening, some for growing young stock, and others for breeding or drought relief.

During the gold rushes of the 1860s, the adjoining goldfield of north-eastern and central Victoria became a steady consumer market for agricultural goods that the squatters in the Murray Valley area produced. Squatters also supplied the breeding stock that the new pastoral enterprises in the Mallee and Riverina demanded.

Most stations carried both sheep and cattle, although seep predominated; stations that dealt primarily with cattle were located east of the Goulburn River. In 1854 the area carried more than 210,000 sheep, 53% of which were in the west, and 42,000 cattle, 60% of them in the east.

Runs normally had a rectangular shape, with a permanent stream forming the short boundary and the run extending back to the drier country. This configuration was enforced by the Crown Lands Commissioners and prevented individual pastoralists from monopolizing large areas simply by securing all the watering points.

The hub of pastoral life was in the near-river environs, where reliable water supply and the best grazing lands were found. Here the squatters built their homesteads and exercised pre-emptive rights to select 640 acres of their runs without competition.

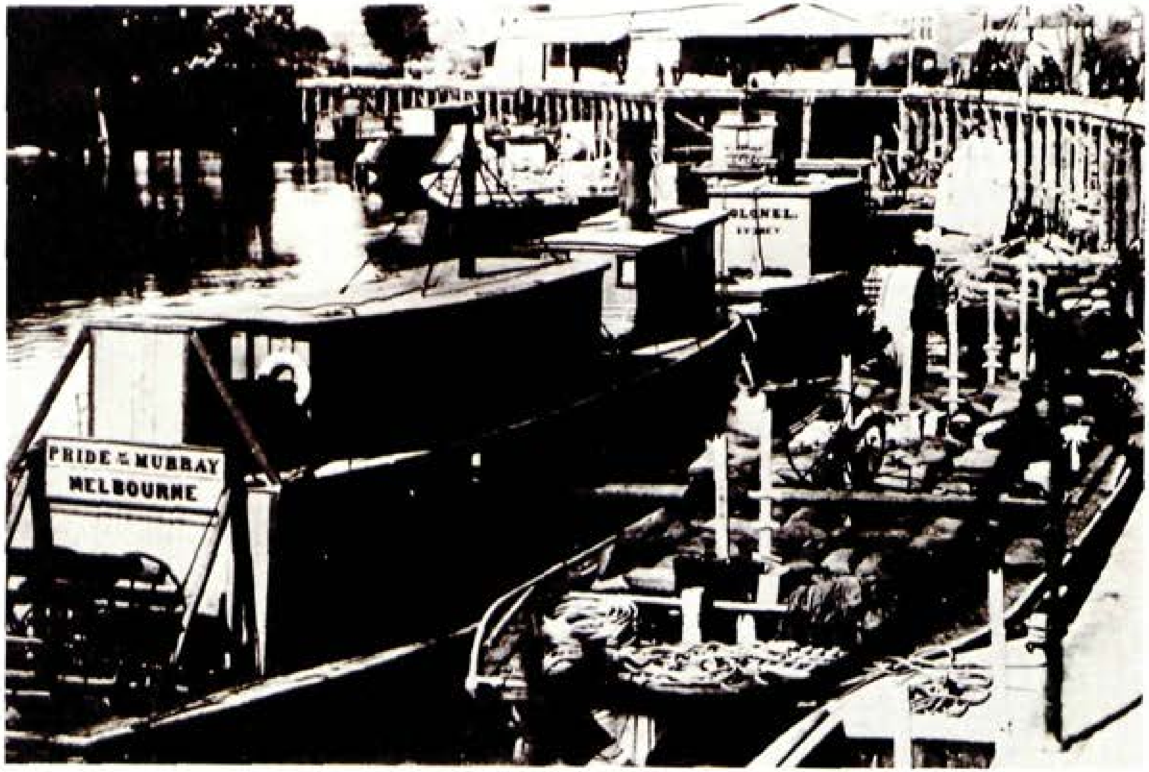
River and Transport

Squatters who built their homesteads beside the Murray and Goulburn Rivers benefitted from the riverboat trade that developed during the 1850s, '60s, and '70s. Paddle-steamers not only provide a convenient means of transporting wool to port, on the return journey they delivered stores including flour, spirits, and tobacco.

The availability of this speedy, relatively cheap transport also accelerated settlement of the Murray Valley in comparison with other dry inland areas of Australia. The comforts of civilization and innovations in farming were more readily available to people with such access. River steamers also provided transport between towns for local residents (until the advent of motor cars); timber was shipped to Echuca and other mill sites; fishing vessels harvested Murray cod; officials of various govern-

The paddle-steamer 'Marion' coming out of the Torrumbarry Lock, Torrumbarry Weir

Echuca wharf, with the stern-wheeler 'Pride of the Murray', about 1870



ment agencies used small vessels for their patrols; and several mission steamers plied the river.

The riverboat era commenced in 1853, when Captain Francis Cadell navigated the 'Lady Augusta' up the Murray from South Australia to Ulupna homestead (Strathmerton). Prior to Cadell's voyage, colonial authorities had been considering the potential of the Murray for navigation, but had not settled on a strategy for removing submerged logs, bars, and overhanging boughs. Cadell had already organized some de-snagging, and his trip highlighted the need for government assistance.

In 1854 he provoked further discussion by announcing he had commissioned a survey of the Goulburn River from Seymour to the Murray and drawn up sailing directions. Developing inland water transport, it was claimed, would enable the Murray Valley to be opened for agricultural settlement, and the produce of the New South Wales Riverina could be taken to Melbourne rather than to Adelaide.

The Surveyor Clement Hodgkinson visited the Murray Valley region in 1856 to assess the prospects for agricultural settlement and the need for de-snagging. He reported that the land between Echuca and Albury would respond well to irrigation and reiterated the concept of capturing Riverina trade either by making the Goulburn navigable or by constructing a railway to Echuca.

Grants for river clearing were later made and in the following 20 years river transport flourished along the Murray.

Echuca, which was originally the site of a river crossing, became the major port and for some time it was Victoria's second largest in terms of tonnage of incoming and outgoing goods. Further, its development as a river port was given great impetus by the completion of the Echuca--Melbourne railway line in 1864. River red gum timber for railway sleepers comprised the bulk of Echuca's trade, although wool, and later wheat, were also significant.

The Goulburn River was not made navigable until 1875. Thereafter steamers traded between Echuca and Shepparton, another town that began as an early river crossing. However, the vision of the Goulburn as a major waterway was not realized. Road improvements and railway construction provided more direct communication, and the river trade between Shepparton and the Murray ceased before 1890.

While no major shipping disasters occurred on the river, many steamers and barges suffered damage by snags, and a few sank. Others were involved in collisions or damaged or destroyed by fire.

The seasonality of river levels and the consequent restriction on travel, together with the extension of the railway to Swan Hill in 1890, contributed to the decline of river transport. By the time construction of locks under the 1914 River Murray agreement began, the heyday of the river had passed. Rail and road transport had made substantial inroads, no large port had been developed at the Murray mouth, and industries producing heavy, bulky goods had failed to develop along the river.

In recent years, steamers that have survived have been rebuilt and installed as museum pieces, or have been refloated to entertain tourists on short or extended river cruises.

Land Selection

Shortly before 1860, the government auctioned lands near Wangaratta, on the Murray River at Gooramada, and along the Broken River north-west from Benalla. Squatters obtained much of this land in addition to their pre-emptive rights, but it represents only a small proportion of the study area. Further sales under Victoria's first three *Land Acts* (1860, 1862, and 1865) heralded the end of the squatting era.

New settlers attracted to the region by the riverboat trade and the prospect of agricultural development were able to secure freehold and, although the areas as a proportion of the region were still comparatively small, pastoralists did lose portions of their runs: agricultural settlement had commenced. Land was surveyed and released for sale along the Campaspe River and also east of the Ovens and north-west of Benalla.

During the 1860s the advance of agricultural settlement was tied to the ability of the Land Department to survey and subdivide the land. The pace was slow. After 1869, however, the principle of selection before survey was introduced and the agricultural lands of the Murray Valley were quickly occupied. By the early 1880s (the end of the free selection period), almost the whole region was leased for agriculture in parcels of up to 320 acres. These allotments were converted to freehold once the lessees fulfilled certain rental, residence, and capital-improvement conditions.

The only remaining Crown lands - mainly areas and frontages along the major rivers - provided free access to water and also preserved the remnant river red gum forests, which were valued for their timber.

Frontage reserves, varying between 100 feet and 100 yards in width, were originally set aside along the Murray and Goulburn Rivers as navigation easements. By the end of the 1860s their importance in providing free public access to water was apparent and the concept was extened to all permanent streams. Prominent reserves were thus retained along the Broken River, Broken Creek, and Loddon River; very little Crown frontage existed along the Campaspe River because most adjoining lands had been sold during the 1860s.

The frontage reserves were important to selectors for stock and domestic water supply, particularly during dry years. Unfortunately, their administration did not consistently meet the needs of all selectors, and for many years they were a source of local conflict. Selectors of land immediately adjoining permanent streams often ran their boundary fences down to the water's edge, enclosing the frontage reserve within their paddocks and using the water as a stock barrier.

Early farming days here - stripping oats with a six-horse-power machine

Kerang floods in 1909

They thus minimized fencing and obtained additional grazing land.

Initially, this practice raised the ire of squatters, who claimed, rightly, that the unselected Crown lands were part of their runs. The Lands Department, which administered both squatting and selector occupancies, supported the selectors, however, and a number received approval to continue their enclosures. In the following years conflicts arose with other selectors, who had taken up drier land some distance from the rivers. Cross fences often precluded access along river banks and hence the freedom of access to water.

Fencing also prevented the frontages being used for common grazing.

In other regions, steep, rocky, or infertile ground that was unsuitable for cultivation often provided an outlet for community grazing while selectors were improving their own lands. In the Murray Valley, however, very little land was unsuitable for agriculture and most was committed for private use. This led to an acute shortage of commonage, particularly in dry years. In such circumstances the right of adjoining selectors to fence across frontage reserves, and thereby exclusively occupy a public reserve, was frequently contested.

Irrigation Development

By 1880 most of the Murray Valley area had been selected, and the pattern of settlement showed a movement from large to small holdings. Most of these small holdings produced wheat and sheep, as the average yearly rainfall could sustain this form of dryland farming.

During the 1870s, despite difficulties, many of the small land-owners growing sheep and wheat prospered; however, the long drought of 1877--81 brought extreme hardship and disaster to many settlers.

The Victorian government responded to the crisis by passing the *Water Conservation Act* 1883, which provided for the establishment of Irrigation Trusts, as by then settlers in the area had realized that the fertile, flat plains were ideal for irrigation agriculture.

In the 1880s and '90s many such Trusts were formed in the Loddon and Goulburn districts, but it soon became clear that they could not cope with the subsequent necessary construction of storage and diversion works. The main problem was one of finance, as in the wet years the land-owners had no demand for water and consequently made no payments. In the dry years both demand for water and willingness to pay for it were high, but very little water was available.

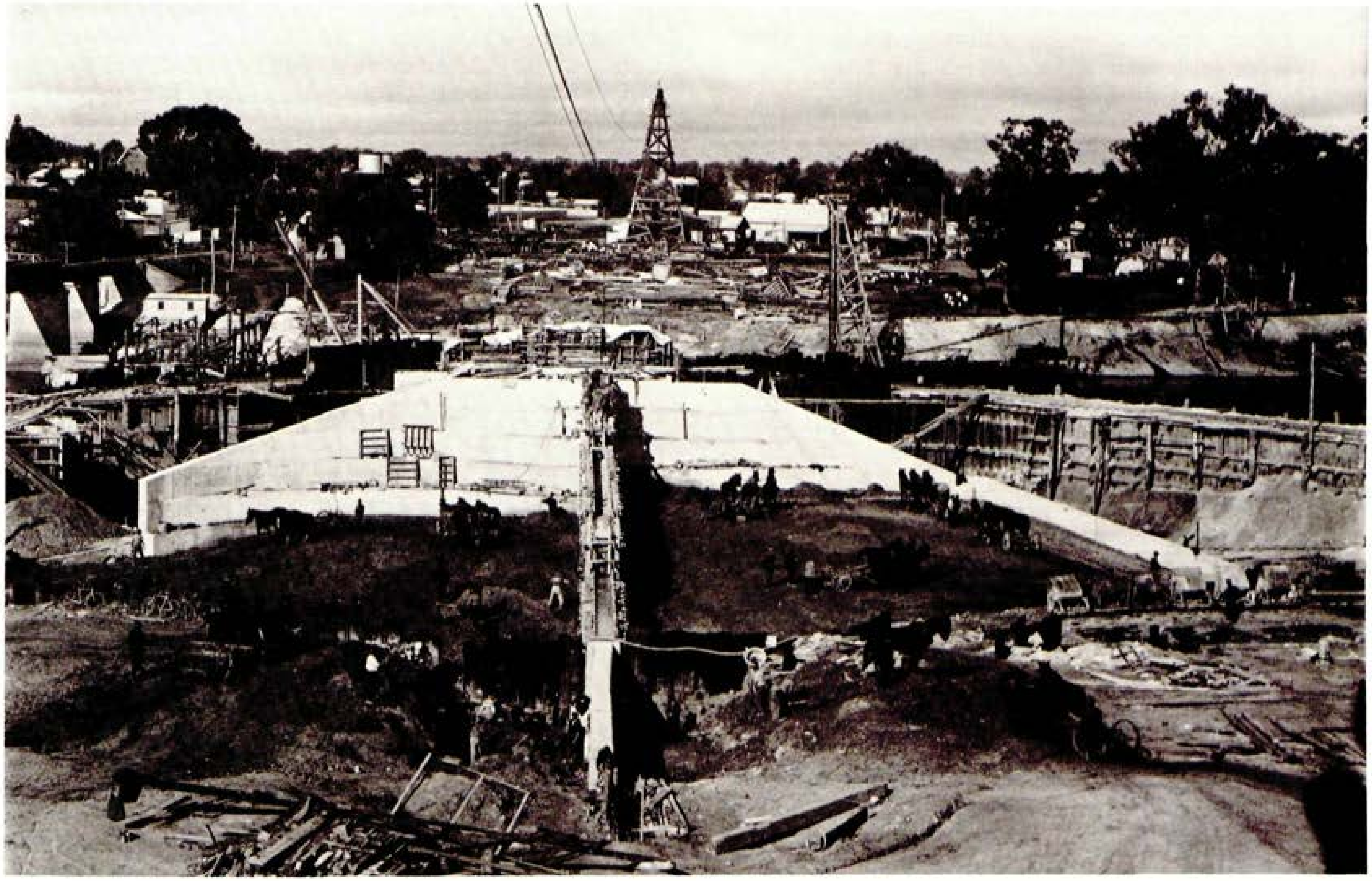
Despite these problems, irrigation finally gained a foothold in the area when in 1889 the State government completed work on the Goulburn Weir, making irrigation feasible in the Goulburn Valley.

In 1905, the government, in a bid for a more integrated and orderly development of irrigation, established the State Rivers and Water Supply Commission. The Commission consolidated the Trust areas into Irrigation Districts and extended diversion from the Murray after 1907 by erecting pumping plants at Koondrook and Cohuna, leading to an expansion of irrigation there, although the lack of major water storages restricted these developments.

Further land division and settlement for irrigation agriculture continued to the early 1960s under various settlement schemes.

From 1913 to 1933 the State Rivers and Water Supply Commission was the statutory Closer Settlement Authority for irrigation areas in Victoria, and it was during this time that the Rochester, Shepparton, and Tongala areas were settled.

With the expansion of settlement and an increasing dependence on irrigation, it was realized that additional storage capacity was needed. This led to the construction of River Murray Commission storages including Torrumbarry Weir (1924), Hume Reservoir (1931), and Yarrawonga Weir (1939). Water from these storages greatly increased the area of



Construction of the Yarrawonga Weir, about 1938

the Murray Valley that could be irrigated. The construction of Eildon Dam, completed in 1955, doubled Victoria's water storage capacity.

Since the 1950s, the main expansion in irrigation has been the intensification of water use and the development of a 120,000-ha irrigation district around

Cobram and Numurkah. Irrigation development near Invergordon commenced in the late 1950s and was completed in the early '60s.

The major irrigation schemes have played a prominent part in development of the Murray Valley area, and have contributed significantly to the State and national economies. They provide stable and assured agricultural production, irrespective of climatic fluctuations, and support strong, decentralized communities. Historically, the capital costs involved in their development have been borne by the State, while the irrigation community has borne the operating and management charges.

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PART II

NATURE OF THE LAND

6. GEOLOGY AND GEOMORPHOLOGY

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

Reference to the geology map and legend (Map 4), the simplified geological history (Figure 1), and the geomorphology map (Map 5), will assist the reader to understand this aspect of the study area. In addition, a glossary at the end of this chapter defines many of the technical terms used here.

A simplified picture of the geological setting emerges from consideration of the region in two parts. The eastern section, which forms part of the northern uplands of Victoria, and the southern margin consist of remnants of uplifted and deeply dissected Palaeozoic sedimentary and igneous rocks. The remnants largely occur as outliers within the south-eastern corner of the riverine plain. To the north and west the Palaeozoic formations pass beneath the Murray Basin, a sedimentary basin of Cainozoic age characterized by the riverine plain within the study area.

Geological History and Geomorphic Evolution

About 570 million years ago, early in the Cambrian period, an extensive marine trough known as the Tasman Geosyncline began to evolve along the eastern margin of the Australian continent. The oldest rocks in the study area - consisting of a thick sequence of interbedded Cambrian igneous and sedimentary rocks - were among the earliest rocks deposited in this trough.

Initial volcanic and intrusive igneous activity gradually gave way to sedimentation by the middle to late Cambrian as the trough continued to subside. At the end of the period, major earth movements resulted in a pause in sedimentation and initiated uplift of the Cambrian rocks, which now outcrop at Dookie and south-east of Rochester.

During the Ordovician period, thick sequences of marine sediments were laid down in a series of fault-controlled troughs within the Tasman Geosyncline.

At the beginning of the Silurian period, large-scale earth movements (Benambran Orogeny) destroyed part of the trough within the study area, resulting in the deformation (folding and faulting) of the rocks within it. In the extreme north-eastern corner of the study area, deformation was much more intense. Ordovician sediments were metamorphosed to phyllite, schist, and gneiss (Omeo metamorphic complex) due largely to deep burial.

Earth movements elevated the Ordovician rocks to a position well above sea level where, in the northern part of the study area, they were subjected to prolonged erosion.

In the central southern part of the study area further marine sedimentation took place (Melbourne trough) in the late Silurian--early Devonian. These sediments were broadly folded during the middle Devonian (Tabberabberan Orogeny) and then intruded by granites in the late Devonian.

The 300 million-odd years from the late Devonian to the early Tertiary seems to have been a time of tectonic stability and prolonged erosion, which resulted in a landscape of low relief extending over most of the study area.

The only significant deposition in this time occurred during the Permian, when the study area (together with most of south-eastern Australia) was subjected to glaciation. Glacial and fluvioglacial sediments were deposited, and are still preserved (mostly subsurface) in at least two fault-controlled troughs. These are the Ovens Graben on the eastern side of the Warby Range and a larger more complex trough extending from south of Shepparton, north and north-west, into New South Wales.

Subsidence associated with tectonic activity in the early Tertiary led to the formation of the Murray Basin. Within the study area, subsidence began to the north of the highland front, and continued until the middle Tertiary. It resumed after a brief period of stability, and perhaps gentle uplift, in the late Tertiary.

In some parts of the basin, downwarping was accompanied by intermittent faulting (such as the Leaghur and Cadell Faults).

During the early to middle Tertiary, the Basin was at first largely swampy, with sediments (including brown coal) being deposited - the Renmark Group. These are found above the buried bedrock surface in many bores in the western and central parts of the study area. The thickest sequences accumulated in broad valleys eroded by the ancestral Loddon, Campaspe, and Goulburn Rivers.

Later in the Tertiary, stream dissection in the adjoining highlands resulted in the deposition of sands and gravels (Calivil Formation in part) covering the

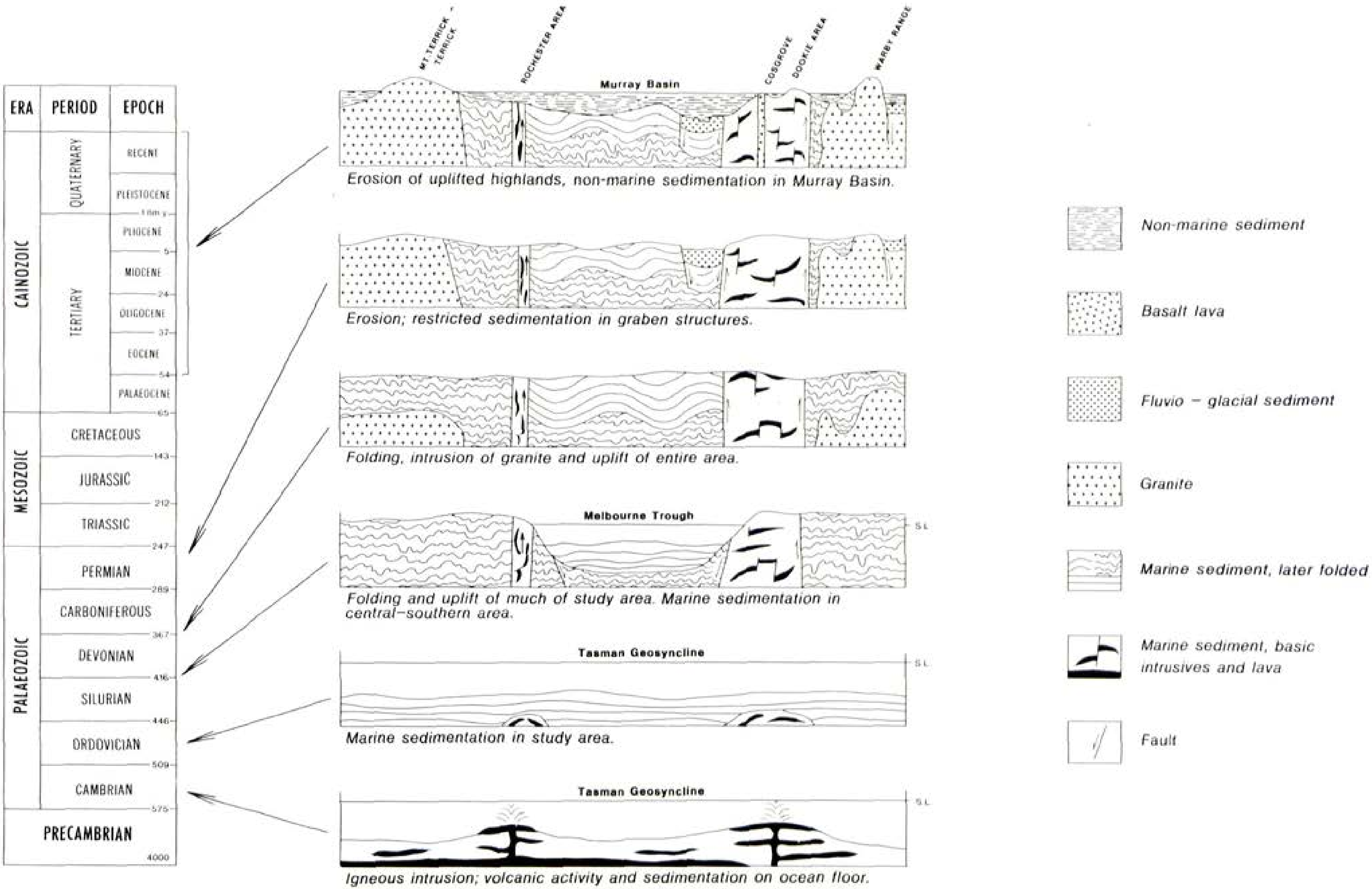
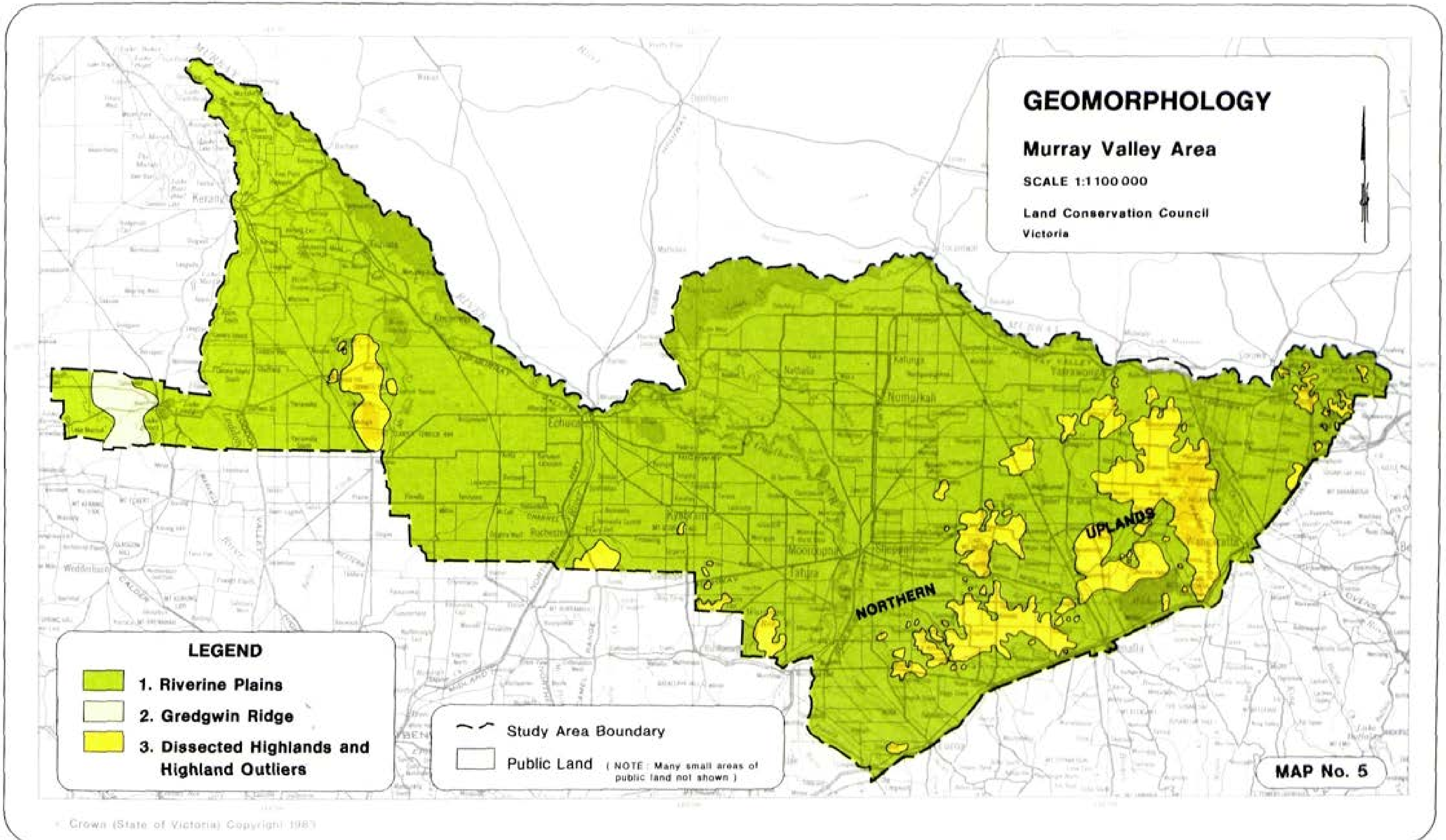


FIG.1 SIMPLIFIED GEOLOGICAL HISTORY, MURRAY VALLEY AREA



GEOMORPHOLOGY
Murray Valley Area
SCALE 1:1 100 000
Land Conservation Council
Victoria
LEGEND
1. Riverine Plains
2. Gredgwin Ridge
3. Dissected Highlands and Highland Outliers
Study Area Boundary
Public Land
(NOTE : Many small areas of public land not shown)
MAP No. 5
NORTHERN
UPLANDS
Echuca
Shepparton
Kerang
Mooroopna
Tatura
Numurkah
Kyabram
Rochester

Renmark Group and the older Palaeozoic bedrock.

In the late Tertiary a marine influence extended into the far west of the study area, with silt and sand (the Parilla Sand) deposited in littoral to near-shore marine environments. The bordering highlands, elevated by movements associated with the Kosciusko Uplift, acted as the source area for both the continental and marine sediments.

Minor volcanic activity took place in the eastern part of the study area at least twice during the Tertiary. The volcanism is represented by small basalt outcrops north-west of Glenrowan and west of Cosgrove.

As the Murray Basin continued to subside, in late Tertiary--early Quaternary times, a thick sequence of alluvium with lesser amounts of lake and swamp deposits (Shepparton Formation) was laid down over Tertiary sediments and adjacent Palaeozoic bedrock to form the riverine plain.

The last major depositional event in the study area consists of alluvial deposits of existing streams and their recent ancestors (Coonambidgal Formation).

Aeolian deposits of clay and/or sand (lunettes and source-bordering dunes) have accumulated adjacent to lakes and stream channels during periods of low rainfall in the late Quaternary.

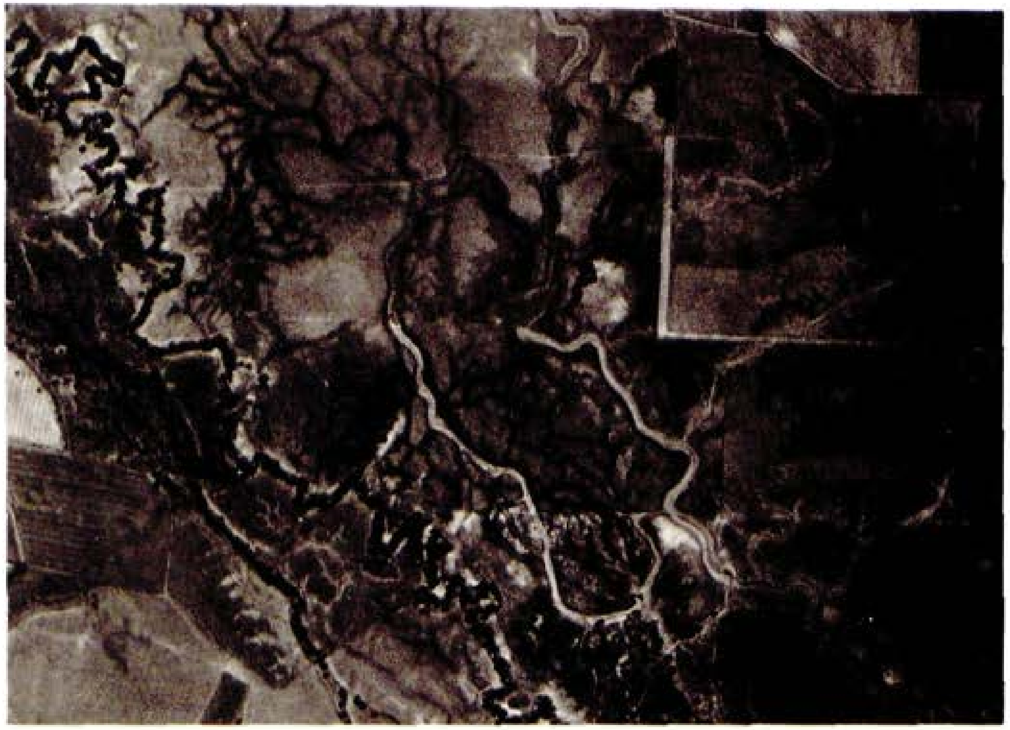
Geomorphology

The study area lies in the south-eastern corner of the riverine plain of south-eastern Australia and consists of two main geomorphic units. Almost flat riverine plains make up most of it, but in the south and east the northern uplands contain largely isolated remnants of the Victorian Highlands. Granite at Pyramid Hill is a more distinct highland remnant within the plains. Another geomorphic unit, the Gredgwin Ridge, occurs in the extreme west. Map 5 shows the distribution of the main geomorphic units in the study area.

Riverine plains

The riverine plains of northern Victoria consist mainly of river alluvium, although lacustrine and swamp sedimentation conditions have also contributed to their development. Minor aeolian deposits - in the form of lunettes on certain lake shores and source-bordering dunes along sectors of the river courses - are scattered throughout the study area.

At present the plains exhibit a remarkable river system, with major streams, anastomosing anabranches, and distributaries. However, with few exceptions the plains of today are the product of deposition not by the existing streams but by an older river system, which may still be traced but the channels of which have in many instances been abandoned.



Playette in the distributary area of the Loddon River, near Boort

The various land forms occurring on the plains are discussed below and illustrated on the geological map.

Prior and ancestral streams

Prior streams occupied the oldest of the channels that may still be traced across the plains. These characteristically had well-defined sandy levee banks enclosing the former channel, which is marked by a winding depression. Below this lies the old stream-bed itself - a deep, wide trench cut into the deposits of the plain, but now filled with sand and gravel.

In the present topography, prior streamcourses stand as sinuous ridges above the plain, which, with minor modifications due to later events, represents the flood-plain laid down by the prior streams themselves. The large extent of the meanders of prior streams and the coarseness of the sediments in their beds indicate that they carried more sediment at a faster flow rate than do most of the present rivers.

In addition to prior streams, other ancient channels exist that were formed by streams that have been called ancestral since they are in many places related to existing streams - for example, the Goulburn River near Shepparton. In such cases the ancestral meanders have longer wavelengths than the present meanders, indicating greater flow rates for the ancestral streams.

Playettes

The lower Loddon of today is exceptional among present streams in the study area, in that the surface of the plains is being built from deposits laid down by the stream when in flood. The river spreads out in a complex system of distributaries, flowing during floods over a clay surface of their own making. The finest networks of these distributaries form web-like systems that have been called playettes.

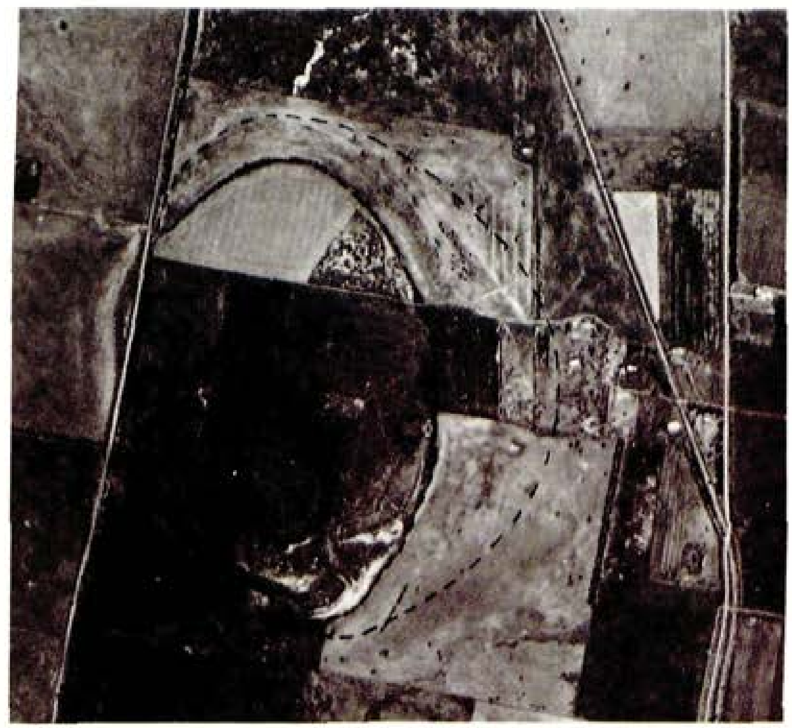
Lunettes

Crescent-shaped dunes on the eastern shores of shallow lakes are numerous on the plains, and are called lunettes. Lunettes can consist of sand or clay. Sand lunettes are formed from beach sand blown into a dune by the prevailing westerly winds; examples include Kow Swamp and a lunette marking the position of the former Lake Mokoan. The development of clay lunettes appears to require periodic drying of the lake beds, when the surface clay forms pellets - these being blown to the eastern shore where they are spread out in sheets to build a smooth ridge. Clay lunettes are present near Boort, and on the Loddon plains.

Appropriate conditions for lunette formation have recurred at intervals over a long time. Many lake--lunette complexes have been much larger in the past, as illustrated by the multiple lunettes in the Boort area. A reduction in the size of the lunettes corresponds with a gradual retraction in size of the lakes.

Source-bordering dunes

Sand, derived from deflation of dry stream-beds and blown into dunes nearby,



Lunette to the east and north of a relict lake-bed north-west of Boort is widespread on the riverine plain. The dunes are termed 'source-bordering', in contrast to those of the Mallee, for which the source area is far to the west.

Tectonic effects

Apart from broad regional downwarping of the Murray Basin and elevation of the highlands along its margins, earth movements have had specific local effects in several places within the study area. East of Echuca, a sub-circular depression about 18 km in diameter was formed, at least in part, by faulting along its margin. South of Echuca, movement along the Cadell Fault has produced an escarpment some 3 m high, uplifted on the west. In the far west of the study area (and outside it), movement along the Leaghur Fault has produced a low escarpment separating the higher Mallee country from the Loddon Plains. This fault may still be active, as many minor earth tremors are recorded in the district.

Northern uplands

The riverine plains are enclosed to the east and south by Palaeozoic rocks of the Central and Eastern Highlands. Along the margin, the alluvium of the plains extends far upstream along river valleys, with interfluve ridges rising above the valley floors and projecting northwards into the plain - for example, the Warby Range and Mount Camel Range. Hills (1975) calls this deeply indented marginal zone of the highlands the northern uplands.

Much of the zone is of low relief, with Palaeozoic (and minor Tertiary) rocks rising gently. The granite of the Warby Range is the major exception, rising high above the level of the plain. The range is deeply dissected, with steep slopes on much of the granitic bedrock. Gentle slopes have developed on the adjacent colluvial aprons.

A number of outlying peaks - such as Pyramid Hill, Mount Hope, and the Terrick Terrick Range - protrude through a cover of younger, Cainozoic sediment as granite monadnocks. Mount Scobie, south-west of Kyabram, is a monadnock of Palaeozoic sandstones.

Gredgwin Ridge

The extreme western part of the study area crosses the southern end of the Gredgwin Ridge. This low north--south trending ridge represents an ancient strand line formed along the edge of the retreating late Tertiary sea.

Stratigraphy

This section describes the rocks in the study area, from oldest to youngest.

Cambrian

Rocks of Cambrian age are the oldest and represent the initial phase of develop-

Pyramid Hill, a granitic monadnock rising above the riverine plain

ment of the Tasman Geosyncline. Two distinct outcrops of Cambrian rocks occur here, and subsurface continuations of these rocks can be traced from bore and geophysical information. Around Dookie, interbedded basic intrusive rocks, lavas, and sediments outcrop above the general level of the riverine plain. The beds have a total thickness of the order of 3,500 m, but the stratigraphy is partially obscured by faulting. The rocks, which have an east--west trend, consist of gabbro, dolerite, basalt, and chert, with minor siltstone, conglomerate, tuff, and agglomerate. The igneous rocks have been altered to greenstones due to deep burial.

In the Mount Camel Range, south-east of Rochester, a narrow belt of Cambrian rocks extends into the study area. These consist of small outcrops of Lower Cambrian greenstone on the eastern flank of the range, with Middle to Upper Cambrian sediments forming the range itself. The sequence is steeply inclined, and bounded on both sides by high-angle faults. To the east, the Mount Ida Fault brings the Cambrian rocks into contact with younger Upper Silurian--Lower Devonian sediments; to the west the Heathcote Fault brings them against Lower Ordovician sediments.

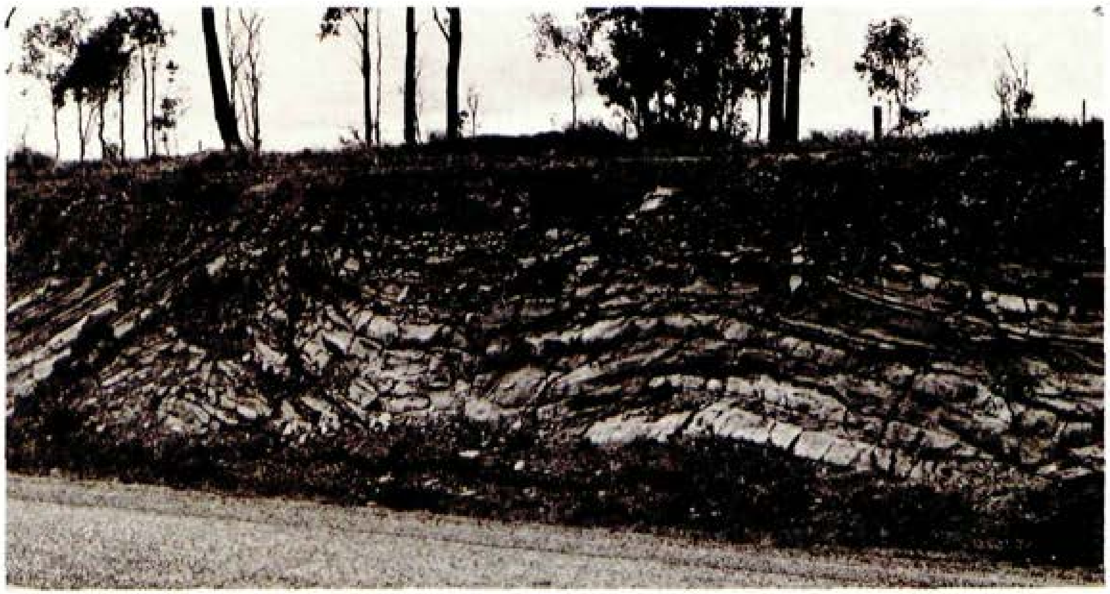
Buried Cambrian greenstones are easily traced, as aeromagnetic highs, beneath the Cainozoic sediments of the riverine plain. The Cambrian rocks forming the Mount Camel Range continue a short distance under the plain and are then displaced some 5 km to the east. In the vicinity of Koyuga the trend changes from north--south to north-west--south-east. At Dookie the Cambrian rocks occupy a relatively broad east--west trending area; however, under the plain to the north-west of Dookie, greenstones continue as a thin north-west trending zone.

Ordovician

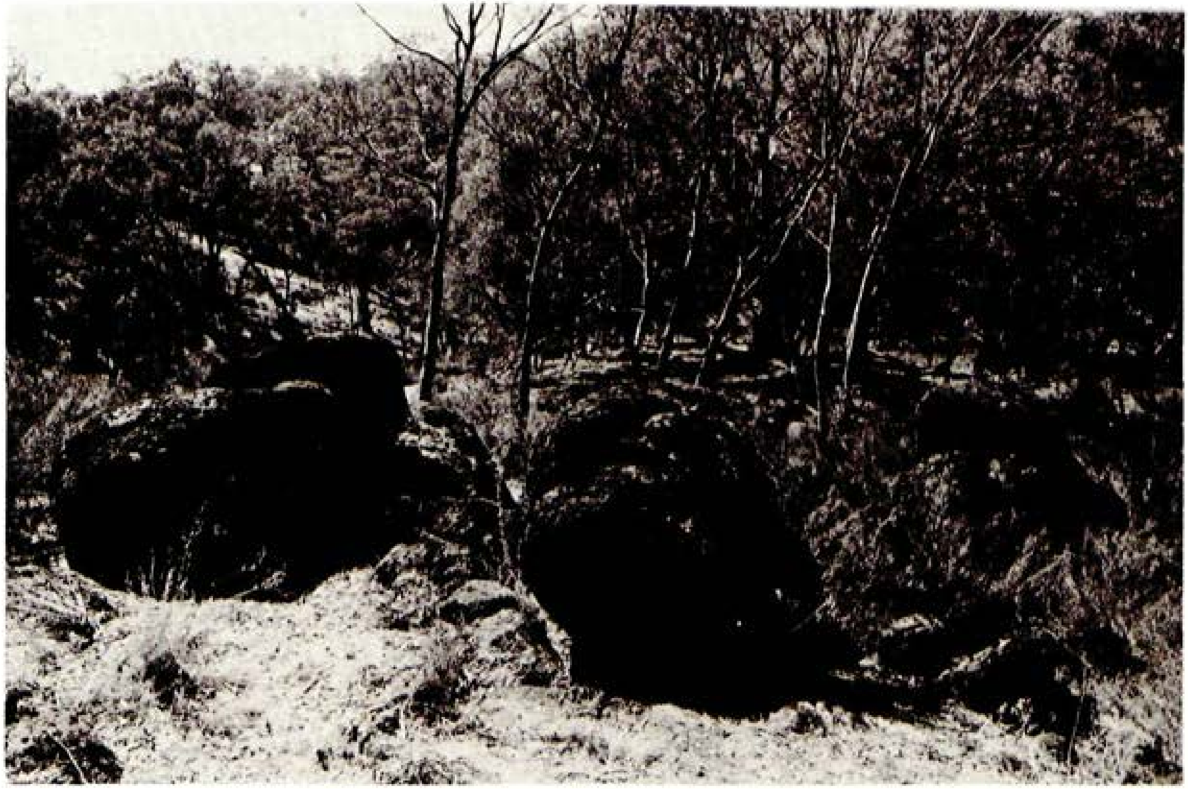
Marine sedimentary rocks of Ordovician age outcrop in the northern uplands, particularly in the eastern part of the study area. They consist of sandstone, siltstone, greywacke, and shale, laid down under deep-sea conditions. Fossils are rare, but some graptolites are present and suggest ages from early through to late Ordovician. During the Benambran Orogeny (early Silurian) sediments in the east underwent strong folding and faulting. In parts of eastern Victoria deformation was much more intense and the Ordovician sediments were regionally metamorphosed to high-grade gneiss and schist called the Omeo Metamorphic Complex. In a small outcrop of these metamorphics, in the north-eastern corner of the study area, mica schist and phyllite occur at Mount Ochertyre.

Silurian--Devonian

Between the Mount Camel Range and Benalla, a marine sequence of interbedded sandstone, siltstone, mudstone, and minor conglomerate was deposited in the northernmost part of the Melbourne Trough during the late Silurian--early Devonian period.



Gently folded sedimentary rock of Silurian or Devonian age in a road cutting on the Hume Highway, south-west of Euroa



Granite tors in the Warby Range

In the middle Devonian these trough sediments were deformed during the Tabberabberan Orogeny, and as a result broad open folds developed in the rocks (in contrast to the tight folds and strong cleavage developed in the Ordovician sediments).

In the late Devonian, granites and associated igneous dykes intruded Lower Palaeozoic bedrock. Within the study area two main granite masses outcrop - one forming the Warby Range and outcropping intermittently west to Katandra (and further west subsurface), and the other forming the Terrick Terrick Range, including Pyramid Hill and Mount Hope.

The granites have yielded radiometric (K-Ar method) ages of 372 ± 6 million years at Pyramid Hill and 375 ± 6 million years near Glenrowan.

Permian

During the Permian, frigid conditions developed over much of Australia, and continental glaciers moved into the study area from the south-west. As the glaciers and ice sheets retreated they left flat-lying tillite (boulder clay) and fluvioglacial sand, silt, and clay, deposited in a number of fault-controlled river valleys and basins.

Small areas of Permian sediments outcrop in the north-east of the study area. Drilling has shown these rocks to be more extensive subsurface, occurring within the Ovens Graben around Wangaratta and in a larger more complex trough extending from south of Shepparton to the north and north-west into New South Wales. Between 70 and 170 m of grey to bluish grey mudstone, tillite, and minor sandstone have been intersected in bores.

Tertiary

Following the brief period of deposition in the Permian, erosion continued for approximately 200 million years. Initiation of the Murray Basin in the early Tertiary resulted in the deposition of up to 250 m of Cainozoic non-marine sediments in the study area. Deposition extended progressively towards the highland front, with thickest sequences developing further from the basin margin. Numerous sedimentary units have been recognized within the sequence, but only the major formations are discussed here.

During the early to middle Tertiary, sediments of the Renmark Group were laid down in lakes, swamps, and deltaic environments, mostly away from the highlands, but also within ancient river valleys (precursors of the modern stream valleys) draining the highlands. The Renmark Group sediments are mostly carbonaceous and pyritic and include brown and grey gravel, fine to coarse sand, clay, and brown coal. Brown coals occur at various levels, and the seams - except for one, which often marks the top of the group - are usually lenticular.

A small, isolated outcrop of basalt overlying Tertiary gravel north-west of Glenrowan resembles Older Volcanic basalts outcropping in the vicinity of Toombullup, to the south. The latter rocks have been radiometrically dated at between 37 and 43 million years. The sub-basaltic gravel north-west of Glenrowan is probably equivalent to Renmark Group sediments.

Another isolated outcrop of basalt occurs to the west of Cosgrove and has been radiometrically dated (K-Ar method) at 6.7 million years. It contains an unusual mineral called leucite and has been correlated with similar leucite-bearing lavas in New South Wales.

Following renewed uplift of the highlands in mid Tertiary times, sand and gravel were laid down in rejuvenated river valleys. These sediments, known as deep leads, were laid down beneath the major rivers draining the highlands at that time. The major early Tertiary river valleys had similar positions to those of the present-day Loddon, Campaspe, and Goulburn Rivers. Other deep lead channels, covered by Quaternary alluvium, occur within the study area (for example, south-east of the Terrick Terrick Range).

To the north of the highland front the deep leads widen and the sediments within them become progressively finer-grained. Clay lenses are occasionally recorded, particularly in the Echuca--Tongala area. Deep lead sediments reach maximum thickness of 52 m in the Echuca district. Along the Loddon River the deep lead gravels are known as the Calivil Formation and are thought to be late Tertiary in age. Elsewhere in the study area, and upstream in the highlands, the deep lead sediments were deposited in the early to middle Tertiary (determined from pollen and spore fossils). A number of depositional periods may be represented in the deep lead sediments, but their similar lithologies and the limited fossil record make these difficult to recognize.

Around Rutherglen and Chiltern, similar deep lead deposits occur at the base of the alluvial sediments. These were worked for their gold at the turn of the century. Small outcrops of gravel resting on bedrock there may also be related to the deep leads or they may be an older phase of alluvial deposition.

Towards its western limit, the Calivil Formation intertongues with (and in part conformably underlies) the Parilla Sand, which outcrops in the extreme west of the study area forming the Gredgwin Ridge. The Parilla Sand consists of silt and fine- to coarse-grained quartz sand, containing marine fossils of late Tertiary age. It ranges between 40 and 150 m in thickness, and in the area concerned marks the most easterly incursion of the late Tertiary sea.

Quaternary

The Shepparton Formation blankets the older Murray Basin sediments and partially covers the Palaeozoic bedrock in and to the south of the study area. It largely makes up the riverine plain we see today. It consists predominantly of fluviatile clay, but shoestring-type sand and gravel (ancient stream-channel deposits) are interbedded at various horizons throughout the sequence. In many areas the shoestring sands coalesce to form sheets of varying continuity and thickness. The maximum recorded thickness of the whole Formation is 132 m, but is generally between 50 and 125 m.

This Formation is regarded as spanning most of the Pleistocene epoch. It was deposited by a system of high-energy meandering streams, traces of which can still be seen on the surface of the riverine plain. The channels are flanked by broad low levee banks composed of fine sandy clay. This is characteristically mottled, and exposures in river banks show fossil soil profiles.

During the Quaternary, aeolian deposits of sand and clay have been accumulating on parts of the plains. Lunettes have formed on the eastern shores of many lake-beds, and source-bordering dunes have been deposited adjacent to a number of stream courses.

The Coonambidgal Formation represents the last major depositional cycle in the study area and consists of alluvial deposits of existing streams and their recent ancestors. The Formation consists mostly of clay and sand channel-fill deposits, in the valleys of the present-day rivers. It is commonly represented by a series of river terraces with surface features such as meander scrolls and oxbow lakes, broad areas of anastamosing channels, fine ephemeral channels, and low-lying areas subject to sheet flooding.

Glossary

Aeolian - deposits transported and laid down by the wind

Aeromagnetic survey - magnetic survey made with an air-borne magnetometer

Agglomerate - a chaotic assembledge of coarse, angular pyroclastic materials

Anastomosing - of streams - branching and rejoining irregularly to produce a net-like pattern

Anabranch - stream that leaves river and rejoins it lower down

Basalt - a dark-coloured, fine-grained, basic volcanic rock composed principally of calcium-rich plagioclase and pyroxene

Basic - said loosely of any igneous rock composed chiefly of dark-coloured minerals, and more specifically of an igneous rock with relatively low silica content

Bedrock - in the area, refers to Lower to Middle Palaeozoic (575--340 million years) rocks

Chert - a hard, extremely dense, indistinctly crystalline sedimentary rock consisting predominantly of silica; flint is essentially synonymous

Deep lead	- generally coarse stream-bed deposits buried under soil, unconsolidated sediment, or rock
Dolerite	- a medium-grained, basic intrusive rock composed principally of calcium-rich plagioclase and pyroxene - mineralogically and chemically the same as gabbro and basalt
Ephemeral channel	- a stream that flows briefly in response to rainfall in the immediate locality, with a channel above the water table at all times
Fault	- a zone of rock fracture along which displacement - from a few centimetres to a few kilometres - has occurred
Gabbro	- a dark-coloured basic intrusive rock composed principally of calcium-rich plagioclase and clinopyroxene (silicate of iron, magnesium, and calcium)
Geosyncline	- a mobile downwarping of the crust of the earth (either elongate or basin-like), measured in scores of kilometres, which is subsiding as sedimentary and volcanic rocks accumulate to thicknesses of thousands of metres
Graben	- an elongate, relatively depressed crustal unit or block that is bounded by faults on its long sides
Graptolite	- any colonial marine organism of class Graptolithina (known stratigraphic range middle Cambrian to Carboniferous)
Greenstone	- a field term applied to any altered basic to ultrabasic igneous rock
Interfluve	- the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction
Intrusion	- the process of emplacement of magma into pre-existing rock; also the igneous rock mass so formed with the surrounding rock mass

Lacustrine	- pertaining to, produced by, or formed in a lake
Levee bank	- a long, broad, low ridge or embankment of sand and coarse silt, built by a steam on its flood-plain and along both banks of its channel, especially in time of flood
Lithology	- the physical character of a rock
Metamorphism	- the mineralogical and structural adjustment of solid rocks to physical and chemical conditions that have been imposed at depth (below the surface zones of weathering and cementation) and that differ from the conditions under which the rock in question originated
Monadnock	- a hill of resistant rock rising conspicuously above the general level of a plain
Orogeny	- process by which structures within mountain areas were formed, including thrusting, folding, and faulting in the outer and higher layers, and plastic folding, metamorphism, and plutonism in the inner and deeper layer
Oxbow lake	- a crescent-shaped body of water situated in the abandoned channel of a stream meander
Peat	- an unconsolidated deposit of semi-carbonized plant remains of a water-saturated environment
Phyllite	- a fine-grained rock commonly formed by regional metamorphism and intermediate in metamorphic grade between slate and mica schist; split surfaces have a silky sheen
Pyroclastic	- pertaining to a rock composed of broken fragments derived from a pre-existing rock by volcanic explosion or aerial expulsion from a volcanic vent
Radiometric age	- an age expressed in years and calculated from the quantitative determination of radioactive elements (such as K-40) and their decay products (such as Ar-40)

Schist	- a strongly foliated crystalline rock formed by regional metamorphism, which can be readily split into thin flakes or slabs due to well-developed parallelism of minerals
Sill	- a tabular igneous intrusion that parallels the planar structure of the surrounding rock
Stratigraphy	- systematic arrangement of the sequence of rock strata of the earth's crust into units
Tectonics	- a branch of geology dealing with the structural or deformational features of the upper part of the earth's crust
Trough	- an elongate depression on the sea floor
Tuff	- a compacted pyroclastic deposit of volcanic ash
Unconformity	- a substantial break or gap in the geologic record, where one rock unit underlies another that is not in stratigraphic succession; it results from a change that caused deposition to cease for a considerable time

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7. CLIMATE

The general pattern of climate is one of gradation rather than fluctuation. Variation in elevation throughout the study area is limited, which results in unfavourable conditions for the development of orographic rainfall and temperature changes.

This gradation is characterized by increasingly longer and warmer summers as one moves from south-east to north-west. Average annual rainfall has a similar monthly distribution pattern throughout but decreases from south-east to north-west across the study area.

The area contains two climatic zones. East of the Campaspe River, where the rainfall exceeds 400 mm, the climate is 'temperate hot summer' while west of the Campaspe, where rainfall is less than 400 mm, it becomes sufficiently dry to be termed 'semi-arid'. Both zones typically have hot summers and mild winters with few frosts. The greater part of the annual precipitation occurs in winter and is of low intensity, while about 40% falls during the summer, chiefly during irregular thunderstorms with intense rain. Annual evaporation is high and greatly exceeds the annual precipitation.

Measurement of the climatic elements is undertaken by the Bureau of Meteorology at a network of stations throughout the area. Rainfall, temperature, and humidity are measured in a fairly intensive network. Wind is recorded at 15 of the stations and evaporation at 7 of them.

Barometric pressure is measured at Echuca and Benalla and a barograph is located at Tatura. Terrestrial thermometers measure air temperature at ground level at Shepparton, Tatura, and Benalla. Thermographs and hydrographs are located at Kyabram and Tatura.

Sunshine recorders are located at Kyabram, Tatura, and Rutherglen; anemometers at Rutherglen, Numurkah, Kyabram, and Tatura; and pluviographs (for rainfall amount and intensity) at Cobram, Rutherglen, Wangaratta, Dookie, Tatura, Kerang, and Pyramid Hill.

Precipitation

Most of the effective precipitation in the area falls as rain and occasional hail; snow is extremely rare.

Annual average precipitation decreases from south-east to north-west across the study area, being lowest (350 mm) at Murrabit in the north-west and highest (672 mm) at Benalla. As in many other parts of Australia, it varies considerably from year to year, with periodic droughts. Table 3 shows the mean monthly and annual rainfalls at selected sites.

Table 3

MONTHLY AND ANNUAL AVERAGE RAINFALL (mm)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total summer	Apr.	May	June	July	Aug.	Sep.	Total winter	Total
Melbourne	68	60	58	48	49	53	336	59	58	50	49	50	59	325	661
Kerang	39	27	26	21	25	29	167	26	36	37	34	36	34	203	370
Boort	40	32	26	23	28	27	176	28	39	41	38	40	38	224	400
Echuca	44	32	29	27	29	33	194	34	42	44	40	43	40	243	437
Nathalia	46	32	30	30	29	33	200	34	43	45	40	42	40	244	444
Tatura Research Stn.	49	34	33	31	31	36	214	38	46	53	49	48	44	278	492
Rochester	44	32	29	30	34	35	204	30	46	43	45	42	41	247	451
Dookie	56	37	34	34	34	40	235	43	53	60	53	57	50	316	551
Yarrawonga	53	37	36	33	33	42	234	41	46	53	46	50	45	281	515
Rutherglen Exp. Stn.	60	42	45	36	37	44	264	44	53	62	60	60	53	332	596
Benalla	65	48	43	40	37	46	279	50	64	75	71	71	62	393	672

Source: Australia, Bureau of Meteorology: *Rainfall Bulletin, Victoria*, 1980

Note: Figures for Melbourne have been included for comparative purposes.

Although somewhat lower in summer than in winter, average rainfall is otherwise evenly distributed throughout the year. The highest monthly average occurs consistently in June, but a subsidiary maximum occurs in October and sometimes August.

Summer precipitation, while substantial, is not sufficient to maintain plant growth, because high summer temperatures result in high evapotranspiration and because much of the summer rain comes from occasional heavy storms of short duration.

Moreover, most of the soils in the area have a dense loamy surface that resists quick penetration of the rainwater. Consequently, losses occur due to run-off, and surface ponding on the plains leads to large evaporation losses immediately following the summer rainstorms.

These adverse conditions of evaporation and run-off seldom apply for areas that carry perennial pastures, however, which are mostly established on the better soils having medium surface textures and a protective cover of grass.

In addition, the rainfall tends to be more erratic in summer and autumn than in winter and spring.

Annual rainfall can vary markedly from year to year. In 1982, a drought year, the area received some 50--60% less than the annual average.

Temperature

Air temperature is measured in a Stevenson screen, where the circulation of air is unobstructed and the instruments are protected from the direct rays of the sun. Mean daily temperature is calculated by averaging the daily minimum and maximum. Temperature is an important factor in plant physiological processes and in influencing the evaporation rate.

Mean monthly long-term averages are remarkably even throughout the area. They range from 14°C minimum to 31°C maximum in summer and 3°C to 13°C in winter. In the two warmest months - January and February - the mean monthly maximum temperatures range from 29.5°C to 31.7°C. By contrast, in the coolest month (July) they range between 12.2°C and 13.8°C.

The range of maximum temperatures can be very marked. Benalla has a summer mean maximum of about 31°C, with a maximum extreme on record of 46°C in January. Temperatures may exceed 38°C from October to the end of March. Generally these extremes correspond to a dry, turbulent, northerly or north-westerly wind.

Table 4 shows the mean monthly and annual maximum and minimum temperatures at selected stations.

Frosts

The occurrence of frost depends not only on the temperature and the humidity of

Table 4

MEAN MONTHLY AND ANNUAL MAXIMUM AND MINIMUM TEMPERATURES (^{o}C)

Station		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Melbourne	A	26.5	25.9	24.0	20.9	16.5	14.5	13.5	14.9	17.1	19.7	21.8	24.0	19.9
	B	14.9	15.3	13.5	11.2	8.7	7.0	6.2	6.8	8.1	10.0	11.4	13.3	10.5
Kerang	A	31.3	30.6	27.5	23.0	17.3	14.6	13.8	15.6	18.6	22.7	25.9	28.9	22.5
	B	15.3	15.5	13.0	9.6	6.9	4.5	4.0	5.2	6.7	9.1	10.7	13.2	9.5
Boort	A	31.2	30.3	26.8	22.7	17.0	14.2	13.5	15.2	17.8	22.4	25.1	28.3	22.0
	B	15.4	16.3	13.2	10.1	6.6	4.2	3.6	4.7	6.2	8.6	10.5	13.1	9.4
Echuca	A	31.2	30.1	27.0	22.5	17.1	14.6	13.4	15.2	18.0	22.0	25.5	28.3	22.1
	B	15.4	15.2	13.0	9.8	6.5	4.5	3.8	5.0	6.4	9.1	11.1	13.3	9.4
Numurkah	A	31.7	31.1	27.4	22.8	17.2	14.3	13.5	15.1	18.1	22.8	25.6	28.8	22.4
	B	15.7	16.6	13.4	9.9	6.4	3.7	3.1	4.6	6.2	8.8	11.0	13.7	9.4
Tatura Research Stn.	A	29.7	29.5	26.2	21.7	16.7	13.9	12.9	14.5	17.1	21.4	24.1	27.2	21.2
	B	13.9	14.5	10.9	7.7	5.3	2.9	2.5	3.7	5.1	7.6	9.2	11.6	7.9
Rochester	A	31.2	30.6	26.7	22.1	16.7	14.0	13.1	14.8	17.5	21.8	25.0	28.4	21.8
	B	14.9	15.8	12.6	9.5	6.1	3.6	3.2	4.4	5.7	8.2	10.3	12.8	8.9
Dookie	A	30.0	29.6	25.9	21.3	16.2	13.3	12.2	13.7	16.4	20.8	23.7	27.2	20.9
	B	15.2	16.1	13.0	9.9	6.8	4.5	3.8	4.9	6.1	8.3	10.3	13.1	9.3
Yarrawonga	A	31.3	30.7	27.5	22.9	17.1	14.2	13.1	14.9	17.7	21.9	25.2	28.6	22.1
	B	16.3	17.1	13.8	10.5	6.9	4.1	3.6	5.0	6.2	8.6	11.2	14.2	9.8
Rutherglen Exp. Stn.	A	31.4	31.0	27.1	22.3	16.2	13.4	12.3	13.8	16.7	21.4	24.8	28.9	21.6
	B	14.0	14.7	10.8	7.5	4.1	1.9	1.5	3.0	4.2	5.8	7.5	11.0	7.2
Benalla	A	31.2	30.0	26.8	22.0	16.5	14.1	12.6	14.2	17.0	20.9	24.9	28.2	21.5
	B	14.4	14.1	11.4	8.2	5.3	3.4	2.9	4.0	5.0	7.5	9.7	12.2	8.2

Source: Australia, Bureau of Meteorology (1975). 'Climatic Averages, Victoria'

Notes: 1. A: Mean monthly and annual maximum temperature (^{o}C)
2. B: Mean monthly and annual minimum temperature (^{o}C)

Table 5

AVERAGE MEAN DAILY SUNSHINE DURATION AT TATURA

Duration (hours)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Average	10.0	9.8	8.6	7.0	4.9	4.3	4.2	5.2	6.5	7.7	8.9	9.9
Highest	11.4	11.0	10.0	8.7	7.0	5.9	5.7	6.3	8.4	9.6	9.8	11.2
Lowest	7.6	7.2	6.9	2.9	2.9	3.1	3.0	4.4	5.1	5.9	7.2	7.2

the air, wind speed, and cloud, but also on characteristics of the ground surface - the slope (and slopes of nearby surfaces), vegetative cover, and water content. Local topography can significantly influence its distribution. Hollows are particuarly frost-prone, due to pooling of dense cold air, while slopes (where the flow of air is unimpeded are much less susceptible to frost.

Frosts may be expected each year over most of the area, but their main occurrence is usually restricted to winter. Spring frosts may constitute a serious hazard to agriculture and in some years a late frost may result in serious crop damage.

In the north-west severe frost (screen temperatures below 0°C) may be expected about eight times annually, and light frost (screen temperatures between 0°C and 2.2°C) about 21 times. Frosts occur mainly from May to October, earlier and later occurrences being rare.

Benalla, in the south-east, generally experiences 44 frosts a year. The first is likely to occur about mid May, and the first severe frost in mid June. The last severe frost generally comes in late August and the last frost of spring may often be in September, but light frosts may continue until mid November.

Sunshine

Sunshine recorders are located at Kyabram, Rutherglen, and Tatura. Data from Tatura can be generally regarded as representative of the whole area. Records from this station (see Table 5) indicate that January has the most sunshine per day (average 10.0 hours), while July has the least (4.2 hours). The averages for the same months at Melbourne are 8.5 and 4.4 hours respectively.

Evaporation

Evaporation, Eo, is the quantity of water vaporizing from a large open water surface such as a lake in a given time, and has an important place in the hydrologic cycle of the area. There is no simple method of measuring it.

The amount of evaporation from a standardized evaporimeter, Ep, is determined by measuring the loss of water from an open-topped standardized tank and dep-

Table 6

ESTIMATED Eo AND MEASURED AVERAGE Ep AT TATURA

Month	Eo (mm)	Ep (mm)	rainfall (mm)
January	224	235	31
February	192	189	31
March	136	149	36
April	74	93	38
May	43	57	46
June	30	38	53
July	31	35	49
August	52	51	48
September	91	79	44
October	137	114	49
November	172	156	34
December	210	209	33
Annual total	1,392	1,405	492

ends on temperature, humidity, and wind speed.

The relation between the two can be written as Eo = cEp where c is the pan co-efficient, which varies with the conditions and time of year.

Based on data and calculations from Gutteridge *et al.* (1970), the potential evaporation Eo and measured evaporation Ep for Tatura are given in Table 6.

Evaporation is important for irrigation management and practice. During summer, evaporation is four to five times the average rainfall. During winter, however, the two totals approach equality. Average annual evaporation is usually three times the average annual rainfall.

Wind

Wind data are available from 15 stations in the area. Anemometers measure wind speed and direction at Rutherglen, Numurkah, Kyabram, and Tatura.

During the summer, predominant winds come from the north-west, west, and south-west, and summers are characterized by strong, hot, north-westerly winds. Southlies and north-easterlies occur at 15% and 10% frequencies respectively. Similar wind patterns are experienced during the winter.

In general, more than 50% of the winds have a speed less than 10 km per hour, and about 10% of them blow at more than 31 km per hour. Wind speeds greater than 51 km have been recorded in the area.

Growing season

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

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

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

Using the Kerang region as an example of the study area, calculations show that average rainfall exceeds effective rainfall from mid May to the end of August. The natural rainfall provides enough moisture for the growing season to last 4--5 months. This assumes optimum distribution of rainfall and minimum moisture requirements for shallow-rooting pasture plants. In these months, however, low solar radiation and low temperatures tend to restrict plant growth.

With irrigated pastures, as with other irrigated crops, the water required to sustain plant growth depends largely on solar radiation, which influences temperature and hence evapotranspiration from the plants. Using estimates of evapotranspiration and leaching, the amount and desirable frequency of irrigation can be calculated. Around Kerang, the annual irrigation requirements in a season of average rainfall and potential evaporation are 920 mm for perennial pasture and 290 mm for annual pasture.

Drought

In comparison with other areas of Victoria, the Murray Valley has a limited surface water resource. If we define a drought year as one when less than 200 mm of rain falls in the seven critical plant-growth months (April to October), with a mean rainfall of 350--450 mm drought may occur one year in five. This situation applies to about half the study area. The remainder has a mean rainfall of 600 mm and the frequency of drought is about one year in ten.

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8. WATER RESOURCES

Surface Water

The study area lies within the Murray--Darling drainage system and contains the lower reaches of five major drainage basins - the Ovens, Broken, Goulburn, Campaspe, and Loddon (see Table 7 and Map 6). Compared with the rest of the State it does not produce a significant quantity of surface water, although the amount is considered enough for habitation and dryland farming in most years. By contrast, however, it utilizes a substantial amount of the State's total production each year for irrigation.

Major streams

Although no significant river system lies completely within it, the study

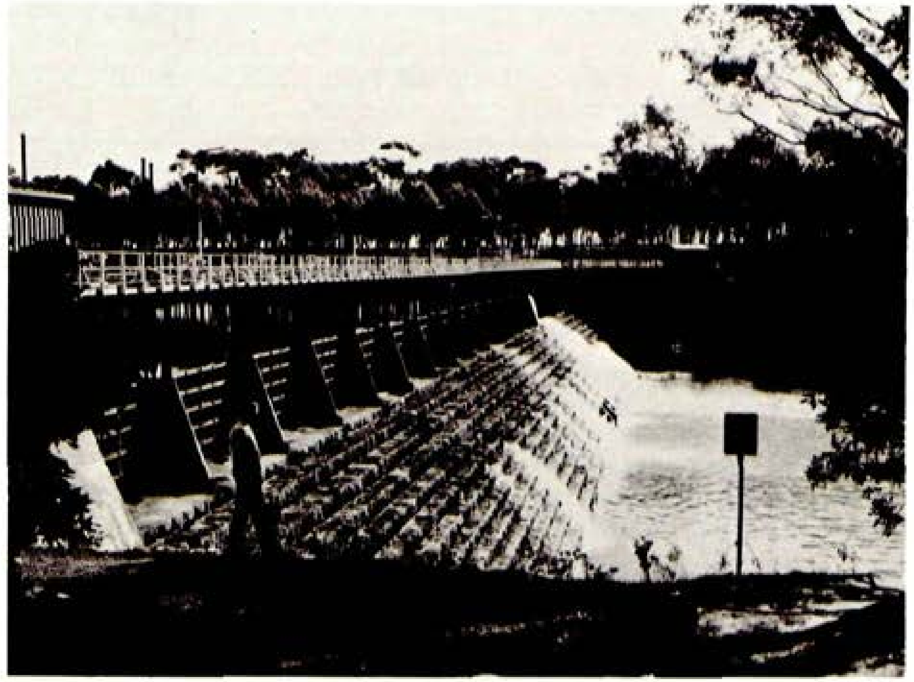
Table 7

SURFACE WATER RESOURCES

Basin	Basin area		Estimated yield		
	'000 sq. km	Percentage in Murray Valley area	Total (cu.m x 10^9)	Exploitable (cu.m x 10^9)	(%)
Ovens	7.8	18	1.68	0.60	36
Broken	7.3	75	0.33	0.19	30
Goulburn	16.8	23	3.19	2.31	72
Campaspe	4.0	13	0.26	0.16	62
Loddon	15.4	28	0.29	0.16	55

Source: P.M. Fleming, 1982.

Water from Goulburn Weir is widely distributed for irrigation within the Murray Valley area, although the weir itself if just outside the area



area is traversed by the lower reaches of the Ovens, Broken, Goulburn, Campaspe, and Loddon Rivers. These rivers - which generally flow northwards - all rise outside it, in the upper reaches of the Eastern and Western Highlands. They all discharge into the Murray River.

The Murray, which is technically outside the study area (the State boundary being the top of the left bank of the River), flows in a westerly direction along its northern boundary and is a major source of surface water for irrigation and domestic use. Many streams in the region, including the Murray, are characterized by a network of anastomosing and distributary streams. Those that diverge from the major channel and rejoin it further downstream, such as Gunbower Creek and parts of the Murray, are called anabranches. Others diverge and terminate in shallow lakes or swamps, or (as Barr Creek does) join another river.

The anastomosing pattern results in complex systems of surface water movement and storage and compounds the difficulties associated with the distribution of irrigation water and the development and effectiveness of flood-mitigation works.

The construction of several water storages (mainly outside the study area -

Table 8

WATER STORAGES OF LOCAL SIGNIFICANCE

River system	Storage	Date of construction	Date of enlargement	Capacity (ML)
Murray	Kow Swamp*	1890	1969	51,000
	Torrumbarry Weir*	1924		35,600
	Lake Hume	1931	1958	3,038,000
	Lake Mulwala*	1939		117,500
	Lake Dartmouth	1979		4,000,000
Ovens	Lake Buffalo	1965		24,000
	Lake William Hovell	1971		13,500
Goulburn	Goulburn Weir	1890		25,000
	Waranga Basin+	1905	1917,1926	411,000
	Lake Eildon	1927	1955	3,390,000
	Greens Lake+	1967		32,500
Loddon	Laanecoorie Reservoir	1891	1909	7,700
	Cairn Curran Reservoir	1956		148,800
	Tullaroop Reservoir	1959		73,700
Broken	Caseys Weir*	1888		300
	Lake Nillahcootie	1967		40,000
	Lake Mokoan*	1970		365,000
Campaspe	Campaspe Weir	1882	1951,1965	2,700
	Lake Eppalock	1962		312,000

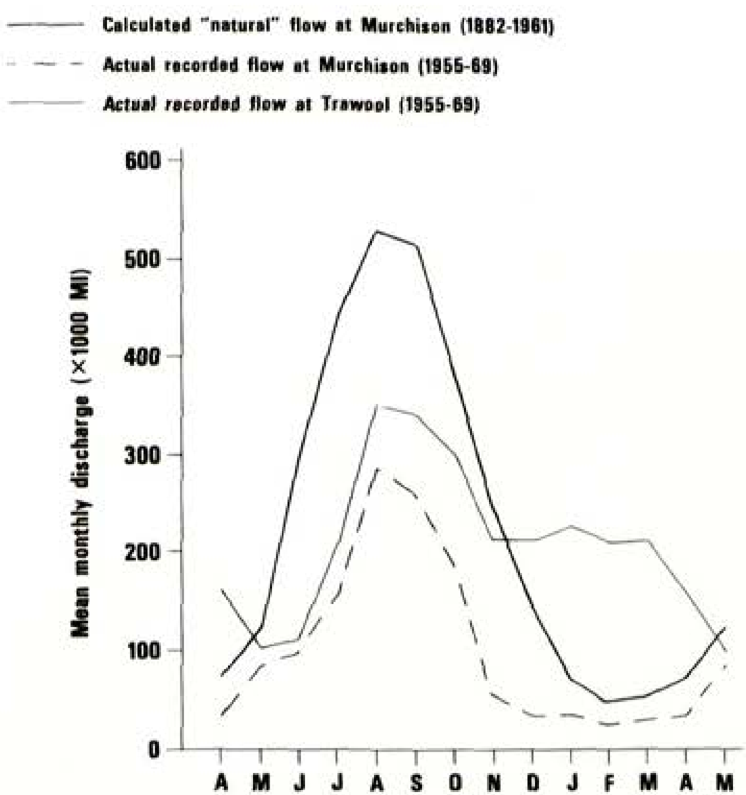
* in the study area + partly in the study area

see Table 8) has provided substantial quantities of water for irrigation purposes. As a result, large tracts of the land are now irrigated with water diverted from these storages via the natural drainage system and a number of artificially constructed channel networks (shown in Map 6).

Stream flows therefore do not reflect natural conditions but rather the impoundment of run-off in the catchments located above the storages and the high demand for irrigation water during the growing season.

Figure 2

GOULBURN RIVER FLOW PATTERNS



The effect of river regulation on the natural stream flow can be illustrated by using the Goulburn River as an example. Figure 2 illustrates the river's flow pattern since the completion of Eildon Reservoir. It depicts the mean flow at Trawool (above Goulburn Weir) and at Murchison (below the Weir). It also shows the calculated 'natural' flow at Murchison, which includes amounts diverted at Goulburn Weir to the eastern and western channels, and the volume and evaporation loss from both storages. As the graph shows, water stored in Eildon Reservoir (mainly in the period June--October) reduces flows downstream; it is released mainly in December--April, augmenting flows above Goulburn Weir. Diversion of water at Goulburn reduces flows below the Weir.

Table 9 lists average annual flows and salinity levels of the major rivers and a number of minor streams.

Minor streams

Local minor streams are usually tributaries or major anabranches of the main rivers. They are the Bullock, Barr, Mount Hope, Broken, Nine Mile, Boosey, Honeysuckle, Castle, Seven, Creighton, and Pranjip Creeks. These contribute an insignificant volume to the total surface water resource here, as most originate in areas with comparatively low annual rainfall and flow through areas with limited run-off. Consequently, total stream flows are low in volume and

Table 9

STREAM CHARACTERISTICS

Stream	Gauge location	Annual average discharge ('000 ML)			Salinity* (mg per L)		
		Max.	Min.	Mean	Max.	Min.	Median
Murray River	Tocumwal	22,416	653	6,064	60	29	34
Murray River	Torrumbarry	19,332	409	5,657	150	42	58
Ovens River	Wangaratta	3,768	159	1,117	73.8	23	36
Reedy Creek+	Wangaratta North	2,987	19	6,110	n.a.	n.a.	n.a.
Broken River	Caseys Weir	1,641	3	241	120	66	86
Broken Creek	Rices Weir	215	22	76	1,236	65	102
Goulburn River	McCoys Bridge	7,884	139	1,841	210	49	105
Campaspe River	Rochester	1,575	0.6	206	1,320	355	579
Gunbower Creek	Koondrook	397	10	102	840	48	66
Barr Creek	Capels Crossing	111	23	68	16,500	708	3,180
Loddon River	Kerang	754	28	201	1,242	97	216

+ Unregulated; supplements Ovens flow

* 1980/81 figures only

Source: State Rivers and Water Supply Commission

Table 10

WATER QUALITY LIMITS

Salinity (mg T.D.S. per L)	Uses
<500	Wide range of irrigation uses; suitable for all stock and domestic uses
500--1,500	Irrigation use may be restricted; suitable for all stock; domestic use depends on a low hardness content
1,500--3,000	Restricted use as irrigation water; suitable for all stock; not suitable for drinking and domestic use
3,000--14,000	Not recommended as irrigation water; various limits for different livestock - poultry at 3,500, horses at 6,000, adult sheep at 14,000
>14,000	Unsuitable for livestock

highly variable. Their presence is noticeable in times of flood, when they frequently cause damage to property and hardship to people.

Water quality

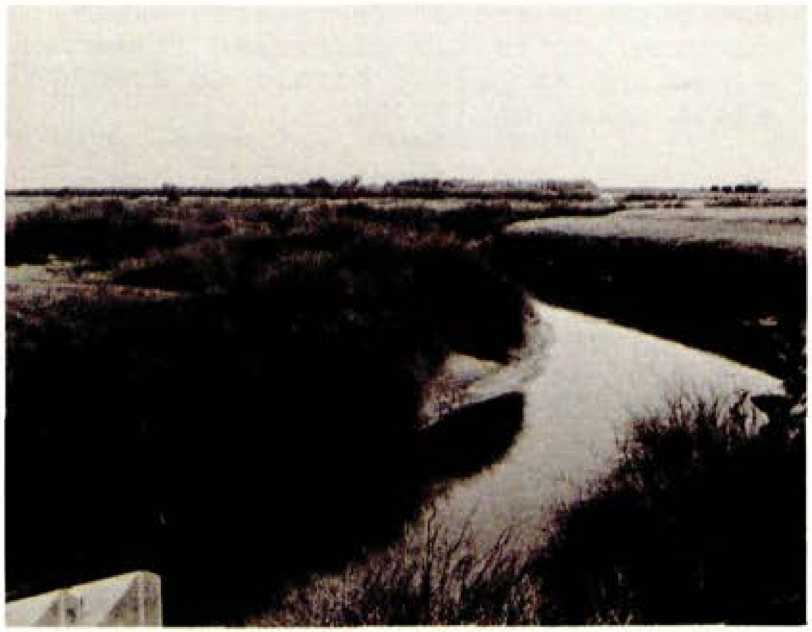
Quality of water is an essential criterion when deciding its suitability for various uses or as an environment for aquatic life.

Suitability for domestic, stock, irrigation, and industrial uses is affected by such factors as hardness, turbidity, colour, organic content, and concentration of total dissolved solids (T.D.S.). The T.D.S. content, or salinity, is the most convenient single parameter of water quality for practical purposes. Table 10 illustrates how rising T.D.S. levels limit the uses to which water can be put.

When streams are in flood, salinities fall because of dilution. When stream flow is low, evaporation tends to increase the concentration of salt.

Water in the major streams generally has low salinity and is therefore suitable for most purposes. By contrast, Barr Creek, which receives irrigation drainage from Kerang district, is frequently highly saline and is therefore unsuitable for a number of uses unless diluted with water of lower salinity (see Table 9).

The hardness of water refers to amounts of calcium carbonate and magnesium carbonate present. As the amounts increase so does the hardness. If they exceed 150 mg per L in water used for domestic purposes, a water softener is needed.



The Barr Creek, which receives irrigation drainage water, is highly saline

Groundwater

Most of the water in any region occurs below the surface as groundwater. Groundwater is held in, and flows through, bodies of permeable rock known as aquifers. Groundwater quality can range from 100 to 20,000 mg T.D.S. per L; bores in the study area can yield up to 60 litres per second.

Two types of aquifer occur here: porous formations such as sand; and fractured non-porous rocks. Aquifers can occur at depths ranging from a few metres to hundreds of metres below the surface, and the groundwater resources they contain are recharged by infiltration of rainfall, river water, and irrigation water.

Occurrence

Groundwater occurrence in the region is closely related to its geology. This area lies in the south-eastern corner of the Murray Basin - a shallow sedimentary basin filled mainly with unconsolidated alluvial sediments.

Older basment rocks (bedrock) surround and underlie the Murray Basin and may be locally important aquifers. The bedrock types include sandstone, mudstone, granite, and volcanic and metamorphic rocks.

Table 11 lists the groundwater characteristics of these two groups of aquifers, and Map 7 shows their locations.

Table 11

GROUNDWATER CHARACTERISTICS

Aquifer	Depth (m)	Salinity (mg per L)	Yield (L per sec.)	Location
Unconsolidated rocks, shallow aquifers				
Coonambidgal Formation				
Alluvial deposits	5--15	< 2,000	< 20	Adjacent to rivers and some creeks
Source-bordering dunes	< 5	< 2,000	< 1	Dotted over the area
Hill wash	aquifers scarce	2,000--5,000	< 1	Bordering mudstone and sandstone outcrops
Shepparton Formation	3--20 May be scarce in some areas	variable 100--20,000	variable < 50	Major unconsolidated formation covering most of region
Parilla Sand	5--30	> 15,000	< 10	Some surface outcrops near Boort; mainly subsurface
Unconsolidated rocks, deep aquifer				
Calivil Formation and Renmark Group	60--120	variable 400--6,000	20--60	Subsurface; infilled valleys, present rivers
Consolidated rocks: includes granite, meta sediment, sediment, and volcanic rock	10--60	variable 100--5,000	1	Highland areas and outcrops on riverine plains

Murray Basin sediments

The Murray Basin sediments comprise several formations, each having its own groundwater characteristics. The hydrogeological map (7) shows these unconsolidated sediments in two main parts.

The first is a series of shallow aquifers within the Shepparton Formation, Coonambidgal Formation, and Parilla Sand; the other consists of a deep aquifer within the Renmark Group and Calivil Formation sediments. These are described below from deepest to shallowest.

Renmark Group and Calivil Formation

The deep aquifer is a sheet deposit consisting largely of sand and gravel interspersed with lenticular non-permeable zones of ligneous clay and brown coal in the Renmark Group and Kaolinitic clay in the Calivil Formation. It ranges in depth from 60 to 120 metres, with a thickness of between 10 and 100 m. The Loddon, Campaspe, Goulburn, and Ovens branches (=deep leads) of the aquifer generally flow from south to north. The deep aquifer near Cobram (known as the Murray branch) flows east to west.

Water quality in the aquifer varies, ranging from 400 mg up to 6,000 mg T.D.S. per L. Salinity tends to increase along the direction of flow, with the freshest water located at the southern end of the Loddon and Campaspe branches and in the Murray branch. Most of the Goulburn branch and the northern end of the Loddon branch have relatively poor-quality deep groundwater.

The highest groundwater yields in the Murray Valley area are obtained from the deep aquifer. Bores commonly pump between 20 and 60 L per second, but lower yields are more common on the margins. Mining records from the Chiltern goldfield indicate that up to 105 L of groundwater per second was continuously pumped from individual deep lead mines over a span of several years.

Parilla Sand

This is found in the far west of the Murray Valley area and has a salinity greater than 15,000 mg per L. Yields are unknown, but are probably less than 10 L per second.

Shepparton and Coonambidgal Formations

The Shepparton Formation overlies the deep aquifer and part of the Parilla Sand. It makes up most of the shallow aquifer system, together with the Parilla Sand and Coonambidgal Formation. The aquifer comprises sand lenses (channel deposits of prior streams) interbedded throughout the clay-rich Shepparton Formation. Their lateral and vertical extents, and consequently their groundwater yield, vary from region to region. Highest yields available from the Shepparton Formation in the Murray Valley Irrigation Area are usually around 50 L per second, north of Numurkah. Yields of up to 25 L per second are found in the Shepparton and Rochester areas. Water quality varies throughout, but the regional trend is an increase in salinity towards the west.

This Formation has a maximum thickness of 125 m near Nathalia, and it may contain up to five separate aquifers at a single location.

The Coonambidgal Formation represents both recent river deposits and source-bordering dunes. In a large number of areas these can provide the best-quality water. Yields are commonly low (10 L per second), but up to 20 L may be possible near the Ovens River.

Bedrock aquifers

These comprise the consolidated basement rocks of the region. Yields are typically low, usually less than 1 L per second, and salt content varies from a few hundred to several thousand mg per L. Salinity appears to be directly related to the rock type and its location. Aquifers can be located in unweathered sandstones and mudstones or in weathered granitic and volcanic rocks. Bore depths usually range between 10 and 60 m below the surface.

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9. SOILS

Soils are formed by the weathering of rocks or unconsolidated material near the earth's surface. Complex interactions between climate, parent material, topography, and living organisms - and the time span over which these have operated - all influence soil formation. Their relative importance varies from one site to another.

In order to discuss the soils of a large region, it is useful to have a broad classification system, free of unnecessary detail, that will include all the predominant soil types. Most soil classifications use easily recognized profile features that are often relevent to a number of land uses or are correlated with the more practical qualities of the land.

The Department of Agriculture has carried out a number of detailed soil surveys on the riverine plain in connection with irrigation land use. These surveys extend from Kerang and Boort in the west to Shepparton in the central portion of the study area, and have been used extensively as references in this chapter to describe the predominant soil types. No comprehensive soil maps are available for the main forest areas or the eastern portion. Throughout this chapter the general occurrence of each soil type is related to the appropriate land system(s) and indicated in the text by the land system symbol, RP4, LL, etc. (see Chapter 12 and Map 9).

This report uses the soil classification according to Northcote (1979), which relies mainly on the morphology of a soil profile. On this basis, three primary profile forms can be recognized:

* uniform soils: profiles exhibiting little, if any, texture changes

* gradational soils: profiles exhibiting no sharp changes in texture, but gradually becoming more clayey with depth

* duplex soils: profiles exhibiting a marked texture change between the A and B horizons, the subsoil being much more clayey than the topsoil

Additional features such as colour, consistence, structure, and the presence of impeding horizons are also considered in the classification (see Table 12).

Table 12

MAIN SOIL GROUPS OF THE MURRAY VALLEY AREA

Primary profile form	Soil type	Parent material	Land system
I. Uniform-textured soils	Fine sands	Quaternary lunette deposits	LL
	Fine sands	Quaternary alluvium	RP4
	Coarse sandy loams	Devonian granite	HG, PG
	Stony loams	Cambrian rocks	HC
	Stony loams	Palaeozoic sediments	HS
	Calcareous clays	Cambrian rocks	HC
	Calcareous clays	Quaternary alluvium	FP1, RP1,3,5,6,7,8
	Sodic calcareous clays	Quaternary lunette deposits	LL
II. Gradational soils	Sandy red gradational soils	Quaternary alluvium	RP4,5
	Stony red gradational soils	Cambrian rocks	HC
	" " " "	Palaeozoic sediments	HS
	" " " "	Tertiary sands	MLH
	Silty gradational soils	Quaternary alluvium	FP2
III. Duplex soils	Red duplex soils	Devonian granite	HG, PG
	Red duplex soils	Granitic colluvium	SC
	Red duplex with ironstone gravel	Tertiary sands	MLH
	Yellow duplex with hardpan	Devonian granite	HG
	" " " "	Granitic colluvium	SC
	Red sodic duplex soils	Palaeozoic sediments	HS
	" " " "	Quaternary alluvium	RP2,3,5
	Yellow sodic duplex soils	Palaeozoic sediments	HS
	" " " "	Quaternary alluvium	RP2,3,4,5,7
	" " " "	Quaternary alluvium and calcareous dust	MP
	Brown sodic duplex soils	Quaternary alluvium	RP4,6
	Red calcareous sodic duplex soils	Quaternary alluvium and calcareous dust	MP

Note: For explanation of land system symbols, see Chapter 12 and Map 9.

Land use

Because land use is intimately associated with soils, the attributes and limitations of the soils in the study area will be discussed in this chapter.

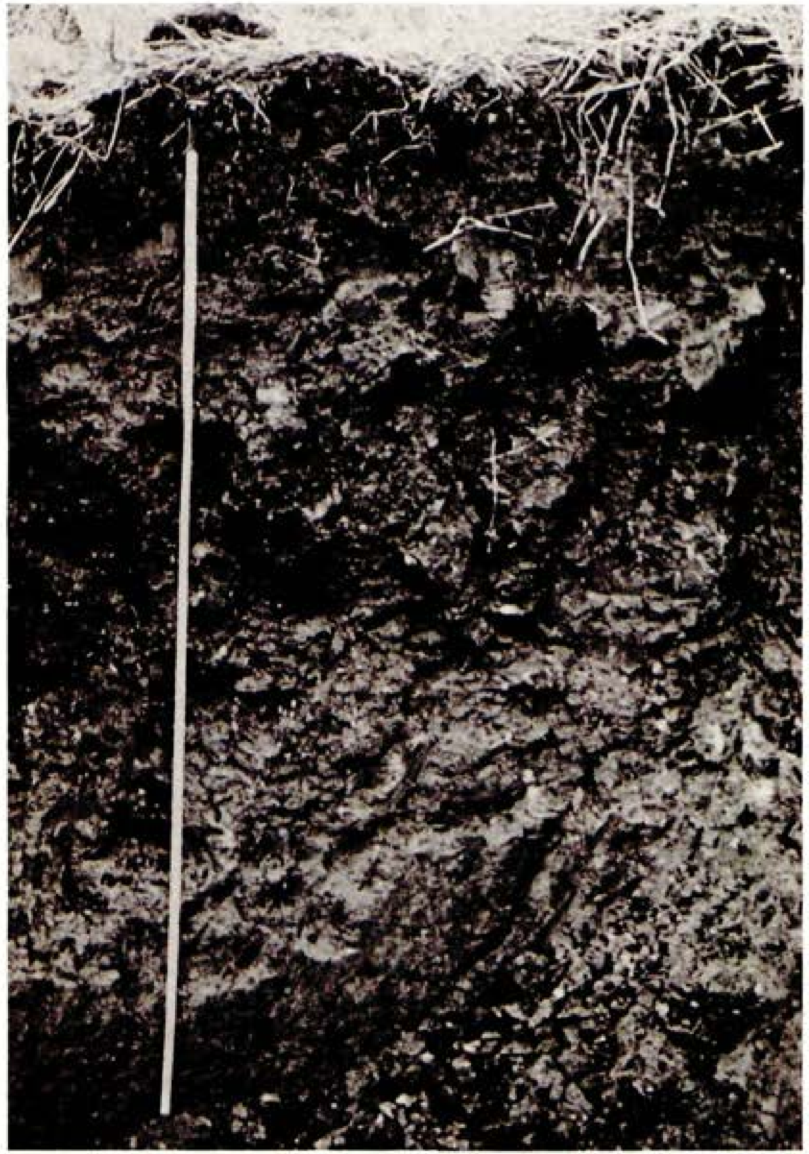
Uniform-textured Soils

Fine-grained uniform sands occur in localized areas of the north and north-east sectors (RP4 and LL). They are associated with sandy lunettes and wind-blown sand dunes derived from stream beds or prior stream levee banks. Colour ranges from a pale grey to a reddish brown, and porosity is high.

On crests and upper slopes of granitic areas such as the Terrick Terrick Range (HG) and the Warby Range (PG), coarse sandy loam soils are common. These have variable depth, but are so well drained that erosion resulting from overland flow is negligible. Their low water-holding capacity does, however, cause serious problems in times of drought.

Shallow stony loam soils are confined to the hill crests composed of Cambrian rocks (HC) and the younger Palaeozoic sediments (HS). The extreme drought-prone nature of these soils restricts land use to annual pastures, unless re-afforestation or deep-rooted perennial pasture is established.

Dark grey to black calcareous clays have been derived from the Cambrian rocks at



A dark, uniform calcareous cracking clay soil, common in the poorer-drained areas of the riverine plain (RP6, 7, and 8)

Dookie (HC). They have a self-mulching topsoil that allows a fine seedbed to be prepared for cropping, although grazing is an equally important land use on these soils.

Grey to grey-brown calcareous sodic clays have developed on the clayey alluvium that predominates on this portion of the riverine plain (RP6, 7, and 8). They occur in the Euroa, Numurkah, Lockington, and Kerang districts. The main variables in this soil type are the amount of colour in the topsoil, the depth at which maximum concentrations of carbonate, gypsum, and salt occur, and the degree of gilgai micro-relief present.

Mottled grey and reddish brown calcareous sodic clays are closely associated soil types in the lake--lunette areas (LL) described in Chapter 12, Land Systems. The mottled grey form occurs on the lake floor where the soils are permanently wet or inundated with saline water. The reddish brown form is found on the lunette ridges bordering the eastern edges of the lakes. These soils are well drained and are successfully cropped, but cover only a small total area.

Gradational Soils

Sandy red gradational soils are of minor extent because of their limited occurrence; however, they are intensively used for crops and improved pastures in irrigation areas, because their profiles are well drained and they have other desirable physical and chemical properties.

They occur with - and often grade into - the red sandy duplex soils typical of the levees in the 'prior stream landscape' (RP4, RP5).

The prior stream levees are slightly elevated above the rest of the plain and are often used for crops or pasture species that require well-drained soils. Unfortunately, however, because of their elevation they are also used as sites for channels. Large quantities of irrigation water are lost through seepage from channels located on these soils, thereby aggravating the problem of rising water tables in the area.

Stony red gradational soils are common on the upper slopes developed on Cambrian rocks (HC) and younger Palaeozoic sediments (HS). The ridge crests usually have a stony loam overlying the shallow bedrock, but soil depth and the proportion of clay both increase further downslope. Rock fragments within the A horizon of the profile represent a lag deposit. An initial low infiltration rate of water into the dry stony topsoil indicates an erosion hazard if vegetative ground cover is removed.

In the west of the study area, such soils are common wherethe Parilla Sand parent material is close to the surface (MLH).

A shallow, stony gradational soil, commonly found on the upper slopes and crests of the Palaeozoic sedimentary areas (HS)

On the ridge crests and upper slopes of landscapes derived from Palaeozoic sediments, the soils have shallow and very stony topsoils. Land use is restricted to sparse native pastures or regeneration of the native scrub vegetation. The stony topsoil has a low infiltration rate during rainfall periods and run-off flows attain their peak in a relatively short time, thereby increasing erosion and depositional problems further downstream.

Silty gradational soils occur on the present flood plains of the Murray, Campaspe, Goulburn, and Ovens Rivers (FP2). The silty topsoil is structureless and, when dry, forms an extremely hard layer that plants find difficult to penetrate. Consequently, ground cover is sparse; because of seasonal flooding, however, river red gums thrive there.

Duplex Soils

Red duplex soils occur on the lower slopes of the Warby Ranges (PG), in association with colluvial deposits (SC) and other granitic land forms such as Mount Terrick Terrick and Chesney Vale (HG). A deep coarse loamy sand topsoil overlies a coarse-structured red clay. The clayey subsoil has a much lower permeability than the topsoil, and lateral movement of water through the A2 horizon is common after prolonged rainfall. Cleared land is used for cropping and grazing, with the main land use hazard being sheet erosion.

In the low stony ridgelands south-west of Boort (MLH) red duplex soils are common. Ironstone gravel occurs throughout the profile and the topsoil consists of fine sandy loam that is particularly susceptible to wind erosion. Cropping predominates as the form of land use on these soils.

Yellow duplex soils with a pallid hardpan layer at approximately a metre below the surface have developed on some granitic parent materials (HG, SC).

The presence of a hardpan layer is a common feature of these gentle granite landscapes, with important consequences for land use. Apart from acting as a barrier to the downward percolation of water and deep root penetration by trees and some pasture species, the hardpan reduces the water-holding capacity of the clay horizon. The soils are therefore used mainly for pasture or may sometimes be extended to grow cereal crops for hay. On the other hand, the presence of the hardpan limits the process of downcutting in gully erosion.

Red sodic duplex soils are most common on the middle and lower slopes of the Palaeozoic sedimentary areas (HS). They consist of loamy topsoils overlying red sodic clays. The predominant land use ic cropping. Sheet erosion is the most common form of land deterioration, but proper management can minimize it.

On the riverine plain (RP2, 3, and 5), red sodic duplex soils have formed on alluvial material and, although well drained, do have a subsoil of low permeability and large quantities of buckshot gravel in the A2 and B horizons. Normally these soils, except for those in RP3, lie within irrigated areas and are regarded as ideal for intensive land use. The very low permeability of the deep subsoil does, however, result in the development of perched water tables, with subsequent waterlogging if the land is over-irrigated.

Yellow sodic duplex soils occur in the drainage depressions developed on Palaeozoic bedrock (HS). Although the gradient of the land is not steep, the sodic, dispersible subsoils are prone to

A red sodic duplex soil with a bleached sandy topsoil over a red clay - a common soil on the mid to lower slopes of the Palaeozoic sedimentary areas (HS) and on well-drained parts of the riverine plain (RP2, 3 and 5)

salting and gully erosion. On the riverine plain (RP2, 3, 4, 5, and 7) and the mallee plains (MP) these soils are associated with poorly drained sites. The land is used mainly for grazing. The subsoils usually remain moist for long periods into the dry summer and under these conditions the clay becomes a sticky almost structureless mass. Once dry, however the soils exhibit a strong, coarse, blocky structure.

Brown sodic duplex soils occur on the slightly elevated portions in the riverine plain (particularly those areas marked RP4 and RP6).

Red calcareous sodic duplex soils only occur in the far west (MP). To the west of Boort, areas of Quarternary alluvium have been blanketed with calcareous dust and this has modified the original soil profile. The soils are well drained and well structured, and have adequate water-storage capacity. They can produce good crop yields in most years; however, the fine sandy topsoil is prone to wind erosion, if cultivated and left unprotected.

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10. VEGETATION

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

The major environmental factors that influence vegetation - described in previous chapters - show variation throughout the study area. This is reflected in the diverse nature of the plant communities, ranging from tall river red gum (*Eucalyptus camaldulensis*) forests to mallee scrub.

Most of the area's public land carries vegetation typical of the riverine plains. This consists mainly of river red gum communities on the flood plains, and box eucalypts on the plains in between: within the river red gum forest on flood-free zones - usually sandy hills - box eucalypt communities are to be found.

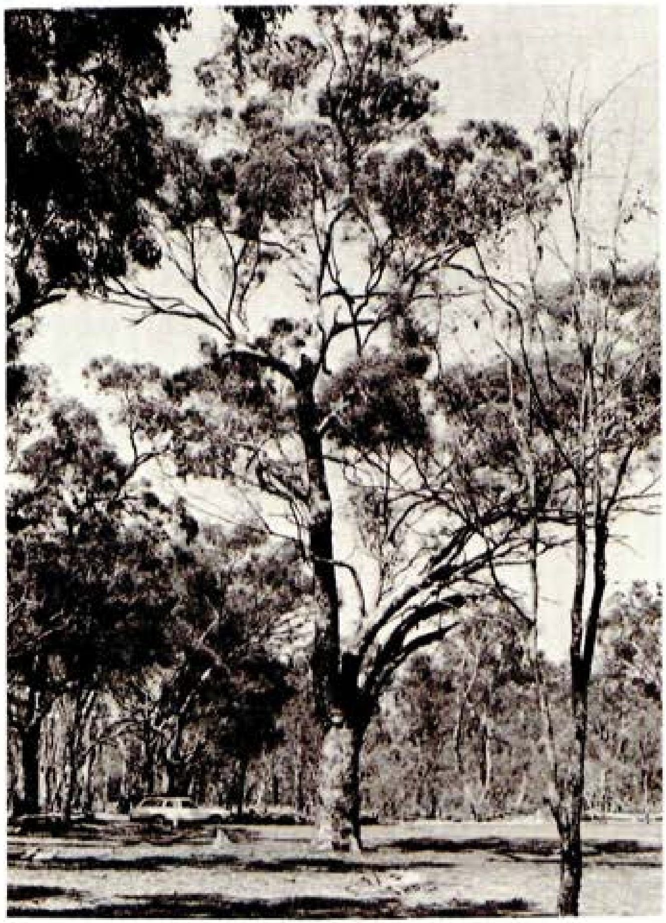
Remnant highland areas such as the Warby Range carry Blakely's red gum (*E. blakelyi*) with box, ironbark, and stringybark eucalypts. White cypress pine (*Callitris columellaris*) and box eucalypts grow on other highland remnants, such as Mount Terrick Terrick.

Prior to European settlement, most of the flood plains carried tall woodlands of river red gum, while the plains carried box and *Callitris* pine woodlands. Most of the latter areas have been cleared for agriculture.

Importance of Vegetation

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

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



Open forest III of river red gum with grey and yellow box

Classification

The vegetation has been classified into a number of structural forms, based on the height and form of the tallest stratum and on the percentage of projective foliage cover (see Table 13).

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

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

Map 8 shows the distribution of these vegetation units.

Vegetation Units

The main vegetation units are set out in Table 14 and briefly described below.

Open Forest III

Structural form open forest III contains one unit with river red gum and a special unit for river red gum regeneration.

10. VEGETATION

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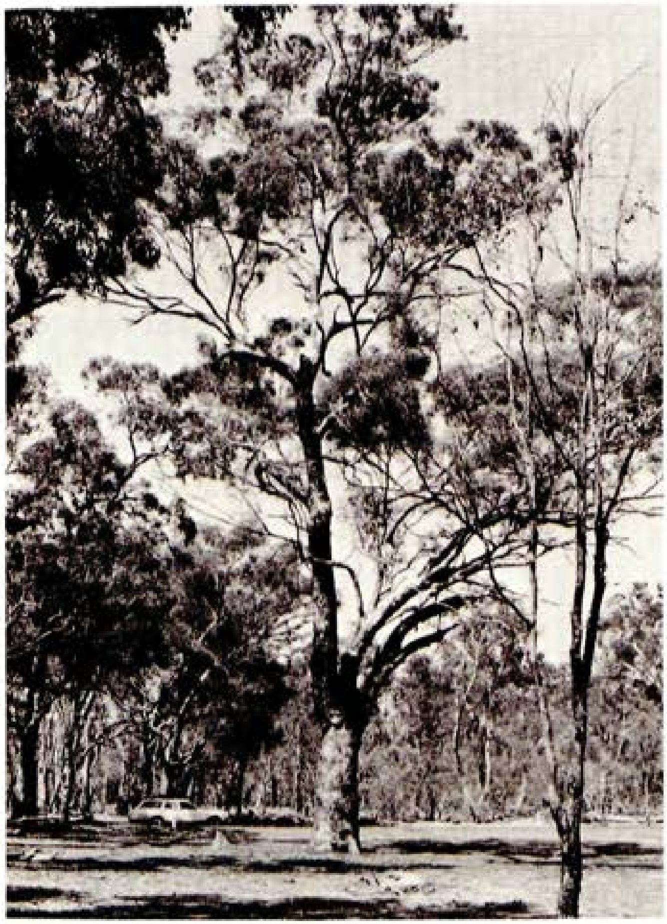

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Table 13

STRUCTURAL FORMATIONS
Modified from Specht (1972)

Life form and height of tallest stratum*		Projective foliage cover of tallest stratum			
		Dense (70--100%)	Mid dense (30--70%)	Sparse (10--30%)	Very sparse (<10%)
**Trees	28--40 m		Open forest III	Woodland III	Open woodland
	15--28 m		Open forest II	Woodland II	
	5--15 m		Open forest I	Woodland I	
**Shrubs	2--8 m	Closed scrub	Open scrub	Tall shrub-land	Tall open shrubland
	0--2 m	Closed heath	Open heath	Low shrub-land	Low open shrubland
Herbs (including grasses)		Closed herbland, including:	Herbland, including:		
		closed tussock grassland	tussock grassland		
		closed grassland	grassland		
		closed herbfield	herbfield		
		closed sedgeland	sedgeland		

* Isolated trees (emergents) may project from the canopy of some communities. Heights are of mature communities.

** A tree is defined as a woody plant more than 5 m tall, usually with a single stem. A shrub is a woody plant less than 8 m tall, frequently with many stems arising at or near the base.

Table 14 VEGETATION UNITS

Structural form	Map symbol	Major species of tallest stratum	Associated tree species	Common species of lower stratum
Open forest III (28--40m height)	1a	River red gum	Generally as pure stands, occasionally with yellow box, grey box	Warrego summer grass, terete-culm sedge, blown grass, moira grass, swamp wallaby grass, common spike rush, knotweeds, common sneeze weed, joy weed, couch grass, flat sedge, wallaby-grasses
	1b	River red gum regeneration on plains		As for Unit 1a
Open forest II (15--28m height)	2a	River red gum	Generally as pure stands, occasionally with yellow box, grey box, black box	Often as for Unit 1a; gold-dust wattle, spear grasses, common wheat grass, windmill grass
	2b	Blakely's red gum	Red stringybark, long-leaf box, red box, white cypress pine	Wallaby-grasses, daphne heath, kangaroo grass, silver wattle, cat's claw, raspwort, austral grass-tree, rock fern, drooping she-oak, black-anther flax-lily
	2c	Red ironbark	Grey box, red stringybark, red box	Wallaby-grasses, tussock grass, golden wattle, spreading wattle, varnish wattle, lightwood, daphne heath, peach heath, gorse bitter-pea, black-anther flax-lily
	2d	Red stringybark	Red box, long-leaf box, Blakely's red gum	Wallaby-grasses, daphne heath, wattles, austral grass-tree, guinea flowers, fringe-myrtle, raspwort
Open forest III -- woodland III (28--40m height)	3a	Yellow box	Grey box, river red gum, white cypress pine, buloke	Wallaby-grasses, blown grass, daisies, wire grass, gold-dust wattle, spear-grasses
	3b	Grey box	Yellow box, white box, river red gum	Wallaby-grasses, spear-grasses, berry saltbush, nodding saltbush, variable sida, bluebushes, blown grass, daisies, gold-dust wattle, tussock grass
Open forest II -- woodland II (15--28m height)	4a	Grey box	Yellow box, white box, river red gum, white cypress pine, buloke	Wallaby-grasses, spear-grasses, berry saltbush, variable sida, wire grasses, ruby saltbush, bluebushes, blown grass, various daisies, tussock grass, rushes, sedges, gold-dust wattle, kangaroo grass
	4b	Yellow box	Grey box, river red gum, white cypress pine, buloke	As for Unit 3a
	4c	Black box	River red gum	Wallaby-grasses, spear-grasses, umbrella grass, lignum, five-spined saltbush, saltwort, saltbushes, desert cassia, nardoo, blown grass, bluebushes, New Holland daisies
	4d	Yellow gum	Black box	Wallaby-grasses, spear-grasses, wattles, eutaxia, sticky sword sedge, Berrigan, kangaroo grass, cane wire-grass, black-anther flax-lily
	4e	Mixed box species: white box, long-leaf box, red box, yellow box	Blakely's red gum, red stringybark	Wallaby-grasses, tussock grass, wattles, herbs, daphne heath, groundsel, rock fern
	4f	White box	Grey box, yellow box, long-leaf box, red box, Blakely's red gum	Wallaby-grasses, spear-grasses, common oat-grass, New Holland daisies, variable sida, wattles, wingless bluebush, saltbushes
Open forest I -- woodland I (5--15m height)	5a	White cypress pine	Grey box, yellow box, Blakely's red gum, buloke, slender cypress pine	Wallaby-grasses, spear-grasses, common wheat-grass, wire-grasses, mat-rushes, wattles, saltbushes, variable sida, New Holland daisies, rock fern, guinea flower
Woodland I (5--15m height)	6a	River red gum	Black box	Wallaby-grasses, spear-grasses, umbrella grass, lignum, nodding saltbush, blown grass, rushes, tussock grass, Warrego summer-grass
	6b	Blakely's red gum	Red stringybark, long-leaf box, red box, white cypress pine	Wallaby-grasses, daphne heath, cat's claw, raspwort, wattles, guinea flowers, nodding blue-lily, austral grass tree, rock fern, drooping she-oak, mosses, lichens
	6c	Black box	River red gum	As for Unit 4c
Scrub — Mallee	7a	Dumosa mallee	Yellow gum	Wallaby-grasses, spear-grasses, ruby saltbush, black-anther flax-lily, variable sida, desert cassia, mat-rush
Scrub — Granite outcrop communities	7b	Wattle		Rock correa, wedge-leaf hopbush, nodding blue-lily, snowy mint bush, raspwort, rock fern, wallaby-grasses, spear-grasses, rock isotome

Structural form		Map symbol	Common species
Swamp and marsh communities	Open scrub	8a	Lignum, umbrella grass, blown grass, five-spined saltbush, wallaby-grasses, nardoo, desert cassia, spear-grasses, rushes, saltwort, scattered black box
	Open heath	8b	Saltbushes, glassworts, seablite, bluebushes, five-spined saltbush, saltwort, umbrella grass, spear-grasses, Dillon bush, sea barley-grass
	Tall closed grasslands	8c	Rushes and reeds: bullrushes, common reed, giant rush, spike-rush, clove-strip, milfoils, floating pond-weed, flat-sedge, water ribbons
Grasslands	Tussock grassland (dry grassland)	9a	Wallaby-grasses, spear-grasses, bromes, sea barley-grass, bluebushes, common oat-grass, blown grass, saltwort, five-spined saltbush, scattered eucalypts
	Low closed grassland (wet grassland)		Moira grass, water-couch, couch-grass, swamp wallaby-grass, lesser joyweed, starwort, knotweeds, swamp isotome, love-grasses; scattered eucalypts
	Volunteer grasslands	9b	Altered sites – introduced species: bromes, ryegrasses, barley-grasses, clovers, canary-grasses, weeds, scattered eucalypts

River red gum (Unit 1a)

This unit has a structure grading from open forest III to woodland III, depending on environmental and prior disturbance factors. It occurs on sites that either receive regular flooding or are believed to receive underground water via sandy aquifers. It generally has a graminoid understorey (grasses, rushes, or sedges). Dicotyledonous herbs may also be locally frequent. Woody shrubs are usually uncommon and localized around watercourses and on sandy ridges within the flood-plain forest.

The unit forms extensive stands on the flood plains of major rivers (Murray, Goulburn, and Ovens), with relatively minor occurrences along some of the creeks to the east, and often as mixed communities with box eucalypts (around Miepoll, Euroa, and Peechelba).

Its understorey floristics may form a mosaic of grassy communities with rushes and sedges. This complex may contain herb-rich depressions. Major understorey species include tussock grasses (*Poa* spp), rushes (*Juncus* spp.), couch grass (*Cynodon dactylon*), sedges (*Carex* spp.), spike-rush (*Eleocharis acuta*), wallaby-grasses (*Danthonia* spp.), warrego summer-grass (*Paspalidium jubiflorum*), and blown grass (*Agrostis avenacea*).

Common herb species include sneeze-weed (*Centipeda cunninghamii*), joy weed (*Alternanthera denticulata*), and various knot-weeds (*Polygonum* spp.). A range of other herbs (notably composites such as (*Gnaphalium*, *Senecio*, *Brachycome*, and *Craspedia* spp.) may also be present.

River red gum open forest III, Ulupna Island

Floodways may support grassland communities that include moira grass (*Pseudoraphis spinescens*) or swamp wallaby-grass (*Amphibromus neesii*). *Cynodon* spp., water-couch (*Paspalum paspalodes*), and the two aquatic species clove-strip (*Ludwigia* spp.) and milfoil (*Myriophyllum* spp.) may also be conspicuous in similar sites. Flat-sedges (*Cyperus* spp.) are often conspicuous near water.

Herbland--grassland in depression, with river red gum along the margin

Depressions may support low herblands of species such as starwort (*Stellaria caespitosa*), swamp isotome (*Isotoma fluviatilis*), swamp stonecrop (*Crassula helmsii*), burr daisy (*Calotis* spp.), and *Centipeda* and *Alternanthera* spp.

The most widespread of the shrub species is silver wattle (*Acacia dealbata*). River bottlebrush (*Callistemon paludosus*) may be present in the east of the study area - for example, along the Ovens River. Along the gravelly banks of the Goulburn River, other shrubs such as grey parrot pea (*Dillwynia cinerascens*) may be present. A sizeable, but localized, stand of *Melaleuca* sp. aff. *ericifolia* occurs along the Ovens River near Peechelba. *Exocarpos* spp. may be present in some areas.

River red gum regeneration (Unit 1b)

This unit comprises areas of former grassland ('treeless plains') now being colonized with river red gum. Presumably the vegetation type will develop into various open forest or woodland formations. Other vegetation components are generally graminoid or otherwise herbaceous. Alien species may predominate.

Such colonizing is scattered and often relatively localized. Major occurrences are in former grassland areas of the Barmah and Gunbower State Forests.

Understorey species resemble those of Unit 1a.

Open Forest II

Four units make up this structural form, each with one of the following major species in the tallest stratum: river red gum, Blakely's red gum, red ironbark (*E. sideroxylon*) and red stringybark (*E. macrorhyncha*).

River red gum (Unit 2a)

This unit varies in structure and physiognomy in a similar way to the river red gum open forest III (Unit 1a), but has reduced stature and occupies relatively lower-quality sites in terms of moisture availability.

It is usually distributed as a mosaic with Unit 1a in the main riverine forests, and along watercourses such as the Loddon, Campaspe, and Broken Rivers. It also occurs in association with swamps and lakes - such as those near Boort and in the Kanyapella Basin - and as narrow strips or pockets along many of the minor watercourses in the study area.

In general, its floristics also are very similar to those of Unit 1a. As it tends to occupy drier sites, however, understoreys may have a higher content of more drought-tolerant plants such as *Danthonia*, *Stipa*, and *Chloris* spp. and common wheat grass (*Agropyron scabrum*), and a reduced content of species with high water requirements (moira grass and other aquatic species).

Blakely's red gum (Unit 2b)

The tallest stands of this species occur on sites of more favourable moisture availability and soil characteristics, such as gullies and scarp bases.

They form a unit with understoreys similar in character to those of Unit 6b, but these may contain less drought-tolerant species such as herbs, tussock grasses, sedges, and silver wattle.

Red ironbark (Unit 2c)

This vegetation unit is characteristic of skeletal soils on certain outcrops of Palaeozoic sedimentary rocks, which tend to be well drained and often gravelly with quartz present. In the study area it occurs on poorer soils of the lower sedimentary hills in the east (in Killawarra Forest, with small areas near Thoona) and on deeper soils of the lower slopes. This unit intergrades with grey box (*E. microcarpa*) open forest II.

Understoreys here generally consist of a sparse ground layer of open grassy

Red ironbark forest, Killawarra

tussocks, typically with an open shrub layer of wattles. A range of other shrub species may be present, but these are generally minor components. Within the Killawarra Forest, the understorey primarily comprises species of wallaby-grasses and golden wattle (*Acacia pycnantha*), varnish wattle (*A. verniciflua*), and lightwood (*A. implexa*). Black-anther flax-lily (*Dianella revoluta*) may also be common. More skeletal soils may carry lichens, *Lissanthe* and *Pultenaea* spp.

Other species occurring with red ironbark include gorse bitter-pea (*Daviesia ulicifolia*), daphne heath (*Brachyloma daphnoides*), gold dust wattle (*Acacia acinacea*), hedge wattle (*A. armata*), cat's claws (*Grevillea alpina*), ruddy beard-heath (*Leucopogon rufus*), slender rice-flower (*Pimelea linifolia*), prickly parrot-pea (*Dillwynia juniperina*), and *Haeckeria* and *Exocarpos* spp.

Yellow box open forest III--woodland III near Cobram

Red stringybark (Unit 2d)

Generally mixed with red box (*E. polyanthemos*) and/or long-leaf box (*E. goniocalyx*), red stringybark largely occurs in association with Unit 6b in the Warby Range region and extends into the Killawarra Forest. Here grey box may also be present.

Understoreys of this Unit within the study area are similar to those of Unit 6b. Major understorey species include silvertop wallaby-grass (*Danthonia pallida*), daphne heath, austral grass-tree (*Xanthorrhoea australis*), *Hibbertia* spp, *Calytrix* spp, wattles, and herbs. Over its range, red stringybark is characteristic of the drier well-drained soils.

Open Forest III--Woodland III

This structural form contains two units, with yellow box (*E. melliodora*) and grey box, respectively, as the major species of the tallest stratum.

Yellow box (Unit 3a)

This represents the tallest of the yellow box stands. It has limited occ-

Open forest--woodland III - of grey box with yellow and white box, Mount Ochertyre

urrence, and may be associated with grey box and river red gum. In the north-east the study area contains relict stands with white cypress pine, particularly on the sandier soils. Understoreys have similar character to those of the yellow box open forest--woodland II formation (Unit 4b).

Grey box (Unit 3b)

Comprising the taller grey box stands, this unit grades into the open forest--woodland II (Unit 4a)

Its distribution is in the higher-rainfall zone in the east of the study area. It frequently occurs in mixture with yellow box and river red gum, particularly as belts along minor water-courses. Understoreys resemble those of Unit 4a, typically dominated by graminoids with various shrub species present (particularly gold-dust wattle).

Open Forest II--Woodland II

As their major species, the six units in this structural form respectively contain grey box, yellow box, black box (*E. largiflorens*), yellow gum (*E. leucoxylon*), a mixture of boxes (long-leaf, red, white, and yellow boxes), and white box (*E. albens*).

Grey Box (Unit 4a)

This generally occurs as small remnants of the originally extensive grey box plains vegetation type, and on the drier margins and the internal sand ridges of the riverine forests (Units 1a and 2a). Grey box communities are also present in various hilly areas near Earlston, Rutherglen, and Killawarra, and extend into the red ironbark open forest II, where it occurs on the deeper soils.

Stands of grey box may be pure or mixed with other box species, in particular yellow box, and may include river red gum. White cypress pine and buloke (*Casuarina luehmannii*) may also be presend, particularly in remnants of the plains vegetation types. Red stringybark and Blakely's red gum are restricted associates, mainly at Killawarra.

The grassy understoreys of this unit are typically dominated by wallaby-grasses, including velvet wallaby-grass (*Danthonia pilosa*), wallaby-grass (*D. linkii*), bristly wallaby-grass (*D. setacea*), wallaby-grass (*D. racemosa*), brown-back wallaby-grass (*D. duttoniana*), and common wallaby-grass (*D. caespitosa*), with variable spear-grass (*Stipa variabilis*) and fibrous spear-grass (*S. semibarbata*). Introduced grasses of the genera *Bromus*, *Hordeum*, *Lolium*, *Phalaris*, and *Cynodon* are often present.

Other indigenous grass species present include wire grasses (*Aristida* spp.), blown grass, common wheat-grass, kangaroo grass (*Themeda australis*),and *Poa* spp.

Major low under-shrubs include nodding saltbush (*Rhagodia nutans*), berry saltbush (*Atriplex semibaccata*), and variable sida (*sida corrugata*). Other chenopods - including saloop (*Rhagodia hastata*), bluebushes (*Maireana* spp.), and *Enchylaena* spp. - may also be present. Rushes and sedges, such as tall sedge (*Carex appressa*), may be common in low-lying areas.

Composites - for example, lemon beautyheads (*Calocephalus citreus*), drumsticks (*Craspedia globosa*), and *Vittadinia* spp. - are present in some remnants and golddust wattle is widespread. Other shrubs include golden wattle, mallee wattle (*A. montana*), *Eutaxia* and *Bursaria* spp., and *Cassinia arcuata*. Flax-lillies (*Dianella* spp.) and mat-rushes (*Lomandra* spp.) may also be present.

Yellow box (Unit 4b)

Although similar in physiognomy to the grey box Unit 4a, this unit occurs less frequently. The two species occur over a similar range, and apparently soil factors mainly determine their relative distributions. Yellow box may replace grey box in some hillier areas (Mount Major) and on sand ridges (near Cobram). White cypress pine may be conspicuous in the latter habitat. In general, associated tree species include those found with grey box.

Yellow box open forest II, Undera

Understorey also is similar, both in formation and floristically, to those of the grey box vegetation units.

Black box (Unit 4c)

Open forest--woodland II of black box occurs on the outer margins of the riverine forests (usually in the less frequently flooded sites) in the western section of the study area, and patches extend along the Murray as far east as Barmah. Sections of some of the other drainage systems (including lakes) also support this unit. Soil and climatic factors, as well as water relations, appear to regulate distribution.

Black box forest near Nathalia

Stands may be pure or include river red gum or yellow box. Understoreys are shrubby - for example, lignum (*Muehlenbeckia* spp.) - through to very open grassy with various saltbushes between the tussocks. Annual species, especially composites such as pale beauty-heads (*Calocephalus sonderi*), may be prevalent.

Dominant grasses of this unit include the wallaby-grasses and spear-grasses, and introduced species such as Mediterranean barley-grass (*Hordeum hystrix*). Other species include blown grass, rigid panic (*Panicum prolutum*), and tussock grasses, and rushes may also be present.

A wide range of chenopods, occurring particularly towards the north-west, may include saltbushes (*Rhagodia* spp. and *Atriplex* spp.) *Enchylaena* spp., and prickly saltwort (*Salsola kali*). Lignum and cassia (*Cassia* spp.) are the most frequent shrubs; a range of others - including *Exocarpos*, *Acacia*, and *Myoporum* spp., and weeping pittosporum (*Pittosporum phillyreoides*) - may be present but are often uncommon to rare.

Clover-fern (*Marsilea drummondii*) may be common in moister sites. Other ground-layer plants include New Holland daisies

Yellow gum, dumosa mallee, and casuarina, Boort

(*Vittadinia* spp.), germander (*Teucrium racemosum*), flat spurge (*Euphorbia drummondii*), quena (*Solanum esuriale*), and loose-strife (*Lythrum* spp.).

Yellow gum (Unit 4d)

Within the study area this unit is confined to disjunct and restricted occurrences in the far west (west of Boort) and the south-east (north of Longwood near Euroa).

In the west, associated species and neighbouring units include black box and mallee (*Eucalyptus dumosa*). In the east, grey box and yellow box are present. Buloke occurs as an associated species in both locations. The ground layer is typically open grassy, and may have a high content of xeric monocotyledons.

Mixed box (Unit 4e)

Mixed stands of long-leaf box, red box, white box, and yellow box comprise this vegetation type. Blakely's red gum and red stringybark may also be present. Red ironbark may be a localized component near the interface between the sedimentary and granitic rock types.

The unit occurs along some gullies and scarp bases of the Warby Range and to a lesser extent on similar sites in the nearby Chesney Hills.

Its understoreys have similar floristics to and intergrade with those of Unit 6b, but may be relatively less xeric. Species include silvertop wallaby-grass, tussock grasses, sedges, wattles, cat's claw, daphne heath, fringe-myrtle (*Calytrix tetragona*), *Cheilanthes* spp., and herbs (from genera such as *Senecio*, *Haloragis*, *Hydrocotyle*).

White box (Unit 4f)

Vegetation dominated by this species is infrequent and localized and may sometimes grade into open forest III--woodland III structural form. Within the study area, white box usually occurs in mixture with other eucalypts, notably grey box, and is restricted to the eastern portion. It often occurs in hilly areas, and may be a component of the mixed boxes (Unit 4e) found in the gullies and scarp bases of the Warby Range.

In general, its understoreys take a similar form to those of the grey box Unit 4a (grassy, with variable shrub content). White box favours fairly fertile soils on gentle slopes and plains, but may tend to occupy steeper dry slopes.

Major understorey species include wallaby-grass, bristly wallaby-grass, velvet wallaby-grass, spear-grasses, common wheat-grass, New Holland daisies, variable sida, nodding saltbush, wingless bluebush (*Maireana enchylaenoides* syn. *Kochia crassiloba*), gold-dust wattle, lightwood, mallee wattle, and golden wattle.

Open Forest I--Woodland I

Only one unit, with white cypress pine as the major species of the tallest stratum, represents this structural form.

White cypress pine (Unit 5a)

Formerly extensive across the plains of the study area, white cypress pine was usually associated with grey box or yellow box and buloke. The original structure was woodland, dominated by box where these species occurred together.

White cypress pine and grey box, Mount Terrick Terrick

The species also occurs on sand hills (often with yellow box), and extends into granitic terrain (such as the Warby Range and Terrick Terrick State Forest near Mitiamo).

The Terrick Terrick occurrence (with grey and yellow box) is the only extensive stand of the species remaining in the study area. This forest has been silviculturally treated to favour white cypress pine, and slender cypress pine (*C. preissii*) has also been recorded there. In the Warby Range and Chesney Hills, white cypress pine occurs with, and it is usually taller than, Blakely's red gum.

Understoreys range from virtually absent in granitic areas, through open grassy, with low semi-shrubs between tussocks, to heathy or scrubby. Floristics are basically as for grey box, yellow box, or Blakely's red gum, depending on the site.

Woodland I

Three units represent this structural form, with river red gum, Blakely's red gum, and black box respectively as the major species of the tallest stratum.

River red gum (Unit 6a)

Occupying the poorest sites for red gum growth, the unit intergrades with black box vegetation of similar stature. Understoreys are typically graminoid or shrubby (lignum) and floristically closer to the black box unit than the tall open riverine forests.

This unit is mostly associated with the braided portions of the Loddon River drainage system (sodic clays) in the far west of the study area.

Major understorey species include wallaby-grasses, spear-grasses, and blown grass. Tussock grasses and *Paspalidium* spp. are relatively restricted here. Chenopods (in particular, nodding saltbush) may be prevalent in the spaces between tussocks. Lignum (*Muehlenbeckia cunninghammii*) may be variously present. Rushes and nardoo (*Marsilea* spp.) may also be present in moister sites.

Blakely's red gum (Unit 6b)

This species (known locally as hill gum) generally occurs as a woodland I formation, but varies to an open forest II in more favourable sites or an open scrub in some exposed sites. It is characteristic of rocky hillsides and some lower sloped habitats, in soils that may become waterlogged during winter.

It may consist of pure stands or be mixed with species including long-leaf box, red box, red stringybark, and/or white cypress pine.

Understoreys vary from open heath through to tussock grassland. Taller shrubs (such as wattles and she-oak) may also be present. More ephemeral vegetation may occur on shallower soils. On extreme sites, the understorey may be almost non-existent.

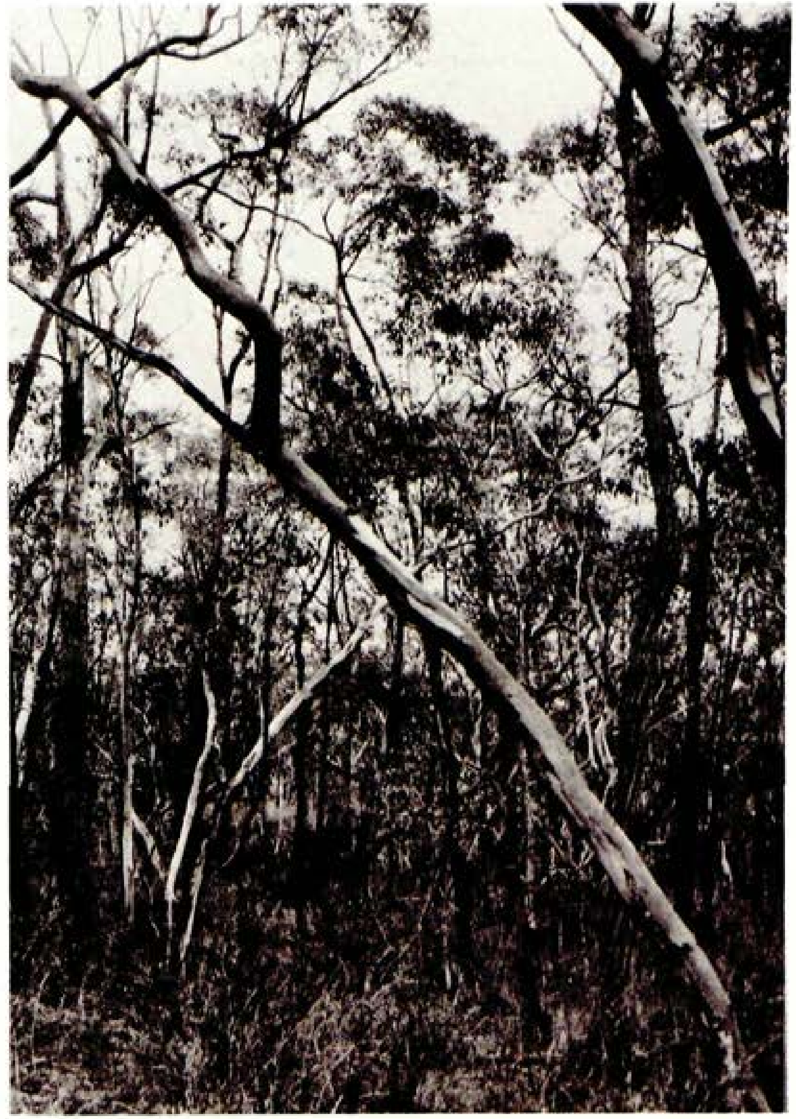
Grassy components of the understorey are generally dominated by wallaby-grasses - notably tussocks of silvertop wallaby-grass - but a wider range of species may be present. Where tussocks are well developed, shrubs may be a relatively minor component. On these sites, tall stands of grass-trees may be conspicuous (trunks of 3 m or more).

Heathy understoreys are widespread, and often dominated by daphne heath. Other major xeric species include cat's claws, guinea-flowers (*Hibbertia* spp.), nodding blue-lily (*Stypandra glauca*), fringe-myrtle (*Calytrix tetragona*), and *Xanthorrhoea* and *Acacia* spp. *Cheilanthes* spp. may be conspicuous in some rocky habitats.

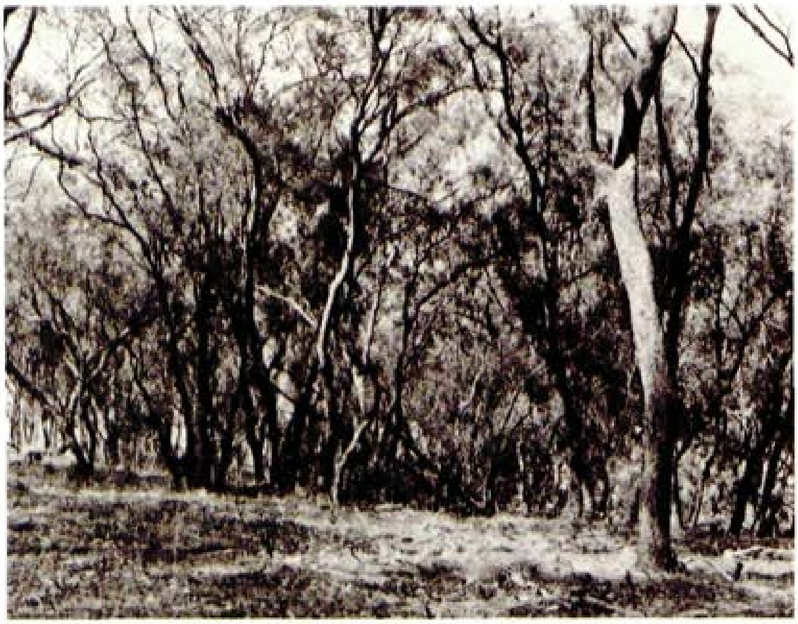
In the more sheltered sites, this unit occurs with a wider range of herbaceous species and tussock grass. Mosses, lichens, and annual species form the major understorey on shallow soils, and some orchids, lilies, and sundews are also common.

Black box (Unit 6c)

This unit occurs on damp flats and along inland intermittent streams, primarily towards the western edge of the study area. Stands are often pure, but may



Woodland of Blakely's red gum and red stringybark, with some Austral grass-tree present in the tussocky understorey - Warby Range



Green mallee with red box near Earlston

include river red gum in some intermediate sites (such as Kanyapella basin).

Understoreys have similar form and floristics to those of the open forest II--woodland II (Unit 4c). Relatively salt-tolerant understorey species often predominate, particularly in more open stands, and the unit may grade into lignum, saltbush, swamp, or grassland communities.

Scrub

In the two units comprising this structural form, the major species of the tallest stratum are dumosa mallee (*E. dumosa*) and species associated with granite outcrop communities.

Dumosa mallee (Unit 7a)

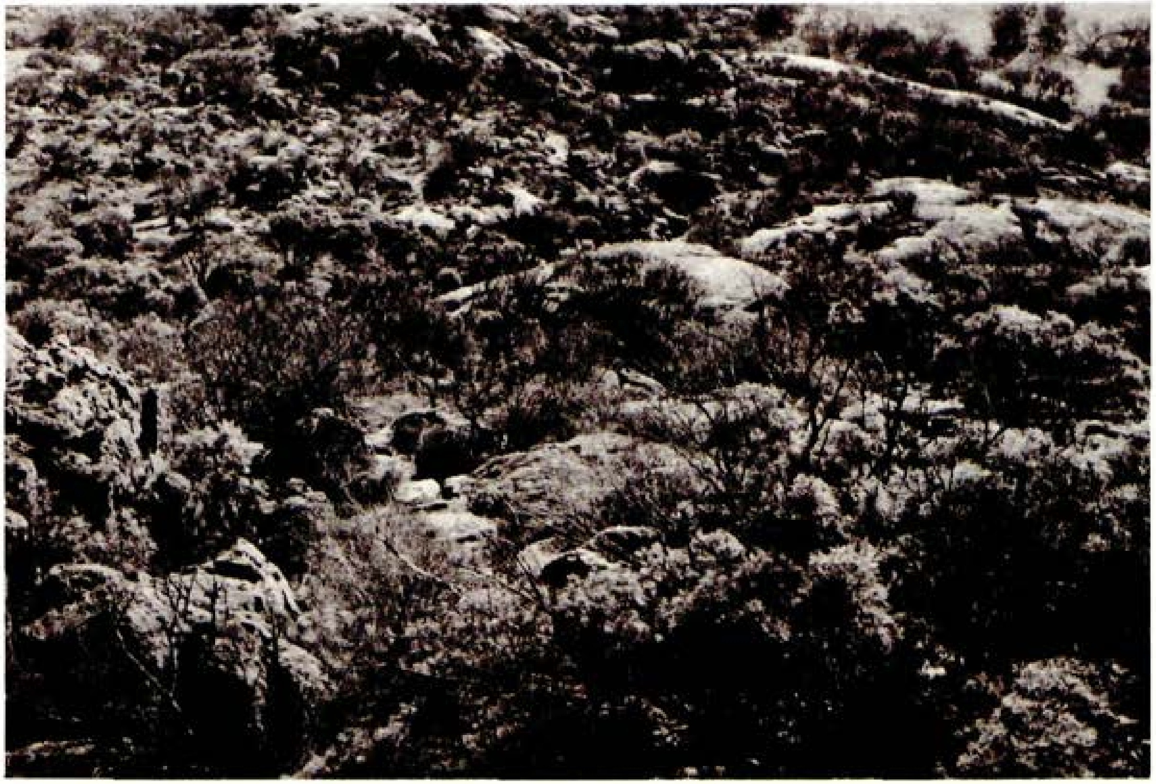
Within the study area, this vegetation type is confined to a few small pockets near Boort. These represent the eastern edge of the main mallee, the distribution of which is determined by climate and soil type.

Dumosa mallee pockets have a very open understorey, including spear-grasses, wallaby-grasses, flax-lilies, and mat-rushes (*Lomandra* spp.) and a range of scattered shrubs such as *Enchylaena*, *Maireana*, *Myoporum*, *Eremophila*, and *Cassia* spp.

Another mallee, green mallee (*E. viridis*), occurs in the study area and its distribution appears to be isolated and very restricted; it is found near Earlston in the south-east. The species occurs as very small patches among box eucalypts (red, white, and grey box) on the dry sedimentary ridges. The understorey consists of wallaby, tussock, and spear-grasses with sclerophyllous shrubs such as *Lissanthe* spp., gorse bitter-pea (*Daviesia ulicifolia*), grey everlasting (*Helichrysum obcordatum*), golden wattle, and gold-dust wattle.

Granite outcrop communities (Unit 7b)

This Unit is typically treeless, although it contains a few old trees of



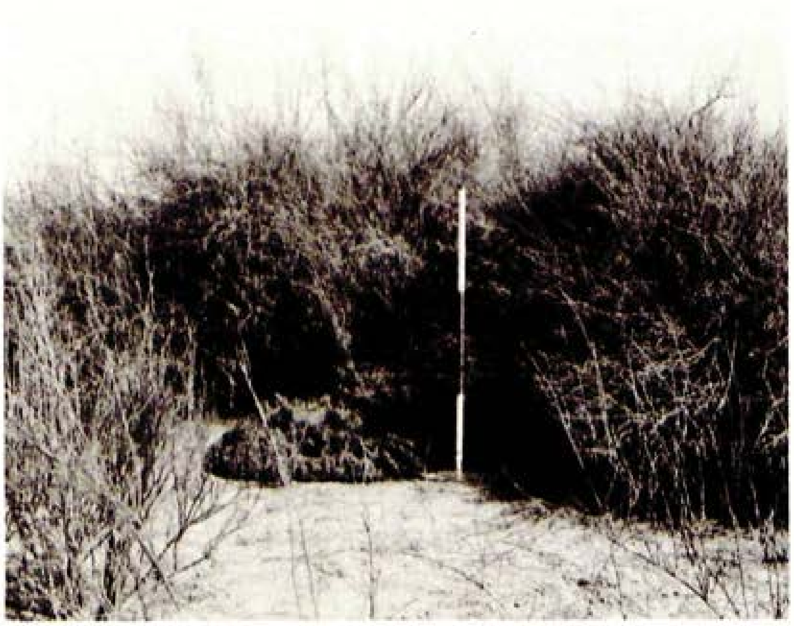
Granite outcrop community - Pyramid Hill

belah (*Casuarina cristata*) at Mount Hope. Vegetation varies from an open scrub of wattle (*Acacia deanei* spp. *paucijuga*) to open heath, and includes extensive areas of bare rock.

It is restricted to granitic outcrops in the west of the study area (Mount Hope, Pyramid Hill, and Terrick Terrick).

The major heath species of this unit are rock correa (*Correa glabra*), wedge-leaf hopbush (*Dodonaea cuneata*), nodding blue -lily, and (less frequently) snowy mint-bush (*Prostanthera nivea*). Wattle (with the mistletow *Amyema quandang*) is present where moisture and soil are sufficient.

Species typical of granite outcrops (for example, rock isotome and *Cheilanthes* spp.) frequently occupy suitable habitats in these communities. Other minor species include slender rice-flower, Australian hollyhock (*Lavatera plebeia*), Australian indigo (*Indigofera australis*), and small-leaf clematis (*Clematis microphylla*).



Lignum, Barr Creek

On deeper soils, particularly towards the base of the outcrops, wallaby-grasses, spear-grasses, and blown grass may become major species.

Swamp and Marsh Communities

These vegetation communities are represented by three units: the major species of the tallest stratum respectively are lignum, saltbush, and rushes and reeds.

Lignum (Unit 8a)

The effects of water regulation and raised saline water tables have altered the distribution of this genus, particularly in the west of the study area. Communities based on lignum (*Muehlenbeckia* spp.), with or without black box, were a feature of drainage channels and swamps of 'treeless' plains here at settlement. Current distribution of lignum, however, largely reflects land-use patterns.

It mainly occurs in the west, in depressions and drainage lines.

River red gum may also be occasionally present, but lignum swamps tend to be sparsely treed. Associated species reflect salt levels and land-use practices.

Other species may include wallaby-grasses, spear-grasses, blown grass, saltbushes, rushes, nardoo and cassia. In certain cases the introduced grass Mediterranean barley-grass may be the main component of the ground layer.

Saltbush (Unit 8b)

While salt-pans and halophytic vegetation were present here at settlement, the area of land affected by surface salt has increased greatly. Consequently, the current distribution and floristics of saltbush communities are largely related to land-use practices.

Diversity is often low, but some of the salt-pans surrounded by original vegetation may include species (not necessarily halophytic) that agriculture has largely displaced elsewhere. Structurally, the unit is an open heath.

Distribution is related to salt levels in the surface soils, and the unit occurs most extensively in the north-west of the study area.

Most of the species found here are from the families Chenopodiaceae (or sometimes Aizoaceae). Succulent chenopods include glassworts (*Arthrocnemum* spp.) and, less commonly, slender glasswort (*Pachycornia tenuis*), sea-blite (*Suaeda* sp.), and bluebushes (*Maireana* spp.). Other species that may be present include spear-grasses, saltwort, lignum, and galenia (*Galenia pubescens*) - the diversity and composition depending on the severity of salting.

In 'natural' communities, a range of species reach their easternmost limits in Victoria in the Kerang region.

Rushes and reeds (Unit 8c)

Structurally, this unit has a tall closed grassland formation. Its habitat is generally permanent shallow water.

Major species are typically bullrushes or cumbungi (*Typha* spp.) and/or common reed (*Phragmites* spp.). Along the Murray (for example, at Top Island, in the Barmah Forest, and Lake Moodemere) extensive beds of giant rush (*Juncus ingens*) occur. The height of these communities may approach several metres.

Juncus ingens, *Lake Moodemere*

In more open communities a range of aquatic and semi-aquatic plants - such as *Eleocharis*, *Ludwigia*, *Myriophyllum*, *Potamogeton*, *Ottelia*, *Azolla*, *Lemna*, *Triglochin*, and *Cyperus* spp. - and other *Juncus* spp. may occur.

Grasslands

These vegetation communities have been ordered into two units. The first, Unit 9a, is predominantly native grasslands, while the second, Unit 9b, is for altered sites - such as hall sites and cemeteries - and for areas that carry volunteer (largely introduced) grass lands.

Native grasses (Unit 9a)

This unit consists of two sub-units, dry grasslands and wet grasslands, which are not distinguished on Map 8.

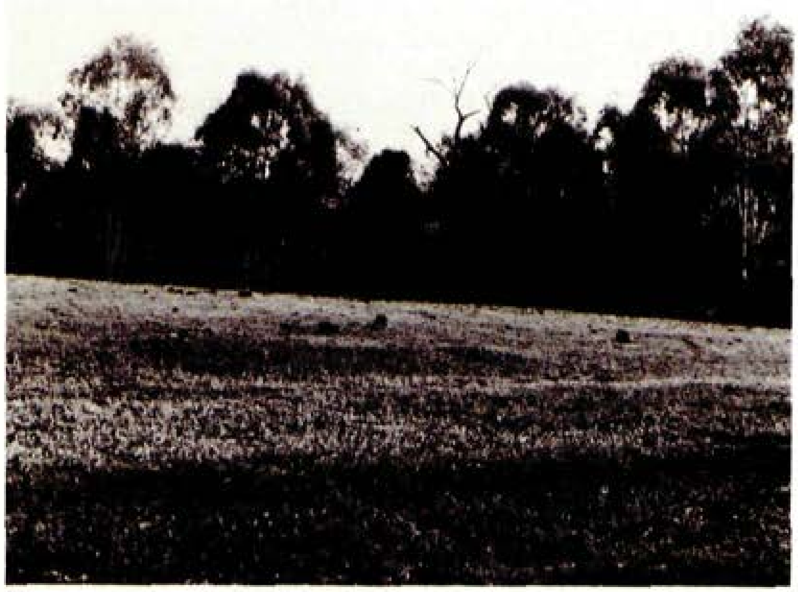
Dry grassland (tussock grassland)

At settlement a large proportion of the plains of the study area supported indigenous grasslands, either treeless or very lightly wooded. The vast bulk of this land was quickly alienated for agriculture, and these communities have virtually disappeared. Remnants that survive include some sand hills and treeless plain units within the major riverine forests and scattered strips along roadsides, but are very restricted and often greatly altered by grazing, rabbits, and weed invasion.

It is largely assumed that these grasslands were dominated by wallaby-grasses and spear-grasses, and in certain regions had low semi-shrubs and/or herbaceous dicots in the inter-tussock spaces. Other indigenous genera include *Agropyron*, *Agrostis*, *Lepidium*, *Sida*, and *Boerhavia* (tarvines), with various chenopods.

Wet grasslands

These communities comprise herblands, including low closed grassland; they are mainly riverine, and occupy the zone between Units 1a and 8c, where inundation prevents tree growth but is not so



Treeless sand hill carrying grassland, Bourkes Bend

consistent as to allow swamp development.

The floristics of wet grassland vary from domination by herbs to grass species and may vary with season. Major grasses include moira grass, water couch, *Cynodon* spp., and swamp wallaby-grass. *Eragrostis* spp. and sedges (*Carex* spp.) may also be present. Herbaceous genera include *Alternanthera*, *Polygonum*, *Centipeda*, and *Dysphania*.

Altered sites (Unit 9b)

Areas such as hall sites, quarries, football ovals, agricultural research stations, cemeteries, etc. have been altered, in some way, to such an extent that the vegetation is largely volunteer or introduced grasslands with scattered eucalypts.

Volunteer pastures

These grasslands have developed after clearing of forest or woodland. Wallaby-grasses and spear-grasses may persist, but generally grazing and agricultural practises have led to replacement by introduced pasture genera (for example, *Lolium, Bromus, Hordeum, Cynodon, Paspalum, Phalaris,* and *Trifolium*) and weeds. Rushes and non-palatable saltbushes may be present.

Many of the smaller blocks of public land support ground flora of this kind, sometimes with scattered remnants of the original tree cover.

In some places (such as the Warby Range, Killawarra Forest, and Kanyapella basin) regeneration of trees or shrubs (wattles) is occurring on previously cleared land.

Vegetation on New South Wales Public Land

Vegetation on the New South Wales Crown land that abuts the study area along the Murray River, which is mainly New South Wales State Forest, has similar patterns of structural form, major species, and floristics to the public lands on the Victorian side of the Murray.

Most of these Crown lands carry pure stands of river red gum. Other eucalypts occurring are grey box, yellow box, and black box. Small areas of white cypress pine are found on some of the sand hills located within the river red gum forest types.

Of the river red gum forests on these Crown lands, open forest II has the largest extent and this form is generally located on the intermediate levels of the flood plain. Open forest III occupies significant areas, and occurs on sites that are frequently flooded, such as river bends or swamps.

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11. FAUNA

The Murray Valley area contains a considerable diversity of faunal habitat. It represents a transition from the warm-temperate Bassian zone of the east to the drier Eyrean zone in the west, with the River Murray traversing the region and exerting a modifying influence by providing a moister environment.

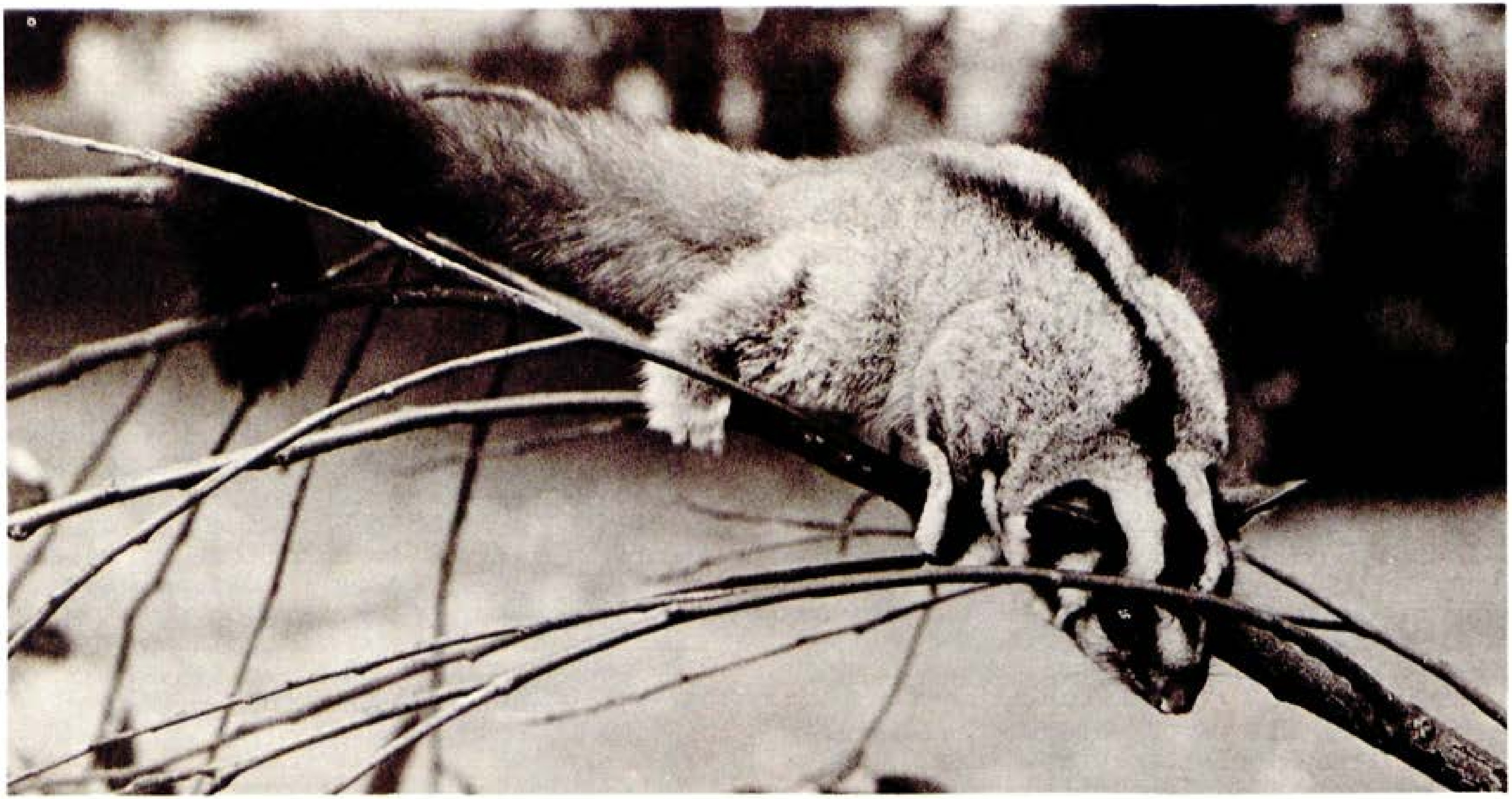
A total of 424 species have been recorded in the area, comprising 45 mammals, 328 birds, 39 reptiles, and 12 amphibians. A full list of species recorded can be found in Appendices 2--4. The fauna of the Murray Valley can be classified into four major categories.

* Those in the first category are adapted to the relatively hot, dry, and open Eyrean environments prevalent in the west. They include the fat-tailed dunnart, orange chat, budgerigar, a skink (*Morethia adelaidensis*), eastern spiny-tailed gecko, and the giant bullfrog. A number of the species are on the eastern limit of their distributions here, and are more common further west in the State.

* Those in the second are adapted to the more mesic, cooler habitats of the warm-temperate Bassian zone and its associated forests. Usually found in the east of the study area, they include swamp wallaby, long-nosed bandicoot, Eastern yellow robin, brown thornbill, speckled warbler, water skink, tree dragon, and the brown tree-frog. The Murray River environs provide a corridor for warm-temperate fauna through an environment that would otherwise be unsuitable for some species. An excellent example is the garden skink (*Lampropholis guichenoti*), which is extremely common in southern Victoria. It is present in the Murray Valley, but rarely ventures more than a kilometre from the river.

* The third category comprises widespread species, usually common throughout both the first two zones. It includes the common ringtail possum, eastern grey kangaroo, echidna, brown falcon, laughing kookaburra, Willie wagtail, marbled gecko, Bougainville's skink, and the froglet *Ranidella parinsignifera*.

* Other species appear specialized for life in the woodlands that form a transition between the two zones.



Sugar glider

They are often uncommon, and include the squirrel glider, grey-crowned babbler, turquoise parrot, and bush thick-knee.

Habitat

A total of 13 broad vegetation alliances can be recognized as faunal habitats and these approximate very closely the units discussed in the previous chapter. While Chapter 10 gives details of these vegetation types, Appendix 2 shows the distribution of faunal species within them.

The categories are based largely on overstorey species of plants, which often have characteristic understorey alliances. Understoreys may vary widely within a category, however, or overlap with other categories. As many faunal species depend on particular understorey characteristics, they may not be distributed uniformly within a habitat category. Moreover, species composition of the overstorey within a category may vary, further complicating faunal distributions.

River red gum community

This habitat includes river red gum in open forest III--woodland III, open forest II--woodland II, and woodland I structural forms, and in regeneration areas.

It supports the highest species diversity of any habitat in the study area. Most species requiring hollows are found here, including the squirrel, sugar, and feathertail gliders and the brush-tailed phascogale. It also supports a large number of feral mammal species, and 12 species of bats.

Among the 103 species of native birds recorded here, the hollow-using species such as parrots and nocturnal birds are well represented. The satin fly-catcher, bush thick-knee, and red-backed kingfisher have also been recorded.

Various components of the habitat support different species of reptiles. The carpet snake requires hollows in trees, while the marbled gecko and snake-eyed skink are found under the bark. Ground-dwelling species such as the garden skink utilize the leaf litter at the base of the trees.

Eight frog species, including Sloan's froglet, are found in the habitat.

Box communities (excluding black box)

Box eucalypts in open forest II--woodland II and open forest I--woodland I structural forms comprise this habitat. It supports a high percentage of the fauna species in the Murray Valley area. The squirrel glider and brush-tailed phascogale have been found at various localities here, and seven bat species.

The 94 species of native birds present include the peregrine falcon, painted button-quail, turquoise parrot, white-bellied cuckoo-shrike, and grey- crowned babbler.

The 14 reptiles recorded include the tree dragon, wood gecko, legless lizard, rainbow skink, and tree goanna. Five species of frogs have been recorded.

Black box (*E. largiflorens*)

Structural forms of the black box community are open forest II--woodland II and woodland I.

Fewer species occupy this habitat than the box communities. The fat-tailed dunnart has been recorded here, but is one of only seven species of native mammal recorded, four of which are bats, including the white-striped mastiff-bat.

The habitat also supports fewer bird species, although one significant bird, the bush thick-knee, occurs here, as do the variegated fairy-wren, inland thornbill, spiny cheeked honeyeater, and zebra finch.

It is important for several reptile species. The hooded scaly-foot is only known in this habitat in the study area,

Echidna are found in these red ironbark and Blakely's red gum forests

and in Victoria is restricted to similar areas with clay soils. A recent record of the curl snake was made in a remnant heavily salted black box woodland.

Red ironbark (*E. sideroxylon*)

Open forest II--woodland II of red ironbark supports a high proportion of the fauna species found in the area. Echidnas and swamp wallaby are common, and the squirrel glider and brush-tailed phascogale are also present. Of six species of bats, Gould's wattled bat is the most abundant.

A recording of the white-throated nightjar was made in this habitat, where the painted honeyeater has also been recorded exclusively. Another important species present is the turquoise parrot.

Only five species of reptiles have been found here, including the rainbow skink and sand goanna.

Blakely's red gum

Two structural forms - open forest II--woodland II and woodland I - comprise the Blakely's red gum community.

It has a high species diversity, with 16 species of native mammals. Arboreal species recorded include the feathertail glider, sugar glider, common brushtail possum, and common ringtail possum. Gould's wattled bat is the most abundant of the seven species of bats found.

Within the study area, the only records of the little button-quail and black-eared cuckoo have come from this habitat - and the rare turquoise parrot is more frequently recorded in this community than in any other. Barking owls and the white-bellied cuckoo-shrike also occur.

A most diverse reptile fauna, with 16 species, includes Dwyer's snake, Burton's snake-lizard and the uncommon wood gecko and rainbow skink. Four species of frogs are to be found, including the brown toadlet.

Mallee (*E. dumosa*)

This community occurs as scrub, found only in small patches on the sandy soils to the west of Boort, and occasionally supports yellow gum. Due to their extremely small size and isolation, these patches support very little fauna.

The common brushtail possum has been recorded here and 14 native birds, including white-browed woodswallow, crested pigeon, Willie wagtail, white-plumed honeyeater, and brown treecreeper.

Reptiles include the bearded dragon, marbled gecko, stumpy-tailed lizard, and tree goanna. Amphibians are represented by the two common froglets.

White cypress pine

This community occurs as open forest I--woodland I. It supports seven species of native mammals, which include the swamp wallaby in the eastern areas only. Eastern grey kangaroos and the common brushtail and ringtail possums are also present.

Southern whiteface, red-rumped parrot, peaceful dove, and galah are the most common bird species found, while the rarer Mallee ringneck and singing honeyeater have also been recorded.

Seven species of reptiles have been recorded, including the wood gecko, small-eyed skink, and black rock skink. Of the amphibians, the two common froglets have been recorded in this habitat.

Granite outcrop

A few small rock outcrops in the west of the study area carry a sparse vegetation of wattle and heath species. These are distinct from the outcrops of Blakely's red gum community found in the Warby Range.

These small highly disturbed areas, have no native mammals present, but the introduced house mouse, fox, and rabbit are common. They also support few bird species, except for birds of prey such as the whistling kite, Australian hobby, brown falcon, and Australian kestrel. They provide more favourable habitat for reptiles, with 12 species being recorded. An isolated colony of eastern spiny-tailed gecko found here extends the known Victorian range and habitat utilization of the species. Cunningham's skink has also been recorded, and the large striped skink and Bougainville's skink.

Grassland

This habitat includes the wet grasslands associated with river red gum forests, the natural dry grasslands widespread in the area (now mostly agricultural land, with a predominance of introduced species), and the volunteer grasslands resulting from clearing of woodlands (usually introduced species).

Some species, such as the echidna and eastern grey kangaroo, can utilize grassland near forested areas, and tiger quolls have been recorded previously in such country. Others can survive, given remnant trees to provide hollows: they include the common brushtail possum and at least four species of bats. The fat-tailed dunnart is one species that has adapted to grazing land and can be found in various localities throughout this habitat.

Many birds have adapted to life in the paddocks. Water birds such as herons, ibis, and spoonbills utilize the irrigated paddocks extensively to feed. Many waders can also be found here. Some species - such as stubble quail, banded lapwing, Australian pratincole, blue-winged parrot, barn owl, singing bush-lark and brown songlark - are found only in this category in the study area.

Some natural grassland reptiles, such as the legless lizard (*Delma inornata*), have suffered due to agriculture as they cannot tolerate grazing and soil compaction. Other species recorded in the grassland included the skink *Morethia adelaidensis*, stumpy-tailed lizard, and eastern blue-tongued lizard.

Six amphibian species may be found in grasslands associated with water, including Peron's tree-frog and the spotted grass frog.

Lignum community

Few recordings of native mammals have been made in this habitat, but it does contain the introduced house mouse, brown hare, and European rabbit.

Among the birds, the black-tailed native hen, purple swamphen, variegated fairy-wren, southern whiteface, white-fronted chat, and zebra finch are apparently attracted by the dense vegetative cover.

Nine reptiles have been recorded, including the tiger, red-bellied black, and eastern brown snakes. The two common froglets are also found.

Saltbush community

The native fat-tailed dunnart has been recorded in this habitat. Birds such as the orange chat, white-fronted chat, white-winged fairy-wren, and Richard's pipit have been recorded here.

Two uncommon reptile species have been found in this community. The skink *Morethia adelaidensis* is normally found in salted areas and is thus adapted to this habitat. The curl snake and the common and widespread Boulenger's skink have also been recorded.

Rushes and reeds - water bodies

These include fresh-water swamps and rivers, and often occur in association with river red gum and black box communities.

Aquatic mammals are the platypus and water-rat - found throughout the study area, with the water-rat more common - and the large-footed myotis - a bat that is restricted to areas containing permanent water.

Many species of water birds are found in the Murray Valley, some of which breed here, including the plumed whistling-duck. The buff-banded rail, Baillon's crake, spotless crake, and painted snipe have been recorded in swamps in the west. Clamorous reed-warbler, little grassbird, and golden-headed cisticola have been recorded in the reeds and rushes surrounding water bodies. Birds of prey associated with water bodies include the white-bellied sea-eagle, whistling kite, and marsh harrier.

All three Victorian tortoise species are found in the Murray Valley, including the uncommon broad-shelled river turtle.

Straw-necked ibis are commonly found in the Murray Valley area

The tiger snake feeds on frogs and so is often associated with water bodies. Eight species of frog have been recorded for this habitat: some require only an intermittent supply of water, while others - such as the barking frog - need permanent water.

Urban areas

Some native species have adapted to living in urban areas - for example, the common brushtail possum. The white-striped bat can be heard over most residential areas and the echidna has been recorded on the outskirts. The black rat and house mouse probably occupy most towns.

Black kites may be seen scavenging at tips. Other species have adapted to life in gardens, including the white-plumed honeyeater, grey skrike-thrush, and restless flycatcher. Introduced birds are common. Boulenger's skink may also be found in urban areas.

Changes in Faunal Distribution

The faunal composition of the Murray Valley area has altered markedly over the last two centuries - mainly due to land-use practices. Some species have disappeared totally, others are restricted to the remnant native vegetation, while a few have adapted to new land-use practices and indeed have flourished.

Loss of habitat, combined with the introduction of competitive herbivores (primarily rabbits and sheep) and predation by introduced carnivores (notably foxes), has had a dramatic effect on some of the mammals. The small macropods comprise one group that has been greatly affected, with at least three species - bridled nailtail wallaby, eastern hare-wallaby, and rufous bettong - now being extinct in the Murray Valley area.

Tiger snake

While most mammal species have been adversely affected by the clearing of native vegetation, a very small number may have benefited. The fat-tailed dunnart, an open-country species that can survive in farmland, may be more common now due to the clearing of the denser vegetation.

Some reptiles were dramatically affected by clearing and the introduction of grazing animals. The hooded scaly-foot and the curl snake inhabit cracking clay soils in the west of the Murray Valley. In Victoria these species are often associated with black box and lignum communities, which have been extensively cleared for agriculture, and both species have become extremely rare.

Bandy Bandy and blind snakes have also diminished, due to areas being converted to farmland. They were formerly widely distributed in the study area in eucalypt woodlands not subject to flooding, most of which are now cleared. Being fossorial (sub-ground dwelling), they cannot tolerate cultivation of the soil. Their specialized feeding needs also make them less adaptable to change: bandy bandy snakes feed only on blind snakes, which eat only ants and termites.

The larger areas of native vegetation remaining are subject to a number of different land-use practices. One such practice, timber-harvesting, removes some of the larger trees containing hollows. A number of species need hollows for shelter or breeding, and removal of large trees decreases the habitat available to these species.

The carpet snake is arboreal and also requires tree hollows. Once widespread in northern Victoria, it is now rare and restricted to rocky outcrops and forests along watercourses that contain trees with hollows. In addition to reduction in its habitat, collecting for the pet trade has had a marked effect on its numbers.

Most of the remnant native vegetation is grazed - mainly by cattle, but also by feral animals. This may remove the plants that provide essential cover and food resources for many native species of mammal, bird, and reptile. Birds such as white-browed scrub-wren, yellow robin, brown thornbill, and silvereye may be affected. (The first two in particular are rare in the Murray Valley.

Reptiles that may have been affected are the hooded scaly-foot, a skink (*Menetia greyi*), and a legless lizard (*Delma inornata*).

Victoria's wetlands have declined dramatically, and it has been estimated that alteration has made about half of the original wetlands unsuitable for some water birds. Loss of habitat has resulted from drainage, river regulation, water storage constructions, flood-protection works, and land reclamation.

Despite this, the Murray Valley area remains very important for nesting water birds even though its potential has been greatly reduced. Some swamps have been totally eliminated, and the condition of those remaining has been greatly altered. A number of factors may contribute to the degeneration of the wetlands, including inadequate supply of water, grazing, trampling and fouling by stock, contamination by effluents, and non-passive recreation.

Within forested areas, the duration, depth, and season of flooding can have marked effects on the breeding of water birds as well as on the ground vegetation that is important to their feeding and nesting requirements.

Water Birds

The Murray Valley includes some of the prime Victorian wetlands used by water birds. It provides habitat for grebes, pelicans, darters, cormorants, herons, egrets, night-herons, bitterns, ibis, spoonbills, ducks, rails, crakes, swamphens, snipe, numerous wading birds, gulls, and terns. Magpie geese once occurred in the area, but had disappeared by 1911, apart from very rare vagrants. They are now presumed extinct in Victoria.

Water birds have quite varied feeding, breeding, and shelter requirements, but many wetlands can provide habitat for a diversity of species. Birds such as cormorants, egrets, night-herons, ibis, and spoonbills breed in colonies. They nest in dead or live trees, rushes, cumbungi, or lignum, where these occur in or near water. Grebes and ducks build floating or anchored nests of waterweeds on the water surface. Birds such as rails and crakes nest in dense tussocks, sedges, or rushes.

Wetlands in the Murray Valley can be broadly divided into those of permanent and those of semi-permanent fresh water. Normally permanent water bodies include Johnson, Hird, Murphy (north-west of Echuca), Reedy (north of Shepparton), and Kow Swamps, Loch Garry, and Lakes Mokoan and Moodemere. They are particularly valuable to waterfowl if they are shallow, have dead timber, reed beds, or lignum in the water, and are fringed by river red gum and box trees above the water's edge.

Semi-permanent wetlands include Gunbower Island and Barmah State Forests, Tragowel, Morphetts, and Dowdle Swamps, many other minor swamps, and irrigated and flooded pastures. The flooded forests provide good breeding and feeding areas. Semi-permanent wetlands that lack timber or lignum are good feeding areas, especially as they dry out and the aquatic animals and plants become abundant in the warm, shallow waters.

The rarer water birds occurring in the Murray Valley include little bittern, glossy ibis, plumed whistling-duck, freckled duck, spotless crake, and painted snipe.

Fish

A number of fish species occur in the streams and water bodies of the study area. Fresh-water crayfish and yabbies are also found in a number of streams, mainly the Murray and Goulburn Rivers.

Most of the rivers and streams can be described as sluggish and snaggy, with either mud or sand bottoms; they usually contain deep pools. This type of habitat largely determines the type of fish species found here.

As it has in other animal groups, human interference has altered fish populations. Both the introduction of alien species and the construction of water storages - through alteration of both the flooding pattern and water temperature - have affected native populations. Murray cod and golden perch are two species known to have suffered adverse effects from these changes.

The main species of fish found in the area are Murray cod, trout cod, tench, goldfish, golden perch, brown trout, redfin, European carp, blackfish, silver perch, catfish, Macquarie perch, bony bream, and eels.

Introduced species include the most widespread and commonly caught species - for sport or for the table - such as

Murray cod, a native game species, may grow to 45 kg in weight

redfin (European perch), tench, European carp, and in some streams brown trout. The native sport or edible fish - Murray cod, golden perch, silver perch, blackfish, catfish, and bony bream - are usually found in the main rivers such as the Murray, Ovens, Goulburn, and Loddon.

Native game fish

Murray cod and trout cod usually spawn on mud substrates in river channels. Spawning generally occurs after flooding (usually from September to November). Both species are carnivorous, feeding on small fish such as tench, goldfish, and bony bream. They provide good angling and eating, but populations have decreased significantly in recent years - possibly as a result of the construction of dams, weirs, and locks on the Murray River.

Fresh-water catfish spawn in clear water from September to November, making a shallow depression in the substrate for egg-laying. Its food consists of invertebrates taken from the bottom of slowly flowing backwaters. Unfortunately this excellent table fish is becoming scarce.

Macquarie perch, an excellent sporting and table fish, has recently had its range drastically reduced and it is now very rare in the Murray River.

Golden perch spawns after floods, which usually occur during spring and summer. Its food consists mainly of crustaceans. It prefers warm, sluggish, muddy waters, and will disappear where dams release cooler water and upset the normal flooding pattern. The species has good sporting and eating qualities.

Yet another good sporting and eating fish, the silver perch, usually spawns after a rise in water level. Its omnivorous diet includes zooplankton, algae, and other forms of aquatic vegetation.

River blackfish, an insectivorous fish, is declining as streams and rivers are cleared of vegetation and snags. It too offers good sport and has excellent eating qualities.

Introduced game species

These species have the same value to man as the native species, but probably compete with them.

European perch (redfin) is a highly successful species whose food preferences often coincide with those of native fish. It feeds voraciously upon smaller fish, but provides good sport and has excellent eating qualities.

Brown trout, although not widespread in the area, has been reported in the Ovens River near Wangaratta. It is an excellent sporting and eating fish.

Tench, a sluggish fish preferring still, muddy backwaters, is omnivorous and scavenges along the bottom of its habitat. It is a good table fish, but is seldom sought-after.

Other introduced species

These have little value to man and are considered detrimental to populations of native species.

Goldfish and European carp are considered undesirable because of their habit of destroying vegetation and muddying the water during feeding. They are becoming abundant, and could result in deterioration of the sport fisheries in the area.

The mosquito fish is widely distributed throughout Australia, having been introduced to control mosquito larvae. It may offer substantial competition to native insectivorous species. It probably has limited value in controlling local mosquito populations, but has some food value for the larger fish.

Significant Species

Squirrel glider

The squirrel glider (*Petaurus norfolcensis*), a nocturnal, gliding, arboreal possum, depends on tree cavities for nest sites and daytime refuge retreats. The first recorded specimen in the area came from Arcadia in 1912, but the species was not recorded again until 1966, when a female was found at Boornooroo, north of Baddaginnie.

During the early 1980s various local naturalists and biologists from various government departments carried out field work to ascertain the squirrel glider's status in the area. Surveys conducted in the Boweya and Killawarra State Forests and in a patch of mature river red gum north-west of Echuca all detected the species.

A recent wildlife survey of the Murray Valley area by the Fisheries and Wildlife Division's Wildlife Survey Unit recorded 12 in nine new localities.

Special habitat requirements for this species are not known, but a number of the recorded sites reveal structural vegetation similarities. Squirrel gliders have been found in vegetation communities with an open-forest, woodland

The squirrel glider is considered to be Australia's rarest gliding possum and is well represented in the study area

formation, or remnants of these occurring as roadside verges or streamside strips.

Overstorey tree species for these communities are river red gum, grey box, yellow box, red ironbark, white box, red box, Blakely's red gum, long-leaf box, and red stringybark. These trees provide a major source of either nectar (for example, yellow box) or pollen (river red gum). Also, many of them blossom during winter, providing a possible food source for that part of the year when insect numbers are low.

Many roadside verges in the Murray Valley contain a high diversity of these species, usually as mature specimens that, if they formed part of a contiguous system, could offer potential habitat.

In the Murray Valley, the squirrel glider has been recorded in 16 localities, representing a major part of its Victorian distribution. In particular, the Goulburn River, areas east and north-east of Echuca, Killawarra, and the Warby Range are strongholds for this species in the State.

Hooded scaly-foot

This legless lizard, *Pygopus nigriceps*, is at the southern limit of its Victorian range here, and is known from only a few records. In Victoria it occurs on cracking clay soils associated with the Murray Valley, usually in black box or lignum communities. Clearing of these vegetation types has probably drastically reduced its populations.

Rainbow skink

The only member of the largely tropical *Carlia* genus in southern Australia, *C. tetradactyla*, is rare in Victoria and restricted to the dry open forests and woodlands of the north-east. It is also of considerable scientific interest, as it retains the tropical reproductive pattern of small, multiple clutches in a temperate environment.

It was first recorded in Victoria in the Warby Range, which is probably its major area of distribution in the State.

Carpet snake

The carpet snake (*Python spilotes variegata*) was once widespread in woodlands, along watercourses, and in rock outcrops of northern Victoria. It is a slow-moving, nocturnal species, specialized for hunting small animals and birds in trees and on the ground. During the day it shelters in tree hollows or rock crevices.

These attributes have made it particularly vulnerable to human interference, both by direct collecting for the pet trade and by destruction of habitat through land-use practices. It is now rare in Victoria, being confined to a few small, isolated populations.

Curl snake

The curl snake (*Suta suta*) is a small reptile that occurs on the cracking clay soils of the Murray Valley. It appears to have similar habitat requirements (in Victoria) to *Pygopus nigreceps*.

Bandy bandy

Once widespread in the box woodlands of northern and central Victoria, bandy bandy (*Vermicella annulata*) is now extremely rare in the State, with the last specimen found in the Murray Valley area in 1942. This small snake is an extremely specialized burrowing species, feeding entirely on blind snakes (*Typhlina* spp.). Blind snakes themselves have become rare in the area as a result of clearing for agriculture.

Both snakes probably do still persist in the area (all are difficult to locate due to their underground life styles), and are most likely to be found in areas of box woodland.

Giant bullfrog

Only three Victorian records of this inland species, *Limnodynastes interioris*, make it one of the State's rarest frogs. On the southern limit of its range in Victoria, the species could be more common in the Murray Valley than is thought (although the widespread occurrence of the closely related southern bullfrog in the area may restrict its distribution).

Plains wanderer

Formerly distributed widely over natural plains in south-eastern Australia, the plains wanderer (*Pedionomus torquatus*), is now considered 'endangered' throughout its range. The bird may be more common in the Riverina and northern Victoria than anywhere else, but most recent records have been north-west of the Murray Valley area.

Plains wanderers feed in short grassland and stubble, on insects and the seeds of native grasses and herbs, and sometimes on those of introduced species. They appear to have declined with the advent of more intensive forms of agriculture, but in areas where broad-acre grazing occurs on unimproved pastures - or where cereal-growing allows a diversity of grasses and herbs to develop between 3-yearly crops - the birds are better favoured.

Brolga

The brolga (*Grus rubicundus*) is widespread in northern and eastern Australia, but is uncommon and localized. Drainage of swamps, which provide important feeding and breeding habitats, and illegal shooting and poisoning have greatly reduced its numbers in southern Australia.

Brolga have been recorded in recent years at scattered wetland locations throughout the Murray Valley. Many of

The plains wanderer occurs in the area and is an endangered species

these wetlands are also breeding grounds for the bird, and therefore may be important in maintaining populations here.

Bush thick-knee

Although it occurs throughout Australia, the bush thick-knee (*Burhinus magnirostris*) is rare in southern Australia, where much of its favoured woodland habitat has been cleared. The species has been observed at a number of sites in the Murray Valley, mainly in river red gum or black box woodlands. It both feeds and nests on the ground, which makes it vulnerable to predation by foxes and feral cats.

Superb parrot

The superb parrot (*Polytelis swainsonii*) is common within a very restricted range

The brolga is an uncommon species in the Murray Valley

- from northernmost Victoria through central New South Wales. It formerly ranged south to central Victoria, but now only occurs near the Murray River.

While it feeds largely on the ground (on seeds of grasses and herbaceous plants), it will also take fruits, nectar, or blossoms from eucalypts such as yellow box, and from acacias. The species nests in hollow limbs of eucalypts, and the loss of mature eucalypt woodlands and illegal trapping for aviaries pose threats.

Turquoise parrot

Patchily distributed (from south-eastern Queensland through eastern New South Wales to north central Victoria) in this State the turquoise parrot (*Neophema pulchella*) is of 'restricted distribution' or rare, or both. While present in the Blakely's red gum open forest--woodlands of the Warby Range it is uncommon. It is also recorded, although less frequently, in box and red ironbark open forest.

The birds feed on or near the ground, their diet comprising seeds of grasses or herbaceous plants. They generally build their nests less than a metre above the ground in hollows of small trees, dead eucalypts, holes in stumps, fence posts, or even logs on the ground. Their apparent decline, from the turn of the century, may have resulted from illegal trapping, predation by feral cats, disease, and the loss of habitat to agriculture.

Grey-crowned babbler

The grey-crowned babbler (*Pomatostomus temporalis*) occurs in mainland eastern, northern, and western Australia. In Victoria, although occurring in all areas except the north-western mallee and Gippsland, it has suffered a dramatic decline in numbers, probably due to extensive clearing and grazing of woodland environments in the centre and south-west of the State. In the Murray Valley it is found in river red gum and mixed box woodlands.

Regent honeyeater

This nomadic species, *Xanthomyza phrygia*, apparently follows the flowering of eucalypts in the forests and woodlands of south-eastern Australia. It appears to have seriously declined in numbers throughout its former range, probably as a result of degradation of its preferred habitat. It has been recorded infrequently in the east of the study area in the past 20 years, being associated in this region with flowering red ironbark and box species.

Notable Species

Tiger quoll

In Victoria, the tiger quoll (*Dasyurus maculatus*) has 'rare' status. Its range has been reduced by approximately one-half during the last 140 years, and is now thought to cover some 30% of the State. Records are concentrated in only three small areas, however: in the Otways, around Portland, and near the headwaters of the Murray River.

Records of sightings in the Murray Valley area mark the north-westernmost limit in Victoria of both the present and past distributions (the extreme case being a report of tiger quolls in Gunbower Island Forest late last century).

Both native quolls and tiger quolls occurred in this forest, and were regarded as pests due to their predation on poultry. It is not known when this species died out in the area, but the native quoll was very scarce in Gunbower Forest by the turn of the century.

Feathertail glider

A substantial proportion of the records of feathertail glider (*Acrobates pygmaeus*) in inland central Victoria come from the Murray Valley area. As far as is known, the record made in Gunbower Island Forest represents its north-westernmost limit in Victoria.

Sugar glider

Currently the sugar glider (*Petaurus breviceps*) is recorded in only eight localities altogether in the Murray Valley, five of which adjoin the northern boundary.

Brush-tailed phascogale

The Victorian range of the brush-tailed phascogale or tuan (*Phascogale tapoatafa*) appears to have diminished during the past few decades.

The marsupial occurs throughout the Murray Valley, with records being concentrated along the Goulburn River, in Barmah Forest, and in the Warby Range. In this area they have been recorded mostly in river red gum woodlands, with other records coming from red ironbark open forest and stunted grey box woodland.

Fat-tailed dunnart

In the Murray Valley area, this small nocturnal insectivore (*Sminthopsis crassicaudata*) is widespread and appears to be on the easternmost limit of its Victorian range.

Large-footed myotis

Until recently the large-footed myotis (*Myotis adversus*) was considered to be a very rare coastal species, restricted in Victoria to the southern side of the Great Dividing Range. It has now been found at four localities in the Murray Valley area, representing (at present) the only known inland records in Victoria.

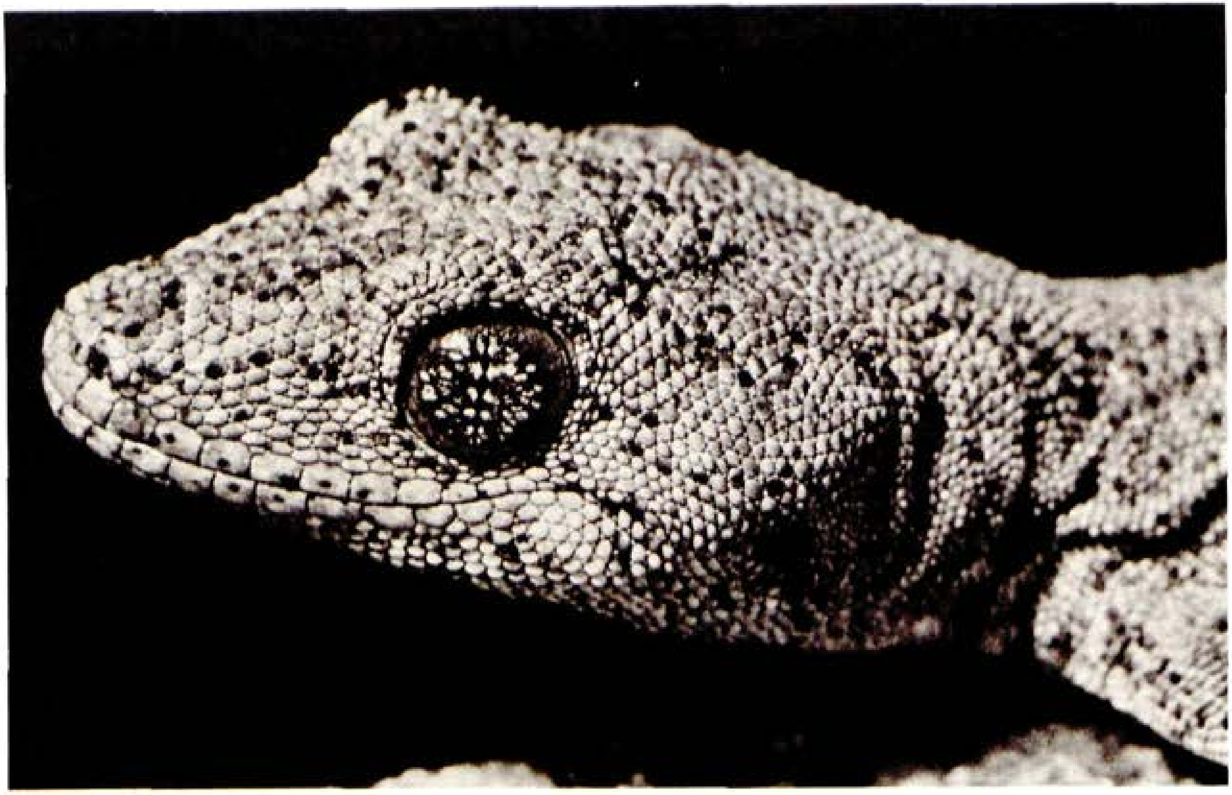
It is normally found near permanent flowing water, and the four captures in this area occurred in the Barmah Forest near the Murray River and along the Goulburn River, Ovens River, and a small creek north of Violet Town. The species was once thought to be strictly cave-dwelling, but has now been found using tree hollows and these, due to lack of caves, are what it probably uses in the Murray Valley.

Eastern spiny-tailed gecko

This species (*Diplodactylus intermedius*) is adapted to the arid conditions of the mallee and, until recently, was known to occur in Victoria only in areas carrying *Triodia* spp. and sandstone outcrops in the 'desert' regions of the State.

A small population has now been discovered on a granite outcrop in the Murray

The eastern spiny-tailed gecko occurs in granite outcrops such as Mount Hope



Valley area, more than 100 km further east than any previously known, and in a markedly different habitat.

Burton's snake-lizard

In Victoria this species, *Lialis burtonis*, is known to occur outside the mallee areas only as one isolated population in the Warby Range.

It is a specialist predator of small lizards, and the prevalence of this food source, combined with the low ground vegetation necessary for shelter, may have allowed its survival in the Range.

Cunningham's skink

This large, rock-dwelling skink, *Egernia cunninghami*, is widespread in southern and eastern Victoria, but is present in the Murray Valley area as only two isolated populations. These populations are markedly different morphologically from the southern populations, and may prove to be a distinct taxon restricted to the area.

Morethia adelaidensis

This skink reaches the eastern limit of its distribution in the Kerang area, where it is found around the margins of brackish lakes and saltpans, and in the chenopod shrubs and adjoining grasslands. The species is generally rare in Victoria.

Short-tailed snake and Dwyer's snake

These two small, closely related snakes are both specialist predators of small skinks. The short-tailed snake (*Unechis nigriceps*) reaches the eastern limit of its range in the west of the Murray Valley area. Dwyer's snake (*Unechis dwyeri*), while still uncommon, has the centre of its Victorian distribution in the Warby Range in the east of the Murray Valley.

Both are burrowing species, and only become active on the surface at night, when they forage and shelter among low ground vegetation.

Long-billed corella

The long-billed corella (*Cacatua tenuirostris*) is distributed from far south-eastern South Australia, through south-western Victoria and the Murray Valley, northwards to Hay in New South Wales. It originally suffered a decline in numbers while agricultural land was being opened up, as overstocking depleted the native grasses it fed on.

In recent times, the spread of introduced onion grass (*Romulea rosea*) and the cultivation of oats may be providing alternative food sources. The birds rely on hollow eucalypts for nest sites.

Yellow rosella

Recorded frequently along the Murray and Goulburn Rivers in the study area, the yellow rosella (*Platycerus elegans flaveolus*) is confined to the river red gum and box woodlands. It feeds extensively on the seed of red gums, and nests in the hollow spouts of eucalypts standing in or near water.

Barking owl

Although generally uncommon, the barking owl (*Ninox connivens*) occurs throughout most of mainland Australia, avoiding the arid regions or those areas without large trees. In the Murray Valley area, it is recorded infrequently in river red gum and Blakely's red gum open forest and woodlands.

Painted honeyeater

The painted honeyeater (*Grantiella picta*) occurs through inland eastern and northern Australia.

In Victoria it is mostly distributed through central and northern parts. It has only been recorded in the red ironbark forest--woodlands in the east of the Murray Valley area. These forests contain mistletoe, the fruits of which provide the bird's main food source.

New South Wales Crown Land

At present, little information is available about the fauna on the New South Wales Crown land that abuts the Murray River north of the study area.

These Crown lands, however, mostly State forest, carry similar vegetation communities and are subject to similar flood regimes and similar land uses. Consequently, we may expect that they support similar fauna to that on the public land on the Victorian side of the Murray.

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12. *LAND SYSTEMS*

This report has so far described the features of the land in the study area - geology, geomorphology, climate, soils, and vegetation

These features are not distributed at random, nor do they occur independently. Rather, distinct environments with characteristic patterns often occur over

Table 15

Land form	Distinguishing features	Land system	Geology	Native vegetation
Dissected plateau and escarpments	Undulating plateau with steep, dissected slopes	Plateau, granitic (PG)	Silurian granite	Open forest I--II; woodland I--II Blakely's red gum; long-leaf box; red box; red stringybark; Austral grass tree
	Low hills and rocky ridges	Hills, sedimentary (HS)	Palaeozoic sediments	Open forest II--III; woodland II--III grey box; red box; red ironbark (Killawarra forest); long-leaf box; red stringybark; yellow gum
Hills	Low hills with massive rock outcrops on crests	Hills, granitic (HG)	Devonian and Silurian granite	Open forest I--II; woodland I--II grey box; yellow box; white cypress pine; buloke In east only: Blakely's red gum; red stringybark

broad tracts. Thus, large areas of land may be described in terms of units, each with a particular range of climate, topography, parent material, soil, and vegetation.

In this method of characterizing the land, each feature of the environment is considered in relation to the others, instead of separately as in a soil or vegetation survey.

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

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

LAND SYSTEMS

Soils	Annual rainfall (mm)	Hazard	
		Form	Susceptibility
Red duplex soils on plateau; uniform or gradational coarse sandy soils	500--700	Sheet erosion	High (steeper slopes)
Shallow stony gradational soils (crests); red sodic duplex soils (mid slopes); yellow sodic duplex soils (lower slopes and depressions)	425--650	Sheet erosion	Moderate to high (steeper slopes)
		Gully erosion	Moderate to high (drainage depressions)
		Salting	Moderate (lower slopes)
Shallow uniform sands (crests); red duplex soils (slopes); yellow duplex soils (depressions and lower slopes)	350--625	Sheet erosion	Low
		Gully erosion	Moderate (drainage depressions)

Table 15

Land form	Distinguishing features	Land system	Geology	Native vegetation
Hills (cont)	Rounded hills and colluvial slopes	Hills, Cambrian (HC)	Cambrian rocks	Open forest I--II; woodland I--II yellow box; grey box; white cypress pine
	Low ironstone ridgeland	Mallee low hills (MLH)	Tertiary sand (Parilla sand)	Open forest I--II; woodland I--II yellow box; various mallees; grey box; buloke
Gentle slopes	Colluvial slopes derived from granitic material	Slopes, colluvial (SC)	Quaternary granitic colluvium	Open forest II--III; woodland II--III grey box; Blakely's red gum; yellow box; white box
Plain	Very gently sloping to flat plain: Uniform north-west direction of drainage lines; some prior stream levees	Riverine plain 1 (RP1)	Quaternary alluvium	Open forest II--woodland II grey box; yellow box; river red gum; buloke
	Slightly raised flat plain with very few surface features	Riverine plain 2 (RP2)	Quaternary alluvium	Open forest I--II; woodland I--II grey box; buloke; white cypress pine
	Well-drained plain; flat to very gently undulating	Riverine plain 3 (RP3)	Quaternary alluvium	Open forest I--II; woodland I--II grey box; yellow box; white cypress pine

continued

Soils	Annual rainfall (mm)	Hazard	
		Form	Susceptibility
Uniform stony loams (crests); stony red gradational soils (slopes); grey-brown to black calcareous uniform clays (lower slopes and depressions)	425--550	Sheet erosion Gully erosion	High (upper slopes) Moderate (drainage depressions)
Red stony gradational or duplex soils; abundant ironstone throughout profile	350--400	Wind erosion	Moderate to high
Red duplex soils (better drainage); yellow to grey duplex soils (poorer drainage)	550--650	Gully erosion	Moderate
Yellow sodic duplex soils (better drainage); grey calcareous sodic uniform clays (poorer drainage)	500--600	Waterlogging	Moderate (depressions)
Red sodic duplex and red duplex soils, often with a bleached A2 horizon and buckshot; yellow sodic duplex (poor drainage)	400--475	Perched water table in subsoil	Moderate (in wet years)
Red or yellow sodic duplex soils, often with bleached A2 and some buckshot; yellow/grey sodic uniform clays in depressions	475--625	Loss of topsoil structure Waterlogging	High High (depressions)

Table 15

Land form	Distinguishing features	Land system	Geology	Native vegetation
Plain (cont)	Well-drained plain with leveed prior streams and wind-blown sand dunes	Riverine plain 4 (RP4)	Quaternary alluvium	Open forest I--II; woodland I--II grey box; buloke; yellow box; white cypress pine; black box; river red gum
	Well-drained plain with leveed prior streams	Riverine plain 5 (RP5)	Quaternary alluvium	Open forest I--II; woodland I--II grey box; buloke; yellow box; white cypress pine; white box; river red gum
	Plains, moderately well drained but with some channels and depressions	Riverine plain 6 (RP6)	Quaternary alluvium	Open forest I--II; woodland I--II grey box; black box (north-west); river red gum; yellow box; grasslands
	Plains, poorly drained with depressions common; deeper depressions permanently wet	Riverine plain 7 (RP7)	Quaternary alluvium	Open forest II--Woodland II grey box; river red gum; yellow box (better drainage) reeds (deeper depressions)

continued

Soils	Annual rainfall (mm)	Hazard	
		Form	Susceptibility
Uniform sands (dunes and some levees); red-brown sodic duplex soils; yellow sodic duplex soils; grey sodic uniform clays (poor drainage)	375--600	Wind erosion	Moderate (dunes)
		Loss of top-soil structure	High (duplex soils)
		Waterlogging	High (depressions)
Sandy red gradational or duplex soils (levees); red or yellow sodic duplex soils (plains); yellow or grey sodic uniform clays (depressions)	350--650	Loss of top-soil structure	High (duplex soils)
		Perched water tables	
		Waterlogging	High (depressions)
Red-brown sodic duplex soils (better drainage); grey and grey-brown calcareous sodic uniform clays (often gilgaied)	350--550	Waterlogging	High (depressions)
		Loss of top-soil structure	High (duplex soils)
		Salting	Moderate (east) High (north-west)
Yellow sodic duplex (better drainage); brown or grey sodic uniform clays (poorer drainage)	400--650	Waterlogging	High (depressions)
		Loss of top-soil structure	High (duplex soil)
		Salting	Moderate

Table 15

Land form	Distinguishing features	Land system	Geology	Native vegetation
Plain (cont)	Plains, poorly drained with channels common; some areas periodically inundated	Riverine plain 8 (RP8)	Quaternary alluvium	Open forest II--woodland II grassland, swamp, and marsh river red gum; black box; grasslands
	Uneven plain	Mallee plain (MP)	Quaternary alluvium overlain by calcareous dust	Open forest II--woodland II grey box; black box; yellow box; yellow gum; various mallees; buloke
Lake--lunette sequence	Areas of lakes or swamps ± permanent water, bordered by wind-blown dunes (lunettes); includes palaeo-lakes	Lake and Lunette (LL)	Quaternary swamp and lake deposits and lunette deposits	Open forest II--woodland I; woodland I, swamp and marsh grey box; buloke; yellow box black box) wetter river red gum) areas
Flood plain	Flood plain with large numbers of anastomosing stream channels (Loddon River)	Flood plain 1 (FP1)	Quaternary alluvium	Open forest II--woodland II; woodland I, grassland, swamp and marsh black box; lignum; dillonbush
	Flood plain with ox-bows, meander scrolls and occasional source-bordering dunes (major rivers except Loddon)	Flood plain 2 (FP2)	Quaternary alluvium	Open forest I, II, III; woodland I, II, III; grassland, swamp and marsh river red gum; black box in north-west

continued

Soils	Annual rainfall (mm)	Hazard	
		Form	Susceptibility
Gilgaied grey or brown sodic uniform clays	325--425	Salting	High in north-west otherwise moderate
		Waterlogging	High
		Flooding	High (seasonal)
Red calcareous, sodic duplex soils; yellow or grey sodic duplex in depressions	350--400	Wind erosion	Moderate
		Salting	Low (depressions)
Mottled grey clays, often saline and calcareous (swamps and dry lake floors); uniform reddish fine sands and calcareous clays (lunettes)	325--425	Rill erosion	Moderate (clay lunettes)
		Wind erosion	Moderate (sandy lunettes)
Yellowish grey sodic clays; self-mulching surface and gilgaied microrelief	325-375	Flooding	High (seasonal)
Variable, but typically silty yellow-grey mottled gradational soils with poor structure; some wind-blown sand deposits	325--625	Flooding	High (seasonal)

repetitive sequence, and an area containing such a sequence is termed a land system.

For the Murray Valley area, 18 land systems have been identified and are shown on Map 9.

Table 15 gives details of the geology, native vegetation, soils, rainfall, and distinguishing features for each of the land systems. It then groups these into land forms. Within each land system the susceptibility of the land to various forms of soil deterioration is outlined.

More detailed descriptions of the hazards of soil deterioration may be found in Chapter 13, Hazards.

An understanding of the nature of the land systems and a knowledge of their distribution is a valuable base for land-use planning.

PART III

LAND USE

13. HAZARDS

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

Since European settlement, however, alterations to the natural environment have taken place. Native vegetation and fauna have been removed or displaced by exotic pastures and introduced animals, soils have been cultivated, rivers dammed, and native forests managed for timber production.

The land has reacted in different ways according to its characteristics, and according to the type of use and management applied. Some land types are particularly sensitive to the changes being wrought on them; others are less so.

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

Land Salinization

Land salinization is serious in the Murray Valley area and is expected to worsen in the future. Its occurrence stems, essentially, from the rise of saline groundwater to within a metre or so of the natural surface. This rise follows either extensive land clearing, in the case of dryland salting, or the introduction of large-scale irrigation in the case of salting in irrigation areas.

The accumulation of toxic levels of salt in the soil that results from high groundwater levels threatens both dryland and irrigated farming areas. Land salinization is insidious, as the first sign is often an indication of a much larger problem affecting the property or district.

Dryland Salting

Dryland salting has reduced agricultural production, initiated soil erosion (such as sheet and gully erosion), and increased the salinity of water in the dams and rivers.

It is not as extensive and has not caused as serious a decline in production as salting in the irrigation districts, but recent years have seen substantial increases in the areas affected.

Dryland salting within the Murray Valley area usually occurs where the northern slopes of the Great Dividing Range meet the riverine plain. Little public land remains here, and so the problem is confined mainly to freehold land. Significant areas of dryland salting occur around Boort, Campaspe, and Caniambo.

Causes

Dryland salting is caused by increased volumes of water percolating through the ground - dissolving salts from the soils and rocks and raising the level of naturally saline groundwater. When the groundwater approaches the surface it will discharge - either by capillarity and evaporation, thereby concentrating salts in the surface soil, or (if the water table reaches the surface) by the formation of a saline spring or seep.

Dryland salting near Violet Town showing saline paddock

Increases in rainfall, changes to vegetation cover in catchments, or land use changes can all increase volumes of subsurface water.

It is believed that the removal of native trees and shrubs from the catchments is the main cause of dryland salting in the Murray Valley area. The removal of these deep-rooting species allows greater volumes of water to percolate into the groundwater - water that the native vegetation would have transpired under natural conditions. Differences in agricultural practice also affect the amount of water percolating into the groundwater and the amount of salt leaching that takes place.

The Warby range is the only significant area of high public land in the study area and, being heavily timbered, is not likely to contribute to dryland salting.

Effects

Salted areas suffer a reduction in productivity or become completely unproductive. Problems also arise because they

Dryland salting can lead to other forms of soil degradation, such as sheet and gully erosion

are usually scattered through unaffected areas. They are therefore cultivated or grazed along with these and this results in an average loss of productivity and an increase in erosion hazard.

In addition, where dryland salting occurs, the salinity of water in the drainage system usually increases. This results in increased levels of salt in the natural rivers and streams and can render water in farm dams unsuitable for domestic or irrigation purposes.

Dryland salting also spoils the landscape by causing the death of farm trees and shrubs along natural watercourses.

Prevention and restoration

Dryland salting is a complex problem and - depending on its location and severity - can require different solutions.

On affected land, salt-tolerant plant species can be grown and the surface soil mulched to encourage transpiration and reduce surface evaporation.

The actual cause of the problem, however, lies in the upper part of the catchment (the 'recharge area'). Land management must be changed so that more efficient water use by plants, trees, and shrubs can reduce the quantity of water infiltrating to the groundwater.

Hydrologic research into dryland salinity in north central Victoria indicates that only small quantities of water enter the groundwater per unit area, and the deep percolation may be reduced sufficiently by the modification of existing farm practices or by greater use of deep-rooted pasture plants like lucerne. The use of trees to prevent deep percolation of rain to groundwater may be the only answer on some specific areas of land that permit high rates of deep percolation.

Salinization Under Irrigation

Local irrigation areas include some of the most productive lands in Australia. They support a wide range of agricultural and horticultural pursuits.

Land salinization caused by irrigation can markedly affect native vegetation

Salinity problems here are not a recent occurrence. For example, on the plains around Kerang it became apparent even in the earliest days of settlement that the salt content of the soils in and near low-lying areas affected plant growth.

Again, earlier this century - before the construction of major storages secured summer flows in the Murray River - very high salinities were associated with low flows in drought years such as occurred in 1914/15.

Although the western parts of the study area contained highly saline groundwater and subsoils before irrigation, the present-day salinity problem has largely resulted from decisions taken in earlier generations to settle and develop them for irrigated agriculture.

Irrigation has changed the hydrologic equilibrium and thereby raised water tables, bringing salt, which was formerly safely at depth in the subsoils, into the root zone.

Degradation of surface water quality has also occurred because of run-off from salinized lands, and as a result of direct seepage from raised groundwater mounds. This degradation can significantly affect the quality of the River Murray waters. For instance, the effect is particularly marked where water from Barr Creek, which drains a substantial part of the Kerang region, reaches the Murray.

The salinity problem

The general spread of high water tables and of salinity threatens both the productivity of the irrigation areas and the prosperous rural communities they support.

Salting of irrigated land leads to a number of associated problems.

Salt that has accumulated in the root zone of the soil can reduce productivity of the plants and can even kill them. Increased salinity of the topsoil may lead to higher salt loads in drainage waters. As the Murray River forms the natural main drain for the irrigation lands here, these increased salt loads may cause higher salinities in the river and thus a reduction in water quality.

Salt-affected land is most obvious in the Kerang region. Two-thirds of the region overlies moderately to highly saline groundwater. As a result, saline areas are extensive, and it is estimated that annual agricultural production is about 25% lower than its potential. Reclamation by subsurface drainage has so far proved uneconomic, mainly because of the high cost of safe disposal of the effluent. However, improved irrigation and land management practices are assisting in the maintenance of production. Some 15% of the annual salt load of Barr Creek is now being diverted to inland evaporation basins.

Saline land is less evident around Shepparton because of lower concentrations of salts in subsoils and groundwaters. High water tables do, however, underlie 175,000 ha and some local lower-lying areas are acutely salt-affected. Groundwater pumping schemes have been introduced to protect orchards, but their extension to pastoral land is complicated by the need for safe disposal of more saline groundwaters in some areas.

Solutions

Any complete solution to the irrigation salinity problem would include subsurface drainage to lower the water table and provide for safe disposal of the salt carried in the drainage water.

Partial solutions include improvements to farm management, including efficient water use and local subsurface drainage.

The current strategy for the control of irrigation salinity in the Murray Valley area is to maintain viability of existing irrigation areas while maintaining the quality of Murray River waters.

Under this strategy a number of works and procedures have been approved and implemented. Both the Victorian government and the Commonwealth government provide funding for these on a dollar-for-dollar basis. Commonwealth funding is provided under the National Water Resources Program.

Further works and procedures for the control of irrigation salinity are currently being examined by the Joint Select Committee on Salinity.

Soil Erosion

A major proportion of the Murray Valley area consists of relatively flat plains and, as a result, soil erosion by water is not a widespread problem. It is, however, a severe problem on undulating granitic and sedimentary lands, where control of erosion on private land still requires considerable landholder and public expenditure. The decline of rab-

Wind erosion occurs mostly on the cropped sandy soils of the area

bits brought about by the introduction of myxomatosis in the 1950s and the increased stabilization of the land due to the use of improved pastures have also reduced soil erosion in the study area.

The gradational and duplex soils of the riverine plain and the soils associated with the gentler slopes comprising Palaeozoic sediments are susceptible to a decline in topsoil structure through excessive cultivation. With the loss of topsoil structure, the soil surface sets hard after rain, thereby reducing crop germination and water infiltration. The resultant increase in run-off leads to soil erosion problems. Methods of reducing erosion and maintaining topsoil structure include the use of gypsum, a reduction in the number of cultivations, stubble mulching, and zero tillage.

Gully erosion, although not a common feature here, creates a moderate hazard which could be enhanced by poor management on the outwash slopes of the prominent granite hills such as Warby Range, Chesney Vale Hills, Mount Terrick Terrick, Pyramid Hill, and Mount Hope.

A moderate gully erosion hazard also occurs on the Palaeozoic sedimentary areas because of the high water run-off from the undulating land and the unstable nature of the yellow duplex soils in the drainage depressions.

Areas with a high water erosion hazard are found on the gentle slopes on Ordovician sediments in the south, the Devonian sediments in the east, and the colluvial outwash slopes associated with the granite hills in the central, eastern, and central western sectors of the study area. Such erosion removes valuable topsoil, with accumulated nutrients and organic matter, if the protective vegetation cover is absent.

Stream-bank erosion, although a natural phenomenon, has greatly increased in rate and extent since European settlement. Factors that have significantly affected stability of the banks include defoliation of river banks (largely as a result of grazing), increased run-off from agricultural and urban areas, the policy of widening and straightening rivers to cope with this run-off, and removal of natural barriers such as logs and rock reefs from the river bed.

Wind erosion is directly related to the lack of vegetative cover and the pulverized nature of the topsoil caused by over-cultivation or grazing. Bare, finely cultivated fallow land is prone to wind erosion, particularly if it has a fine sandy topsoil in a dry condition. Locally severe wind erosion may occur in conjunction with poor land management on the more susceptible soils, extensive wind erosion does not occur in the study area, however.

Floods

The Murray Valley area contains the lower reaches of the Ovens, Broken, Goulburn, Campaspe, and Loddon drainage basins and includes a portion of the Murray River flood plain. All of these rivers and their tributaries are subject to flooding.

Because of the physical characteristics of the land, flooding is a natural occurrence in many districts during the wetter seasons. The generally flat terrain contains numerous natural depressions and drainage is often ill-defined. Flooding therefore involves a steady rise in water levels, followed by weeks of inundation, in contrast to the flash flooding and rapid run-off experienced in the higher country to the south.

Seasonal flooding thus presents a serious hazard for agricultural land use, but depends on the amount of winter--spring rainfall in the major catchments.

Flooding in the area has a major impact on farm production. Estimates suggest that the 1975 flood in the lower Loddon district resulted in a loss of some $1,800,000 worth of production.

Flooding of irrigated pastures can aggravate salinity. It usually results in a rise in the water table level, which kills the pasture grasses and leaves the soil bare and susceptible to salting.

The Campaspe River is deeply incised into the riverine plain, and only becomes susceptible to floods when dammed back by flood-waters in the Murray. This situation makes the City of Echuca very flood-prone, and quite significant damage and inconvenience occurred there in 1973 and again in 1974. The possibility of a repetition of the destructive 1870 flooding is of considerable concern to the town.

Land adjoining the Goulburn, Broken, and Ovens Rivers is particularly susceptible - as is the Murray flood plain. Levee banks have been built on the flood-plain margin in an effort to protect the abutting freehold land.

Flood problems in the lower Goulburn area are thought to be exacerbated by the presence of some protection levee banks

These flood problems are currently being examined in the State Rivers and Water Supply Commission's Shepparton to Kanyapella Floodplain Management Study.

The Loddon River has no well-defined flood plain, and when it moves out of its broad valley tract near Durham Ox it divides into a series of anastomosing channels. During a wet winter the lower Loddon area is transformed into a broad sheet of water flowing northwards, making it one of the most flood-prone areas in the State.

Serious floods have always been a major land hazard in the Murray Valley area - Numurhak floods, 1917

Several flood studies have been undertaken or are planned for rivers within the Murray Valley area. These are conducted by the State Rivers and Water Supply Commission in conjunction with local municipalities and other interested agencies. The studies examine the causes, extent, and effects of flooding, and make recommendations on the structural or other works required and the proclamation of lands subject to flooding.

The Lower Loddon Flood and Drainage Study 1982, carried out under the auspices of the Commission and the local municipalities, produced a series of management guidelines for flood plains, which have been endorsed by the Australian Water Resources Council and adopted by the Commonwealth government. They provide a basis for planning, with the aim of preventing or reducing flooding. These guidelines set an average recurrence interval of one flood in 100 years as a reference for declaring flood-prone areas and the control of flood-plain development.

River Improvement Trusts have been formed for the Bullock and Black Dog Creeks and the Ovens and Broken Rivers. They have been formed to carry out works to reduce the frequency and extent of nuisance floods. Throughout the study area, many drainage schemes have been constructed and numerous levees built in order to reduce the frequency and extent of flooding.

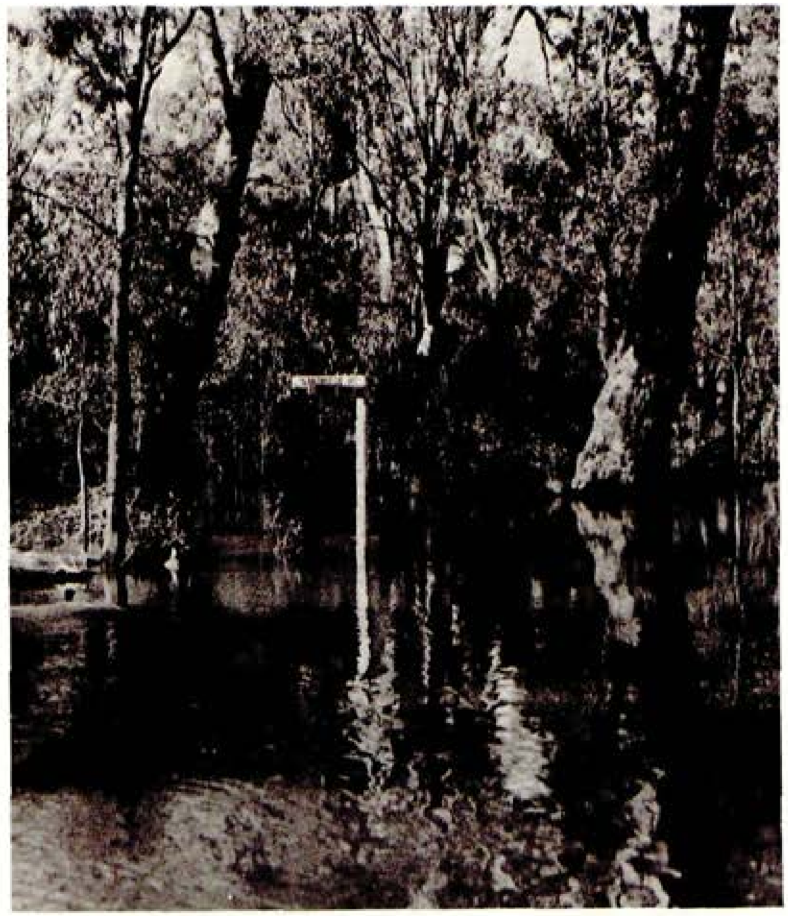
Floods and the River Red Gum Ecosystems

Average annual rainfall in the Murray Valley area is not sufficient to support the vigorous growth of river red gum (*Eucalyptus camaldulensis*), and the forests of the species rely on regular flooding to meet this deficiency. These forests have evolved under a pattern of flooding characterized by:

* a regular winter--spring flooding, of sufficient duration in most years to: stimulate regeneration and growth of trees and associated plant communities; provide suitable wildlife habitat (particularly for water-birds); and recharge the subsoil to ensure adequate soil moisture for plant growth over the summer and autumn.

* late spring--early summer recession of flood-water, which facilitates seedling establishment and provides favourable feeding and breeding habitat for many water-birds that next in spring or continue nesting in summer on low-lying areas.

Regulation of the major rivers in the study area has altered flood patterns. Sections of the red gum forests are now frequently flooded in summer, when controls keep the rivers high to provide water for irrigation, while the impounding of winter and spring flows has reduced the frequency, duration, and extent of normal flooding. These changes



The river red gum forests that abut the Murray River depend on periodic winter--spring flooding to maintain their health and vitality

in pattern have created hazards for: regeneration and tree growth; access for fire protection; harvesting of forest products; recreation; and maintenance of wildlife breeding areas and habitat.

The alteration of the flood pattern on individual rivers depends on the extent to which the river is regulated. Flows in the Murray are regulated through the operation of the Hume and Dartmouth Dams. Periodic unseasonal flooding along this river now occurs once or more during the summer and autumn.

Regulators have been constructed on some of the effluent creeks from the river to restrict the entry of water into the red gum forests during summer. When river levels rise higher, however, water often flows over the banks at points between the regulators.

The Barmah Forest in flood (about 1920)

This problem is particularly bad in the Barmah Forest, where a restriction in the river known as the Barmah Choke, combined with the low-lying river banks, results in this forest being readily flooded. The overflow tends to occur when summer rain adds to the already high river levels and reduces the demand for irrigation water.

Along the Goulburn River, the winter--spring flood frequency has decreased due to the retardation of water in the Eildon Dam, Goulburn Weir, and Waranga Basin. Flooding of red gum areas adjacent to this river now only occurs during the occasional very wet seasons, when storage capacities are exceeded.

The Ovens River has not been regulated to the same extent, as only one storage, Lake Buffalo, has been constructed in its catchment. Flooding on the Ovens River therefore occurs fairly frequently as a result of average seasonal falls of rain and snow in the catchment areas.

Negotiations between the River Murray Commission, Forests Commission Victoria, and the State Rivers and Water Supply Commission to attain better working arrangements for summer stream flow have been in progress for some years, but no agreement on an acceptable flood regime for the river red gum forests has yet been achieved.

Damage, and perhaps even death, can also occur to the river red gum forests as a

Summer inundation of some river red gum stands has resulted in tree deaths and disruption of access

result of drainage from irrigated paddocks.

A similar problem arises along streams that are used as irrigation channels. During periods of high flow, these sometimes cannot accommodate additions due to rain, and unseasonal flooding of adjacent low-lying forest areas can occur.

Fire

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

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

The study area generally has hot dry summers, and this climatic factor adds significantly to the fire hazard. About 90% of the fires on public land occur from November to April, although in dry years the fire danger period is longer.

Tables 16 and 17 give statistics for fires attended by Forests Commission personnel during the period 1972/73 to 1980/81 inclusive.

As the statistics indicate only 7% of fires were known to have been caused by lightning and the balance (93%) can be regarded as having been caused by man.

Table 16 SUMMARY OF FIRE ORIGIN, CAUSE,

Year	Lightning		Deliberate		Escapes from fires in private property		Tourist/campers	
	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)
1972/73	1	10	1	3	2	4	11	37
1973/74	1	<1	-	-	-	-	-	-
1974/75	1	160	1	-	1	1	7	109
1975/76	-	-	-	-	3	165	7	3
1976/77	1	200	8	5	2	8	7	23
1977/78	1	-	2	1	1	8	15	27
1978/79	1	-	-	-	3	18	7	73
1979/80	1	1	1	-	1	12	11	51
1980/81	8	167	-	-	1	2	23	51
TOTALS	15	539	13	9	14	218	88	374
PERCENTAGES	7	16	6	1	7	6	42	11

* These figures include four major fires that burnt a total of 1,930 ha. Details of the land status and locations of these burnt areas are given in the text.

AND AREA BURNT (1972/73 TO 1980/81)

Cigarettes/matches		Miscellaneous		Unknown		Totals	
No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)
2	7	7	29	9	11	33	101
1	<1	-	-	1	<1	3	1
2	1	4	92	1	-	17	763
-	-	5	2	1	8	16	178
-	-	1	1	3	1	22	238
4	10	2	401*	3	4	28	451
2	57	5	877*	2	5	20	1,030
1	5	5	18	2	31	22	118
4	29	6	182	5	550*	47	981
16	109	35	1,602*	27	610*	208	3,461
8	3	17	46	13	18	100.0	100.0

Note:
Fires attended by Forests Commission personnel, including those that started outside the study area; they may include land outside the area

Table 17

FIRES IN THE STUDY AREA*: CLASSIFICATION BY SIZE AND AREA BURNT (1972/73 TO 1980/81)

Size	Number	Percentage of total	Total area+ (ha)	Percentage of total
1 ha or less	122	59	6	1
1--5 ha	34	16	130	4
5--10 ha	21	10	177	5
10--50 ha	20	10	476	14
50--199 ha	7	3	742	21
200 ha or more	4	2	1,930	56
	208	100	3,461	100

* Fires attended by Forests Commission personnel, including those that started outside the study area

\+ Includes land outside the study area

The major cause of fires (42%) was carelessness with the use of barbecues and campfires. Deliverate lighting, escapes from private property, and carelessly discarded matches and cigarettes accounted for 6, 7, and 8% respectively. Very few fires (three) occurred during 1973/74, due largely to the late and extended presence of flood-waters, and the general summer rains, experienced during the fire season.

One of the four major fires (200 ha and more) burnt 200 ha on the New South Wales side of the Murray River and spotted across the river to State forest in Victoria, but burnt an area of less than 1 ha in Victoria. Of the other three, one burnt 500 ha of private property to the north of the Killawarra State Forest, another burnt 830 ha (including 40 ha of State forest near Barmah), and the third burnt 400 ha, of which 20 ha was

Crown land located north-east of Rutherglen.

Victoria's eucalypt forests are usually regarded as being among the most fire-hazardous areas in the world. Those in this study area have a lower hazard than the more common stringybark-gum-type foothill forests, because the relative sparseness of understorey vegetation and the low quantities of fuel on the forest floor reduce their ability to develop 'crown' fires.

The river red gum forests have an understorey of lush grasses, rushes, and reedbeds resulting from flooding. Other portions of the forest include permanent wetlands such as swamps and lagoons. On the other hand, floods often move tree branches about and heap them against standing trees, which fires, burning in these accumulations of tree debris and cured grasses, can badly damage.

River red gum is less fire-resistant than the coarse- (rough-) barked eucalypts such as box, stringybark, and ironbark. Its seedlings and saplings are killed by fire, but older trees, when defoliated by scorching, can often survive by re-establishing crown cover with epicormic shoots from dormant buds under the bark. When the trees are subsequently harvested, however, they may produce poor-quality defective timber.

Box forests occur both within and adjoining the red gum forests on areas not usually subject to flooding. These comprise grey box (*E. microcarpa*), black box (*E. largiflorens*), and yellow box (*E. melliodora*). Box forests also occur in the Warby Range, and comprise grey box and red box (*E. polyanthemos*) in association with red ironbark (*E. sideroxylon*), Blakely's red gum (*E. blakelyi*), and/or red stringybark (*E. macrorhyncha*).

These box forests and other associated eucalypts have scattered patches of scrub understorey, but a lighter growth of grasses and sparser accumulations of litter than the river red gum forests. Wildfires are usually less frequent and smaller, due to the lack of ground fuel.

The Terrick Terrick forest reserve contains an open forest consisting mainly of white cypress pine. Two species, *Callitris columellaris* and *C. preissii*, occupy most of the reserve. Other trees to be found are grey box, yellow box, buloke (*Casuarina Luehmannii*), and sheoak (*C. stricta*). These have a sparse understorey of *Pittosporum*, *Hakea*, and *Acacia* spp., and native grasses grow throughout.

The terrain in the study area is mostly flat to slightly undulating, with isolated higher outcrops. This topography seldom causes problems in fire suppression operations. The river red gum areas do, however, contain lagoons, swamps, and creeks that can restrict access. Access is also difficult in parts of the higher outcrops, and the effect of slope can increase fire intensity on these hills.

Control of fire

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

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

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

The Country Fire Authority is responsible for fire suppression on all private land in the study area. Fragmentation and dispersal of the public lands thus make co-operation and liaison between the Commission and the Authority essential. Co-ordination is achieved and maintained through well-established working arrangements and consultations between personnel of the two organizations.

Fire suppression is usually carried out by Forests Commission personnel on public land and rural fire brigades on private property. Co-operative efforts by both organizations are common, however, especially when outbreaks spread quickly and have potential for developing into major fires. On isolated blocks of public land the local fire brigade usually provides the first attack crew at a fire until Commission resources arrive to complete suppression works.

In most river areas where water is readily available and access is good, fire-fighting techniques are based on the use of tankers and, on occasion, direct pumping of water onto fires. The occurrence of summer flood-waters can create problems with suppression when transport for fire-fighters by flat-bottomed boats may need to be arranged. In box forest areas, emergency water dams are provided where necessary.

Several fire-prevention measures are adopted on public lands. These include: maintenance of perimeter firebreaks and access tracks; restoration of track surfaces and crossings following floods; maintenance of access routes to water points at rivers, lagoons, swamps, and dams; slashing of grass on the surrounds of picnic and camping areas, and provision of fireplaces along the major rivers.

Logging slash is burnt in some areas and stock are grazed to reduce the quantity of grass.

Fuel-reduction burning is not generally used in this study area as the technique has only limited application there. Broadscale fuel-reduction burning is not practicable in river red gum areas, due to the occurrence of flood-waters, the build-up of grass fuels, and the fire-sensitivity of the species. In box --ironbark forests, it is not warranted due to the very slow accumulation of leaf and litter fuels and the sparseness of understorey vegetation.

Detection of fires in the riverine forests and throughout the western and central parts of the study area depends on observation by local landholders, forest travellers, timber-cutters, and Commission personnel. The flat topography makes fixed lookout points unpractical. One fire tower is located at the northern end of Warby Range and this, together with towers on Mount Pilot and Mount Stanley outside the area, provides detection over some of the eastern part of the area.

Fire damage on forest land

Both timber and environment values are at risk from wildfire. The major threat that it poses to timber production on forest land is to the more highly productive red gum stands and to privately owned poplar plantations at Cobrawonga.

Box-ironbark forests resist fire more readily, and the mature trees are rarely killed. The main losses to production in these forests arise through retarded

The Warby Range fire tower

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

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

Wildlife values may also suffer. Populations of many animals are depleted in severe and widespread fires and their recovery will vary according to habitat and biological requirements of the species. Generally, fire affects them less severely where burnt areas form a mosaic with untouched or lightly burnt ones. This is likely to be the case in much of the study area because of the intermixing of river red gum stands with lagoons or swamps and creeks.

Biological Hazards

During the last 100 years, the Victorian Parliament has passed various Acts in the attempt to control pest plants and animals.

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

Control is carried out by the Department of Crown Lands and Survey. The Department's works crews control vermin and noxious weeds on Crown and other public land and roadsides. Inspectors enforce control on private land either by requiring the land-owner to carry out control himself or, on occasion, by arranging for Departmental works crews to undertake the work on a paid or 'entry' basis.

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

Animal and fish pests

Within the Murray Valley area the main introduced animals declared as vermin are the European rabbit, fox, feral pig, and wild horse.

Predators such as foxes and feral cats are widespread. They are opportunist feeders - eating the most abundant form of food available at the time - and prey to some extent on the smaller native birds and animals. Foxes can contract well-known bacterial and viral diseases, such as rabies (not currently present in Australia) and distemper, that affect dogs, humans, and possibly native animals. Control measures include 1080 poisoning (sodium monofluoroacetate) and shooting. The fox provides recreational value as a game animal and the winter pelt realizes high prices in the fur trade.

The European rabbit is by far the greatest single animal hazard to the Australian environment and to primary industry. Within the study area, rabbits are found mainly on cleared freehold land and are also present in most areas of public land. They pose a particular problem in the sandhills and river red gum forests along the Murray River. In the past their rapid breeding rate - coupled with their destructive grazing habit - has caused serious depletion in native vegetation and crops (with consequent erosion problems) throughout the State: only the control programs are preventing a return to this situation.

Biological control - introduced in 1950 in the form of myxomatosis - provided a major breakthrough and it is still in use today. This form of control, the fumigation and ripping of warrens, and the use of 1080 poison in carrot bait combine to form a cheap and effective program, and as a consequence the rabbit problem is not serious at present.

Feral pigs (wild domestic pigs that have established self-sustaining populations in the area, especially along the Murray and its tributaries) were first proclaimed as vermin in Victoria in 1959.

While the present population of feral pigs in the area is small, there appears to be potential for build-up in numbers. Coupled with this is the risk of their becoming infected with serious exotic diseases such as swine fever and foot and mouth disease. At present they have minimal impact on agriculture in the study area; only isolated incidents of damage to cereal crops and livestock are reported. Little is known of the current disease status of feral pigs.

Wild horses are found in the Barmah Forest. They are present in small numbers, being controlled by periodic round-ups, and they therefore do not present a major problem.

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

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

Carp probably exceeded those densities during the late 1960s and early 1970s, when they were increasing in numbers and expanding their range. Currently, some fishermen endorsed for the commercial exploitation of carp operate within the study area, mainly west of Echuca.

Native animal and bird pests

A number of native animals and birds have caused localized problems in the area, and in some cases the Fisheries and Wildlife Division has issued permits for the control of a species population - as may be the case with kangaroos.

Eastern grey kangaroos are widespread, sheltering in forests during the day and grazing on adjacent crops or pastures in the mornings and evenings. They cause physical damage to fences and crops as well as reducing the productivity of farmland. Kangaroos in the Barmah area cause moderate problems; flooding, which reduces food availability within the forest, may aggravate these. Similar problems occur in the vicinity of Killawarra, the Warby Range, Tungamah, and Kilby.

Brush-tailed possums cause localized problems, by roosting in house roofs and occasionally eating young plants and flowers in suburban gardens.

Sometimes tunnelling by water rats around irrigation channels and structures can lead to seepage of irrigation water. Fruit bats, when migrating, very occasionally cause problems in stone fruit orchards.

Native birds that have created a nuisance in the area are discussed below.

Cormorants cause some problems by taking fish from hatcheries and from farm dams, which are frequently stocked with native or introduced species by land-owners.

Black swans may cause problems by grazing young crops and pastures, usually adjacent to large bodies of water. Eastern swamp hens, coots, and dusky moor hens cause similar problems.

Sulphur-crested cockatoos, galahs, long-billed corellas, and ravens can damage cereal crops, mature sunflowers, and pears. Sunflowers, in particular are affected in the Echuca, Boort, and Kerang districts.

Destructive insects

Pasture pests such as the red-legged earth mite, lucerne flea, and cockchafer occur throughout the study area. The blue-green and spotted alfalfa aphids that have been recently introduced cause severe losses in non-resistant lucerne.

Plague locusts are a problem in some years when conditions for hatching and survival are suitable in New South Wales. In general, the damage they cause is slight.

The major insect pest affecting forests of river red gum in the Murray Valley area is the gum-leaf skeletonizer (*Uraba lugens*). Twelve outbreaks have been recorded since 1969, with up to 40,000 ha of forest defoliated on at least two occasions. Maximum defoliation occurs in dense stands with low hanging foliage - since such stands provide suitable sites for egg-laying and also allow the larvae to move from crown to crown.

The larvae are vulnerable to the entomogenous fungi *Asperillus flavus* and *A. parasiticus*, and flood-waters provide humid conditions that favour the spread of these. Such fungal control of the *U. lugens* population only seems to be effective, however, if floods occur between spring and summer or between March and June, when the insect's early and final instar larvae and pupae are located close to the forest floor.

Another insect, the mottled cup moth (*Doratifera vulnerans*) affects a number of *Eucalyptus* species. It is present in low numbers on river red gum along the Goulburn River downstream of Shepparton, and in recent years has defoliated extensive areas in the Warby Range. The affected trees included grey box (*E. microcarpa*) and Blakely's red gum (*E. blakelyi*). The insect's larvae are prone to a disease that is thought to be of bacterial origin, and outbreaks usually occur during periods of low rainfall.

Some damage to red gum regeneration in the Barmah forest has also been caused by the steelblue sawfly (*Perga affinis affinis*) whose larval stage occurs in winter: defoliation reaches its peak in spring. Irregular outbreaks of psyllids (Hemiptera: Psyllidae) have occurred during dry periods on red gum in the Barmah forest and along the Hume Highway near Benalla.

Weeds

Many factors govern the extent and density of infestation by any weed, whether it be a declared noxious weed or regarded only as a pest plant. Rainfall, soil type, and utilization have the greatest influence.

Under the 1958 *Act*, 93 plant species have been proclaimed as noxious weeds in Victoria (except the Melbourne metropolitan area), and a significant number of these occur in the study area. Many of them are presently established on both Crown land and freehold, particularly in areas that have suffered soil disturbance.

Legal provisions of the *Act* require control measures to be carried out on these plants irrespective of location. Details of the present legislation and various control methods are set out in 'Noxious Weeds in Victoria' (Parsons 1973).

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Cumbungi infestation of a natural water channel - Kerang area

Appendix 5 lists recorded noxious weeds in the Murray Valley area. Most of them can be controlled by spraying with herbicides, by mechanical methods such as mowing, slashing, or cultivation, or by biological means. Advice as to the most effective method is available from the local district Inspector of Lands.

Annual burr-producing weeds are common throughout the study area and can flower and set seed under extremely adverse conditions, including low rainfall. Weeds such as Bathurst burr, Noogoora burr, spiny emex, and caltrop are examples.

Heliotrope, although not a noxious weed, is a summer annual that occurs on cultivated dryland farming areas and has toxic properties that can cause problems to livestock.

Patersons curse, widespread in the study area, is causing problems, as it is taking over in some places. Weeds related to irrigation, such as ox tongue and rushes, are common throughout.

Boxthorn, sweet briar, and blackberry all occur here: they restrict use, provide excellent harbours for vermin, and remain potential sources of infestation.

St. Johns wort infests both agricultural and forested land. In one of the few instances of biological control in Victoria, the chrysomela beetle has been moderately successful in reducing infestations of this weed.

Fungal diseases

Fungal diseases are not a significant problem in native forests in the Murray Valley area.

The American poplar rust (*Melampsora medusae*) does, however, cause very severe defoliation of the cottonwood (*Populus deltoides*). Similarly, the European poplar rust (*M. coleosporoides*) defoliates the evergreen poplar (*P. nigra*, var. *italica*). These diseases appear to be worse in wet years and also when heavy deposits of dew coat the leaves.

The most effective control measure is the use of rust-resistant varieties (hybrids) of poplars.

Agricultural Chemicals

Residues from the use of herbicides and insecticides in agricultural areas are recognized potential hazards to soil and water quality.

Many modern agricultural chemicals are, however, biodegradable, and farmers are becoming more aware of the importance of using these chemicals in crop, pasture, and livestock management.

Monitoring levels of non-degradable chemicals in the soils is important, especially with the increasing use of chemical ploughing, which is used to prevent deterioration of soil structure,

Spear thistle is found on farms and public land in the area

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and decreases the costs associated with the sowing of crops.

The potential hazard from agricultural chemicals is greatest in areas used for horticulture because of the large amounts required to maintain adequate production. To date, however, pollution from these high-usage levels has been low.

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14. CONSERVATION

Conservation is concerned with man's relation to his environment. The need for conservation of economic resources is obvious, because society uses them for many of the material comforts of modern life. These aspects are considered in subsequent chapters under such headings as timber production, water use, and minerals and extractive industries.

Conservation also embodies the concept of preservation and protection of native species, natural features, and landscapes - and preservation of archaeological and historical features. In recent years, society has placed greater emphasis on the need to protect and preserve these attributes. Management to achieve these aims is important when land is set aside for reference, conservation of species, recreation, and education. None of these uses necessarily monopolizes the land; often conservation uses are compatible with each other or with commercially productive uses.

Use of Conservation Areas

Reference areas

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

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

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

Although all land types should be represented in reference areas, the need is most urgent in those that have already been extensively developed for various

A tranquil scene of the River Murray and the Barmah Forest uses. Few, if any, areas suitable for reference remain for some land types in the study area. For example, the grassy open woodlands that were once widespread over the area have been extensively altered by agriculture and only small pockets remain in public ownership.

Conservation of species

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

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

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

Appendix 1 lists significant plant species in the study area. The status of the vertebrate animals recorded in the area is noted in Appendices 2, 3 and 4.

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

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

Special natural values

Particular areas of land are often needed to preserve such natural values as distinctive geological features. Many of these have great scientific interest, while others are valuable for education. The more accessible and spectacular features also attract tourists; but, unlike historical or archaeological sites, the geological features are not protected by specific legislation in Victoria.

A Register of Historic Buildings was established in accordance with the *Historic Buildings Act* 1974 and 1981. It applies to buildings, works, and objects not covered by the *Government Buildings Advisory Council Act* 1972, as amended in 1981, when a Register of Government Buildings was established.

Legislation currently before Parliament proposes one Council, to administer both registers. The National Trust of Australia (Victoria), however, records or classifies all buildings, landscapes, areas, objects, and sites that its expert group consider worthy of preservation.

The study area contains a wealth of Aboriginal relics and sites, mainly located around the lakes, swamps, and rivers and in forest areas such as the Barmah Forest. Many of these relics and sites have not yet been fully documented, nor have they been set aside in reserves managed for their protection and preservation.

Recreation

Most Australians live in the artificial environment of large cities and towns, and many find that their lives are enriched by contact with the natural world. The need for natural surroundings for certain forms of outdoor recreation is discussed in Chapter 15. Birdwatching, nature study, hunting, and bushwalking all require the conservation of the native plants and animals; picnicking and pleasure driving simply require a background of trees or shrubs in the recreational areas. These requirements can be filled in the study area.

Few parts of the study area are very far from the obvious hand of man. Taken alone, therefore, the Murray Valley area has little scope for true wilderness recreation. However, some areas are valuable in providing some degree of solitude and contact with nature, and in reducing the pressures on places better suited for conservation of particular natural features or species.

The public land that immediately adjoins the Murray River - both on the Victorian side and on the New South Wales side - and the river itself together form a valuable recreation resource. As yet, the capabilities of this part of the study area for many different forms of recreation are only minimally developed.

Culture

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

Education

Another important use of land in a natural or near-natural state is education. 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 biolog-

Both Victorian and New South Wales river red gum forests abut the River Murray ical processes. In some circumstances, laboratory facilities and associated accommodation are needed so that successive groups can undertake long-term studies. This may require land to be specifically set aside for education.

Viability

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

Different natural systems have different degrees of stability. In some of the most vulnerable, stability depends on a particular facet, such as specialized vegetation; others may have inherent topographic, soil, or hydrological weaknesses.

The viability and effectiveness of conservation areas therefore depend on a number of factors, including the size of the area, the type of community, ecosystem, or features to be conserved, the degree to which the area can be managed to control influences that upset the natural balance, and the usage of surrounding land.

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

Small areas can nevertheless contribute to nature conservation or the preservation of particular features. These include narrow reserves along streams, roadsides, and railways, and many of those set aside in the past - for instance, gravel, water, cemetery, school, and camping reserves. Where these small areas retain native vegetation - and are surrounded by cleared and developed land - they can make a contribution to the regional character of the landscape. They are also often the only refuges for populations of the remaining native animals.

Narrow strips of native vegetation are valuable for migratory and nomadic birds and as wildlife 'corridors' for small animals. This applies particularly in those parts of the study area that are predominantly agricultural.

Careful management may enable small areas to remain viable. Management may take the form of using controlled fires to change vegetation, culling animal populations, practising silviculture, strictly controlling the number of visitors, fencing to exclude introduced animals, eradicating introduced species, and preventing rubbish being dumped in the area.

In the past, many such areas have not been properly administered nor have they been well known to the public. Because of this, they have not been used as they might have been, nor have they been as secure from alienation or despoliation as they should have been.

Types of Reserve

Many of the uses discussed above are complementary, and this is reflected in the types of reserves into which natural land is placed. In reference areas, where the emphasis is on the retention of natural conditions, conservation of species and water production are the only other compatible uses.

Parks, however, encompass a wider range of uses - conservation of plants, animals, and land forms; differing forms of recreation; education; and other uses such as preservation of important landscapes and historical sites. There are different types of parks, and individual parks are zoned to reduce conflict between uses.

In wildlife reserves, the conservation of species of animals and their habitats is the main aim, and this may sometimes be compatible with recreation.

Education areas may need to be set aside where alterations to the environment for experimental purposes - not permitted in parks or other reserves - can be carried out. Other types of reserves that may be proclaimed include flora, flora and fauna, bushland, streamside, scenic geological, and historical reserves.

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15. RECREATION

Recreation can be defined as any activity (or planned inactivity) undertaken for pleasure during a person's leisure time. This chapter concerns outdoor recreation, and those activities carried out on public land, and should be read in conjunction with Map 10.

Resources for outdoor recreation include both natural and man-modified landscapes such as forested and cleared lands, water bodies, and air space. The recreation resource itself is a combination of physical and biological features and the ability and desire of man to appreciate or use it. The attributes that comprise the resource are often the same as those for other forms of land use, such as forestry, agriculture, grazing, and mining. In many cases recreation and other land uses may be complementary, but occasionally they compete and certain conflicts must be resolved.

The Murray Valley area has many fragmented and scattered blocks of public land containing a variety of recreational features. Many active recreational pursuits here are water-based, and consequently most of the rivers, lakes, and swamps are popular recreation areas. The Murray River attracts the greatest number of visitors, as it is suitable for a variety of activities and is readily accessible from a number of population centres, including Melbourne.

Few rugged areas suitable for adventure-type land-based pursuits occur, but the extensive areas of river red gum forests and even the rural environment provide opportunities for many forms of recreation. Public lands also provide scope for the study of Aboriginal cultural heritage. The local Aborigines, for instance, consider that the Barmah forest is a storehouse containing many examples of their cultural heritage. In addition, public lands contain relics of the early European pioneering, settlement, sawmilling, and river-boat days.

Recreation demand

Even if the popularity of various outdoor recreation activities remained constant, it could be expected that demand for recreation resources (much of which will need to be provided on public land) would increase as populations and their discretionary income and leisure time increase.

Since the 1970s tourism has been actively promoted as an industry in the area. Echuca's annual Rich River Festival, commenced in 1971, provides an example, together with the opening of the Port of Echuca in 1974 as a tourist attraction.

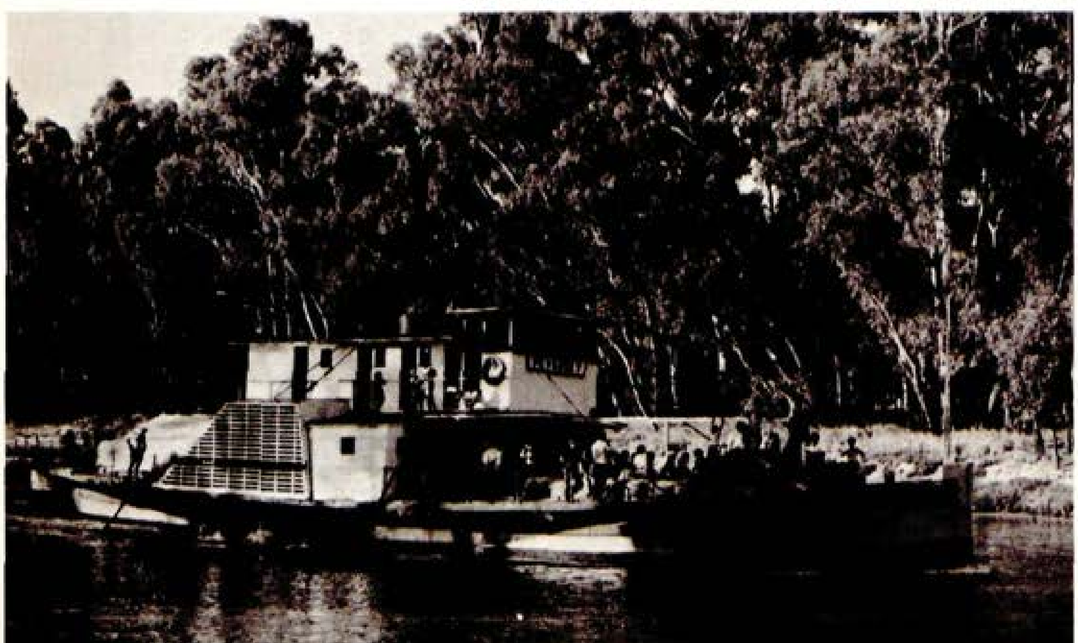
This emphasis on tourism has in turn led to the development of facilities to cater for it, especially accommodation and recreation facilities in places such as Rutherglen, Echuca, and Shepparton.

An organization aiding the dissemination of tourist information is the Goulburn Valley Tourist Authority, a partnership between State government, local government, and the private sector.

It appears unlikely that the local population will have a major influence on increasing recreation demand in the short-term future. With a shorter working week and the existing road access to the region, most of the future demand for its recreation resources will probably be generated by residents of metropolitan Melbourne seeking opportunities for nature-based recreation.

Environments

Definitions of several environments, and of the various recreational activities and their requirements, will make it easier to understand the recreational potential and types of recreational use.



Paddle-steamer rides form a popular tourist attraction

Urban

Cities and townships in the study area offer facilities for formal activities such as tennis, golf, bowls, and football, as well as parks and playgrounds for more passive recreation. These user-oriented resources are located close to the home base, enabling ready access and a high frequency of use. Most of them have been developed on public land, usually by municipal councils.

Urban environments also include many tourist-oriented facilities - such as caravan parks, historic parks, museums, galleries, and ornamental gardens.

The Echuca area is probably the most popular for tourists, with many historic attractions associated with the Murray River paddle-steamer trade of the late 19th Century.

Agricultural

A large proportion of the study area is agricultural land, characterized by extensive clearing or alteration of the natural vegetation. Because of the general lack of features, and problems of access through private land, the open landscape of the broad plains does not have a high potential for recreation.

Viticulture around Rutherglen provides recreation opportunities for the wine-loving tourist, seeking out the wines of individual vineyards. Rutherglen's popularity with wine-lovers was enhanced after the first Rutherglen Wine Festival of 1967. This festival continued on a biennial basis until 1975, when it was replaced by the Winery Walkabout.

Forested

Usually located on public land, the forests within the Murray Valley area generally belong to two types: the river red gum and the box--white cypress pine--stringybark--ironbark forest types and associations.

River red gum forests mainly grow along the margins of river and streams. They usually contain wetland areas, are traversed by many effluent creeks, and have an abundance of associated wildlife, especially waterfowl.

The box--white cypress pine--stringybark--ironbark forest types and associations offer less diversity of recreation pursuits, because they generally occupy the drier or unflooded areas. Yellow, grey, and black box eucalypts usually adjoin the river red gum forests on areas that are rarely flooded.

Also these box eucalypts form pure or mixed stands on the sandhills located within the river red gum forests.

The larger blocks of forested pubic land contain a range of recreation resources: geological, floral, faunal, and water-based. Such resources provide opportunities for hunting, horse-riding, nature study, bushwalking, camping, and canoeing.

Often these forested areas provide the venue for extended trips. For example, the Gunbower and Barmah forests are popular with hunters and campers, who visit for the week-end or an extended stay.

Forested areas form an important part of the landscape here. Local residents use them intensively on a day-to-day basis for activities that include picnicking, nature study, pleasure driving, riding motor-cycles and horses, orienteering, jogging, shooting, and walking. The same resources provide forestry, firewood, flood mitigation, bee-keeping, and grazing.

Rivers, lakes, and swamps

Much of the active recreation in the study area is water-based. The rivers, natural lakes, reservoirs, and swamps have always been popular attractions for fishing, swimming, shooting, boating, picnicking, and canoeing.

The activities allowed depend on the use for which the water is intended, and to some degree on physical parameters, such as the size of the water body. Access to urban supply reservoirs is normally restricted to protect water quality. Irrigation supplies have fewer restrictions and many of these storages - like Lake Mokoan, Lake Mulwala, Torrumbarry

Many of the swamps near Kerang are popular for bird-observing - ibis, Kerang

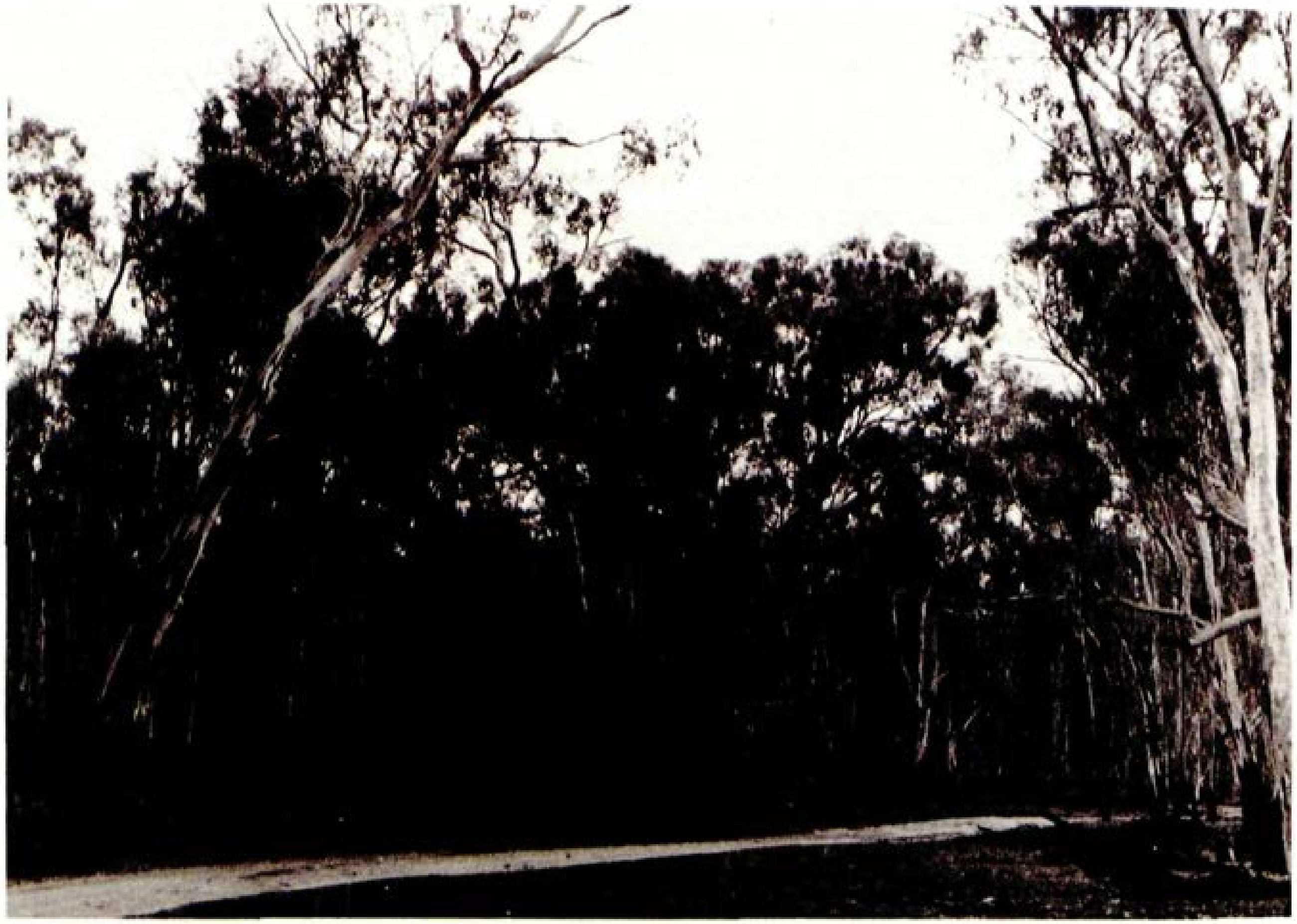
Weir, Kow Swamp, and Waranga Reservoir - are very popular.

Main Public Land
Recreational Resources

Barmah State Forest

Often referred to as the 'Jewel of the Murray', this 29,000-ha reserved forest provides opportunities for a wide range of recreational activities. These include camping, boating, pleasure driving, trail-bike riding, fishing, hunt-

The Barmah Forest, where river red gum reaches its best development as a forest species



ing, nature observing, picnicking, and swimming.

The waterfowl and birds of Barmah Forest are a major recreation attraction. The forest affords breading habitat for many birds and mammals, including kangaroos, emus, eight varieties of bats, and water birds. Wild duck and ibis are particularly common; the ducks provide game for hunters and the ibis are acknowledged as important predators of crop pests.

A network of roads and tracks, many of which are sign-posted, ensures good access within the Barmah Forest.

Popular areas in the Forest include the Barmah Lake, Barmah Island, Top Island, The Gulf, and Buck's Sandhill. Most of

The Barmah cattle muster is a noted tourist attraction

the public land immediately abutting the Murray River is used for recreational purposes.

The Forest also contains a wealth of history, both European and Aboriginal. Landing sites where paddle-steamers loaded red gum logs for transportation to the sawmills, old sawmill sites, and cattle yards recall European history, while examples of Aboriginal history include midden sites, burial sites, canoe trees, fish weirs, and meeting places.

Munroe's pile, Tingates pile, and a number of other river red gum trees with superior dimension and form are located here. A noted tourist attraction is the annual Barmah cattle muster, held in May each year.

Recreational use of Barmah State Forest is high during the Christmas and Easter holidays, and large numbers of shooters visit the forest to hunt duck in the open season. Use falls markedly from April to October, however. It has been estimated at some 5,700 visitor-days and 33,600 camper-days annually. To cater for this usage, the Forests Commission maintains 45 picnic tables and 75 fire-places, as well as toilet facilities and a number of informal information boards. The Commission has recently appointed a Ranger for the Barmah Forest.

Similar recreational usage occurs in the river red gum forests immediately across the Murray, in New South Wales.

Gunbower Island State Forest

This State Forest provides recreational experiences similar to those of the Bar-mah Forest.

Wildlife abounds, and many secluded fishing spots are to be found along the Murray River. The convoluted course of the Murray here and the many streams and swamps that occur within the Gunbower Island Forest add to its recreational attraction.

Its most popular area is in the vicinity of the Torrumbarry Weir, where water-based recreation such as boating is con-centrated. The Forest contains a network of roads and tracks, many of which are sign-posted, and they facilitate access.

Duck-hunting is carried out in Gunbower Island Forest, except in the wildlife sanctuary where, under the *Wildlife Act*, no person shall hunt or wilfully disturb wildlife.

Gunbower Creek is used for water-skiing in summer as it remains deep, unlike the Murray, which in some years can be too shallow to allow water-skiing.

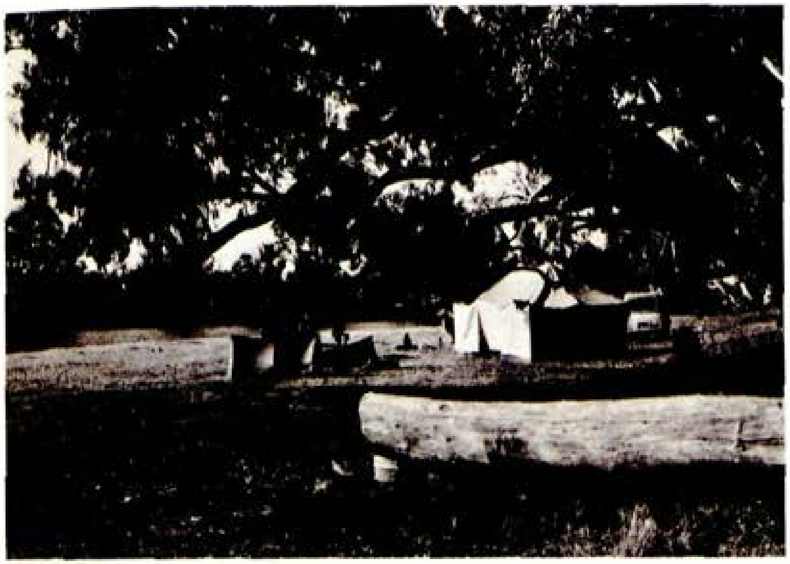
Recreational usage of the Gunbower Is-land Forest, including the Guttrum and Benwell forest areas, has been estimated at some 42,600 visitor-days and 81,200 camper-days annually.

To cater for this usage the Forests Com-mission maintains 145 picnic tables and 170 fireplaces, most of which are locat-ed beside the Murray River. Eight in-formation shelters provide interpretat-ive facilities.

Similar recreational usage occurs in the river red gum forests immediately across the Murray, in New South Wales.

Murray River environs

Other public lands along the Murray River are also intensively used for rec-reation experiences. Small areas of re-served forest such as the Guttram, Ben-well, Cobram, Yarrawonga, Wharparilla, and Ulupna Island forests are scattered along the river. These are used for fishing, camping, boating, swimming, shooting, and pleasure driving.



Camping along the Murray is extremely popular form of recreation - Carters Beach, Ulupna Island

Public lands abutting the Murray in the Ulupna Island--Yarrawonga stretch are heavily used for recreation, estimates of usage being 47,500 visitor-days and 64,000 camper days. These figures reflect the popularity of the numerous sandy beaches along this section of the Murray River. These attractive sandy beaches include Carters, Lovetts, and Bourkes Number One, Two, and Three.

The Ulupna Island Public Purposes (Preservation of Flora and Fauna) Reserve, north of Strathmerton, is well known for its scenic and floristic values and is managed by a local committee of management.

The Shire of Cobram has permissive occupancy of Horseshoe Lagoon near Cobram, which contains an artificial lake site that is being developed for tourism. School and Scout groups also regularly use Cemetery Bend for camping and other recreational purposes.

Estimates put recreation use of public land abutting the Murray near Rutherglen at 9,000 visitor-days and 6,800 camper-days annually. This part of the Murray does not have sandy beaches. Popular areas are Police Paddock, Doolans, and St Leonards Winery. Lake Moodemere is very popular for swimming, water-skiing, rowing, and bird-watching.

Water-skiing on Lake Moodemere

66163/83—13

Ovens River

Public land that abuts the Ovens River near its junction with the Murray carries river red gum. It is popular for camping, fishing, swimming, canoeing, trail-bike-riding, and duck-hunting. Its most notable feature comprises the many islands and river courses of the Ovens here.

Recreation usage of this public land is estimated to be 3,200 visitor-days and 9,400 camper-days annually. It mainly occurs in the summer and Easter holiday periods and long week-ends.

Terrick Terrick State Forest

Characterized by its white cypress pine--grey box vegetation, this area of public land, located on a granitic outcrop, provides landscape relief from the surrounding flat plains. Recreation usage is mainly restricted to day visitors, estimated at 2,500 yearly, who mainly picnic at the Terrick Rocks Reserve. The lack of natural water restricts camping.

Mount Terrick Terrick affords commanding views of the surrounding plains.

Goulburn River

The public lands located along the Goulburn River are popular for duck-hunting, camping, fishing, boating, swimming, picnicking, and trail-bike-riding. They provide an important recreation resource for the people living in the cities of Shepparton and Echuca.

Popular areas for camping are the junction of the Goulburn and Murray Rivers, Bangarang Park, and Ashes Bend. Loch Garry is popular for bird-observing, picnicking, duck-hunting, and fishing.

Access to public land along the Goulburn River is much more restricted than along the Murray River. Often the only access is through private property.

Recreation usage for these public lands is estimated at 15,400 visitor-days and 28,400 camper-days annually.

Killawarra and Warby State Forests

Extensively used for both recreation ad environmental education, these are popular for pleasure driving and picnicking. Killawarra State Forest is very popular for orienteering. The Warby fire tower provides excellent views of the Eastern Highlands and the Ovens River Valley.

Recreation usage here is estimated at some 15,600 visitor-days annually.

Lake Mokoan

Lake Mokoan is the fourth-largest lake in Victoria. Situated just north of the Hume Highway between Benalla and Glenrowan, it is in open grazing land except for a small zone of State reserve on the northern side. Much of the lake is studded with dead trees, and fences cross it in many areas. Because of these hazards, a speed restriction to 8 km per hour applies over most of its surface. It is very windswept and reedy, and water birds abound.

The lake is very popular for sailing and with shooters during the duck season. It is also popular with fishermen.

Warby Range State Park

This Park extends for 27 km north from the township of Glenrowan. It lies on a steep scarped range known locally as the Warbys, and forms the divide between the Broken and Ovens Rivers. The Range has an elevation of between 300 and 400 m above sea level and features a series of rocky prominences, steep escarpments, and eroded plateau, which stand about 180 m above the surrounding plain.

Warby Range State Park covers 3,270 ha altogether, and consists of four areas separated by freehold land. It offers excellent vantage points (especially at Mount Glenrowan), pleasant picnic spots, an outstanding variety of bird life, and clumps of unusually tall grass-trees.

The flora of the Range is more prominent in the winter and spring, when nodding blue-lily, common fringe-myrtle, daphne heath, guinea-flowers, grevilleas, and orchids flower. The spur-wing wattle and the sandalwood have their only Victorian occurrence in the Warby Range.

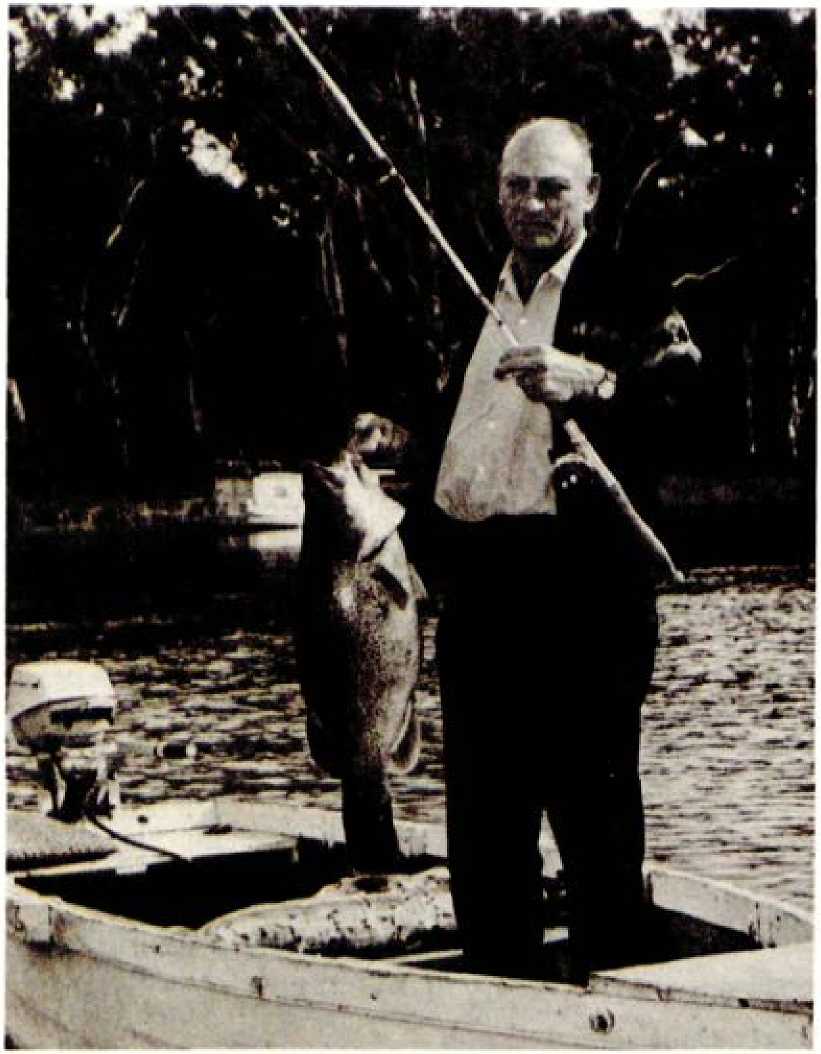
Ryans Lookout, in the Warby Range

Recreation facilities have been developed in a number of sections. They include the Pine Gully nature walk, Pine Gully picnic area, Jubilee Falls picnic area, Ryans Lookout, and Salisbury Falls walking track. Recreation usage of the Park over the last 3 years has averaged some 6,600 visitor-days annually.

Other public land reserves

Many other parcels of public land in the Murray Valley have been reserved for recreation or for other purposes associated with recreational usage. None of these reserves cover substantial areas.

The Forests Commission has a number of reserves (under section 50 of the *Forests Act* 1958) in the study area: Gemmill Waterfowl Reserve, Native Water Wells Reserve, Shepparton Flora and Fauna Reserve, Shepparton Urban Waterworks Trust area, Village Scenic Reserve, and the Terricks Rocks Reserve. None of these covers a substantial area; they have been reserved mainly for their scenic and floristic values.



New South Wales Public Land

As mentioned earlier in this chapter, the New South Wales public land that abuts the Murray River provides similar recreation resources - used by recreationists in a similar manner - to those on Victorian public lands abutting the Murray.

The forests on these New South Wales public lands are a recognized tourist attraction, providing for the recreation of people from towns such as Deniliquin, Barham, Mathoura, and Echuca. Their most attractive features are the waterways, lakes, and lagoons they contain. They are easily accessible, as they are well roaded.

Camping occurs extensively in the forests, with popular locations all along the Murray River, particularly adjacent to Fisherman's Bend, Edward River in the vicinity of the old Murray Management Survey Camp, Gulpa Creek, Barmah Beach, Campbells Island State Forest, and Koondrook--Perricoota State Forest.

Fishing is a major attraction. Fishermen may or may not use boats, which they occasionally launch from the forests. The Murray is the most popular fishing water, but the various lagoons and larger effluent creeks contained within these forests are also used.

Hunting also attracts a large number of visitors here, usually to hunt duck, but also pigs. Duck habitat has probably been increased by the increased summer flows of the Murray River and the consequent enlargement of still-water areas in the lakes and swamps. Unfortunately, it is believed that hunting is associated with some incidents of vandalism that occur in the public lands.

Other activities, such as pleasure driving, picnicking, swimming, and sightseeing, are very popular recreation activities.

Swimming and picnicking are usually family affairs, as they are in Victoria, and usually take place close to a town at locations that include a good beach for example, Barmah Beach.

The many miles of attractive river frontage and secluded creek and lagoon sites allow people to picnic or observe wildlife.

Recreational Activities

Bushwalking

A variety of walking activities, whether involving overnight camps or short walks with interpretive services provided, are undertaken on public land in the area. They are mainly restricted to short hikes and walks to sites of interest or for nature study. Few are strenuous, as the vegetation is generally open, and often tracks make for ease of walking.

A number of tracks constructed in the Warby Range State Park provide pleasant walks to scenic features.

Camping

Although informal camping takes place on public land throughout the study area, it is overwhelmingly concentrated along the Murray River.

It mainly occurs on undeveloped sites or sites with few facilities, and usually in conjunction with fishing or hunting expeditions.

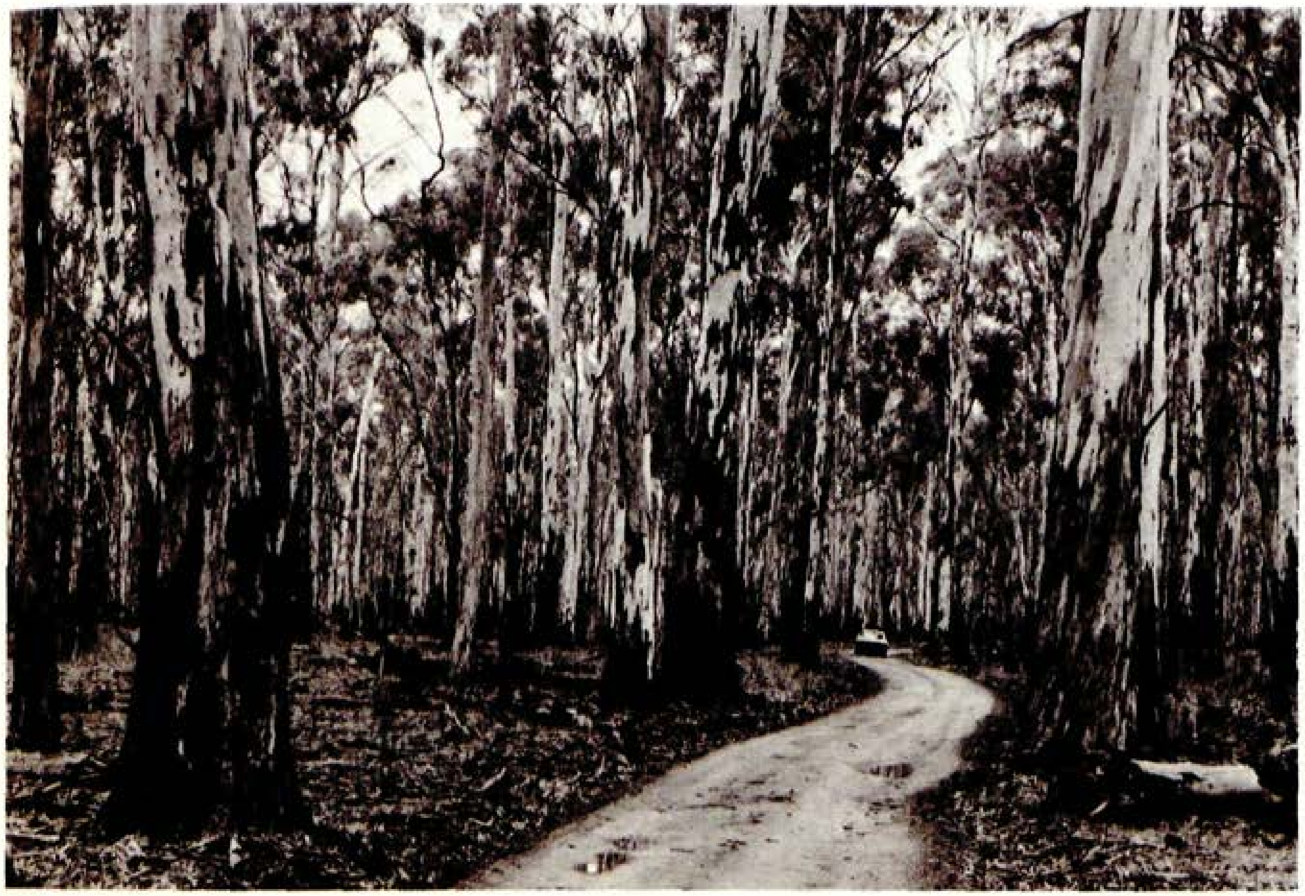
Most of these campers are entirely self-sufficient and provide their own sanitary facilities and other camping comforts. They often use portable generators to power lighting, cooking, and refrigeration equipment.

It is not unusual for people who camp on public land abutting the Murray River to return to the same location each year for their annual holidays. At any one site campers are usually well acquainted from years of camping near each other. A number of Shires operate camping and caravan parks with full facilities, including powered sites, on public land here.

The Boy Scout Association leases public land at Kialla and Cohuna for purposes of camping. The Girl Guides Association's Algerinda Camp is located on public land in the Warby Range.

Most of the formal camping and other accommodation facilities are located on private land. The many caravan parks, motels, and holiday flats offer everything from a bush retreat atmosphere to

The Barmah and Moira Lakes areas - popular for camping, fishing, and duck-hunting



Pleasure driving is popular in river red gum forests

a lakeside holiday. Some commercially run camps distinguish themselves from the others by offering a range of additional activities. For example, they may offer safaris or hunting expeditions or a greater range of recreational facilities. In all cases, parties use camps as bases for recreation and for excursions to surrounding places of interest. In most cases, they also make use of nearby public land for fishing, hunting, horse-riding, walking, nature study, and swimming.

Pleasure driving

A survey carried out for the Department of Youth, Sport and Recreation by McKenry (1975) showed that 86% of the sampled Victorian adult population had been pleasure driving in the country at least once in the preceding 12 months.

This does not mean that all of these people toured through public land in the Murray Valley area, but it does provide a measure of the popularity of pleasure driving, which was the most popular pastime recorded.

The study area offers a variety of tours over a well-maintained road system. The River Track through the Gunbower Island State Forest offers the tourist excellent opportunities to view the forest sights, and numerous branch tracks leading from it allow ready access to the Murray River. Similarly, the main access tracks through the Barmah State Forest offer the tourist excellent views and access to the numerous lakes, swamps, and creeks as well as the Murray River.

Local pleasure driving is also common in the Warby Range, attractions being the scenic views and the wildflowers when in bloom.

Motor-cycling

Trail-bike-riding is popular. This form of recreational riding may present certain problems to the land manager in terms of road damage and off-road activities, as well as those of unlicensed riders and unregistered vehicles. Under the *Land Conservation (Vehicle Control) Act* 1973, no vehicle (four-wheeled or two-wheeled) may leave a formed road, except with permission, and only registered drivers may use roads on public land. The Echuca District Motorcycle Club leases an area of public land north of Echuca Village for a scramble track.

Orienteering and jogging

The popularity of orienteering is growing. Orienteering groups use areas such as the Warby Range and Killawarra State Forest. Indeed, the Australian Orienteering Championships for 1978 were held in the latter. Part of the Warby Range State Park, and an adjacent area of reserved Crown land north of Taminick Gap, is very popular with joggers ad cross-country runners from around Wangaratta.

Organized sports

Throughout the study area, small blocks of public land are used for golf-courses, rifle ranges, football and cricket grounds, race-courses, tennis courts, and the like.

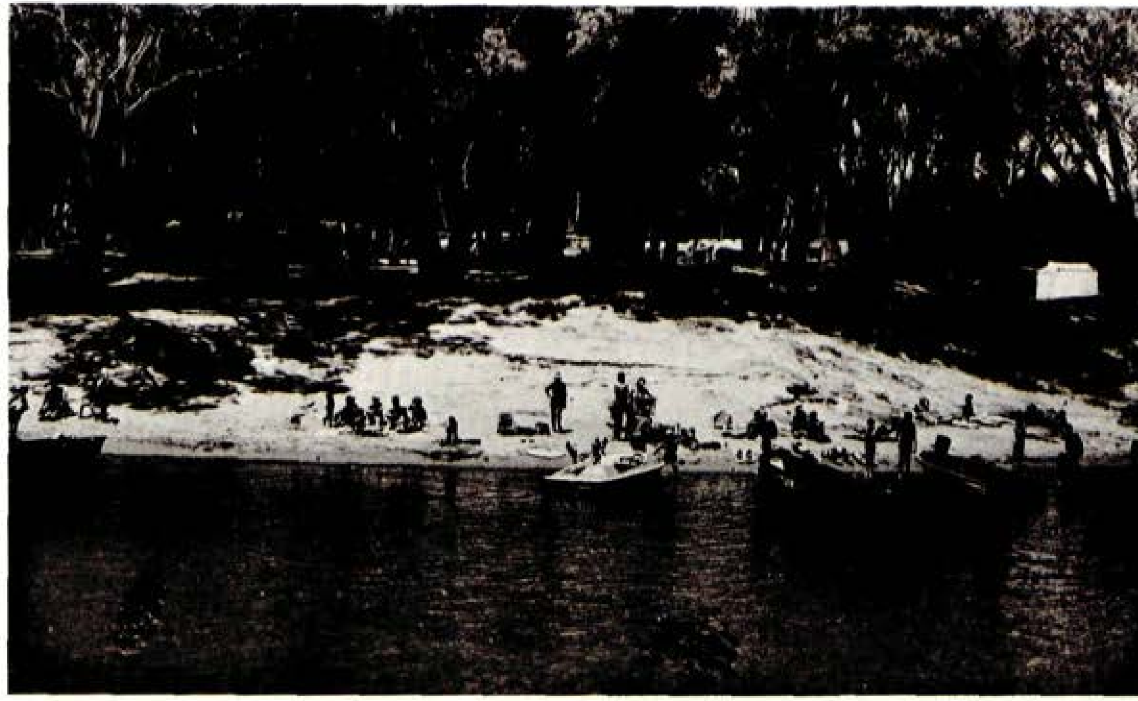
Horse-riding

For many residents (especially children) horse-riding is a popular hobby. From time to time many of these people take rides into nearby bushland. In addition, organized trail rides are conducted through the Barmah State Forest and the Warby Range.

Swimming

The study area, with its rivers and water bodies, has many excellent swimming

Watersports and sunbathing are popular recreational activities along the River Murray



sites. Especially popular are the sandy beaches with road access along the Yarrawonga--Cobram stretch of the Murray River.

Picnicking

Picnic facilities are provided throughout, as shown on the outdoor recreation map. The sites usually coincide with spots of recreational interest - such as Ryans Lookout or Mount Terrick Terrick. Many spots not serviced with any facilities are also popular.

A picnic or barbecue is often the main aim of a day-trip and such outings are frequently associated with pleasure driving.

Nature study

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

Various tracts of public land offer interesting opportunities for the study of natural history. The main recreational resources of the Murray Valley area discussed earlier in this chapter - some with interpetative facilities - are most important in this regard.

Popular bird-watching areas include the Barmah Forest, Gunbower Island Forest, Warby Range, Lake Moodemere, Kanyapella Basin, and Morphett's Swamp. Koalas may be seen in the Warby Range, following

Bird nesting boxes being erected at Morphetts Swamp

their release in the area by the Fisheries and Wildlife Division.

Geological features such as Pyramid Hill, Mount Hope, and Mount Terrick Terrick are of great interest to the naturalist and the general observer.

A wildlife management co-operation project, involving the State Rivers and Water Supply Commission and Fisheries and Wildlife Division jointly, has developed the Kanyapella Basin as an artificially controlled wildlife habitat.

The Basin, east of Echuca, is prone to natural flooding and is timbered predominantly with river red gum. The Commission acquired the Basin in 1967/68 and managed it until the end of 1975, when co-operative management by the Commission and the Fisheries and Wildlife Division was initiated.

Since then, earthworks and embankments have been constructed to allow the pondage of water for waterfowl management. This waterfowl management program started in 1977 and, as envisaged, will provide opportunities for research programs, educational needs, and recreation.

Fossicking

Week-end prospectors fossick for alluvial gold at many of the old goldfield sites near Rutherglen. Also, some fossick for precious stones such as zircon and beryl in the Warby Range.

Hunting

Duck-hunting during the open season is very popular throughout the Murray Valley area, with both local and Melbourne-based shooters. Open season for wild duck is generally declared between March and May. Both public lands and freehold lands are shot over. Local concentrations of game birds occur on rivers, swamps, billabongs, and dams throughout the study area. The irrigation districts are very popular due to the numbers of duck that the water attracts. Of the five State Wildlife Reserves (Morphett, Dowdle, Tragowel, Hird, and Johnson Swamps), only Tragowel Swamp is closed to duck-hunting during the open season.

The main species of duck hunted in the area are the black duck, grey teal, wood duck, and mountain duck. Less common species hunted include chestnut teal, hard-head duck, pink-eared duck, and blue-winged shoveler.

Foxes and rabbits are hunted for sport, for income, and for vermin control. Pigs are hunted in the Barmah Forest.

Fishing

Recreational fishing is one of Victoria's most popular leisure activities; a public opinion poll has indicated that approximately 1 million (35% of the State's population) go fishing at least once a year. Of course, not all of these anglers use the Murray and other local waters for fishing, but a substantial proportion probably would, as fishing is very popular and widespread throughout the area in lakes, streams, irrigation channels, and rivers.

Many Victorians fish the Murray River. As this is New South Wales water, they need an amateur inland fishing licence for New South Wales. They require a Victorian amateur fishing licence to fish all other rivers, streams, and water bodies in the study area.

On the Victorian side, the Murray offers the angler some 600 km of river frontage - most of it public land. The flow of the river is governed by the system dams and weirs, and fluctuations in the river level influence the fishing.

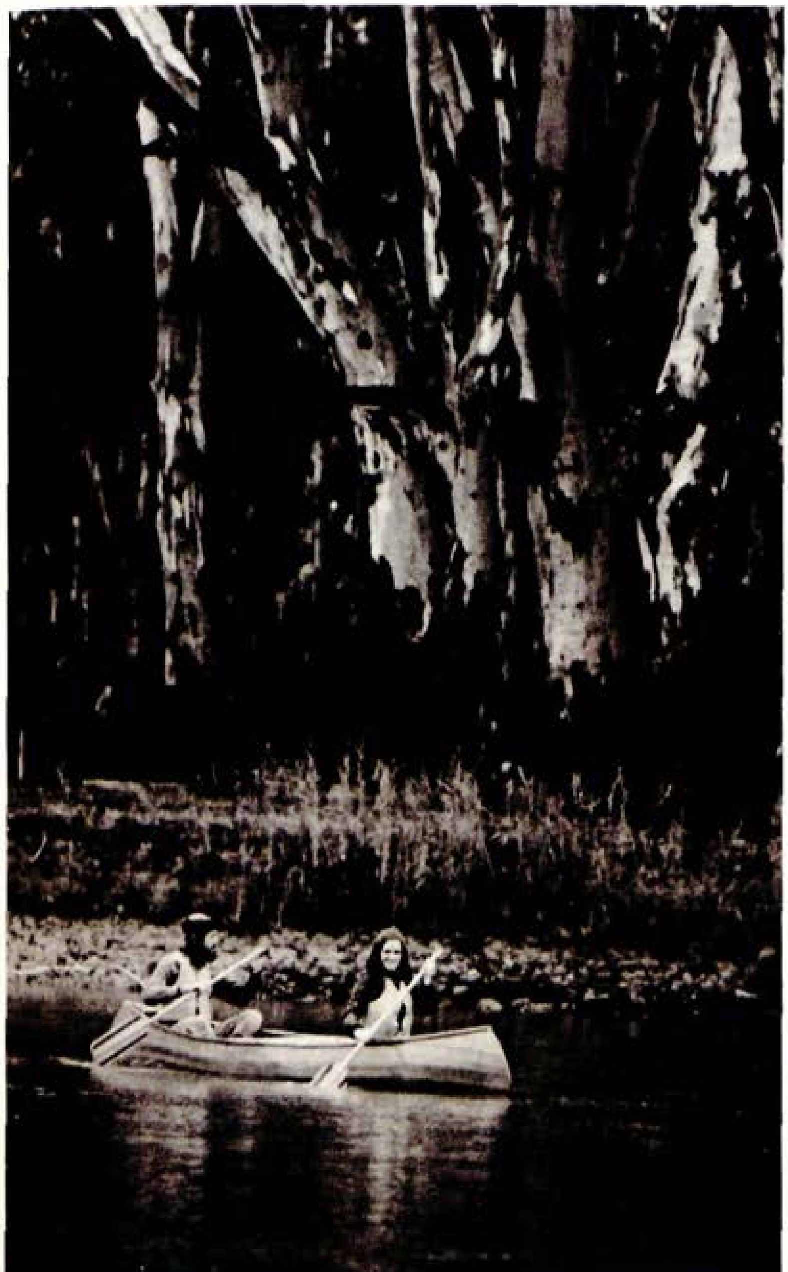
The river is best fished when the level is steady after an increased flow. As the Murray contains snags, the best catches are usually taken from boats. Fish caught in the Murray are Murray cod (ranging up to 52 kg), tench, redfin, crayfish, golden perch, silver perch, European carp, yabbies, and catfish.

The Ovens River is rated average for red fin and high for Murray cod, with considerable potential for Murray perch in the section downstream of Wangaratta.

The Goulburn River is rated high for recreational fisheries associated with Murray cod and golden perch, and also has considerable potential for development and conservation of other fisheries associated with trout, cod, and Macquarie perch.

Although relatively low in sport fishery potential, the Campaspe River has value for redfin perch.

Lake Mokoan is popular for fishing, particularly along the outfall channel,



where good catches of redfin are to be had.

Boating and canoeing

Power-boating, sailing, water-skiing, and canoeing are popular forms of outdoor recreation here.

The Murray River is very popular for power-boating and water-skiing, while Lake Moodemere, near Rutherglen, is popular for both these sports, as is the Goulburn River.

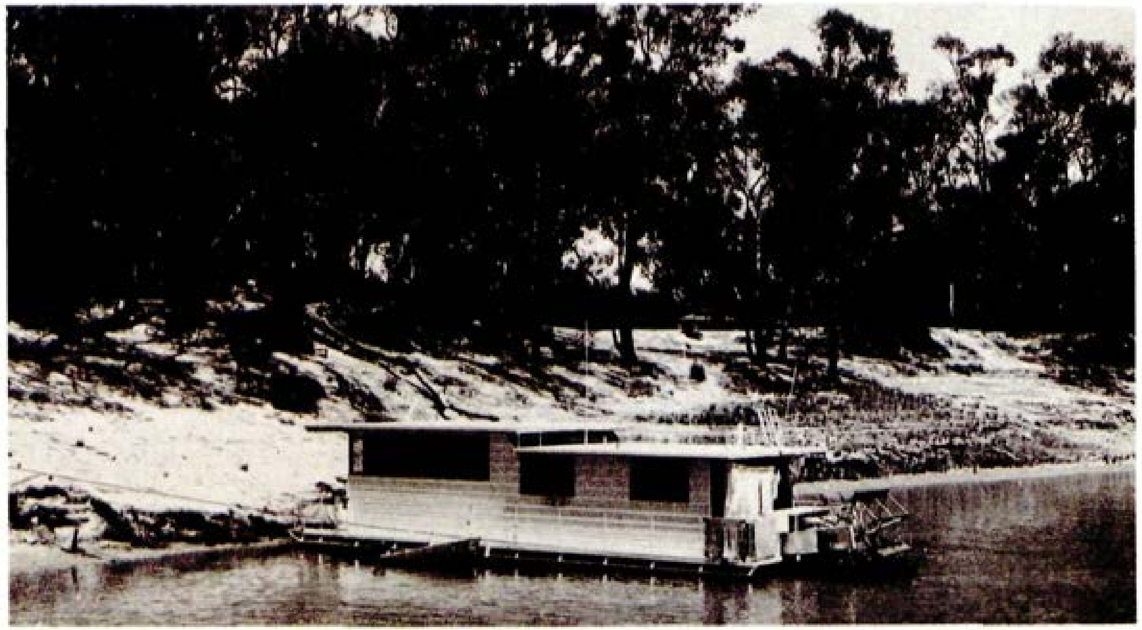
Houseboats on the Murray River are very popular with holiday-makers. They allow freedom of movement along the river and the novelty of a unique form of accommodation.

Paddle-steamer cruises of the Murray - both day and overnight trips - are popular and attract many visitors to the river and to Echuca, where the paddle-steamers are based.

Lake Mokoan provides a popular sailing venue for the people of Benalla and Wangaratta, while Lake Boort is popular with the local people for all forms of water-based recreation.

The reaches of the Loddon, Campaspe, Goulburn, Broken, and Ovens Rivers that traverse the study area are serviceable for boating, but have a low usage level for this purpose because of the generally slow stream flow. The Murray River

Houseboats provide a unique way of exploring the Murray and the local riverine forests



is popular for touring canoeing. Canoeists come from all parts of Austrlia to take part in the annual Red Cross Murray River Marathon - from Yarrawonga to Swan Hill.

Future demand

A number of factors are expected to markedly increase recreation pressures on public land in the study area. Significant population growth in Melbourne and regional centres such as Echuca, Shepparton, and Albury--Wodonga may lead to greater recreational use of this public land.

Other factors increasing the demand for recreation include greater leisure time, mobility, environmental 'awareness', and disposable incomes, combined with improved access and facilities. Planning for outdoor recreation must cater for these increases, but must also be flexible in order to cope with possible changes in the nature of the demand.

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16. TIMBER PRODUCTION

The forests of the Murray Valley area have, since the earliest days of European settlement, been utilized for the production of durable timbers. Victoria is not well endowed with extensive resources of durable timbers: however, the area contains a significant proportion of those it does have, mainly the riverine red gum forests. For this reason, and their accessibility, these forests have been, and remain, important in supplying the demand for durable timber products.

Production levels of the durable timbers from the public land have declined over the last two decades. Despite this declining productivity, the industry still has local economic importance.

History of Timber Production

The forests and woodlands of the area provided the Aborigines with shelter, implements, and food. European settlers brought greater demands, however: initially they took only local building materials and fuelwood, but subsequently they cleared the forests and woodlands for agriculture and cut the trees for fencing materials, for railway timbers, and to supply the timber industry.

From the first days of European settlement, timber production mainly supplied local consumption. From about 1865, however, the advent of river transport coupled with the burgeoning of the State's railway system greatly increased timber production, mainly concentrated on the river red gums beside the Murray. Early production was for sawn sleepers and heavy construction timbers.

The paddle-steamers consumed firewood in substantial quantities in their boilers as they plied upstream and downstream of Echuca - estimates suggest that an average steamer burnt half a tonne of firewood an hour in its boiler.

During the 1870s and 1880s at the height of the river transport era, many sawmills came into existence to cater for the demand. Some were located in the forest, such as those at Barmah and Gunbower Island. Echuca, with its rail link to Melbourne and port facilities, became the main centre for timber production in the area. Its proximity to the Barmah Forest ensured that this was heavily cut to meet the demand.

Generally, local timber production since the 1920s has been controlled. Efforts were made in a number of forest areas to tend the forests and ensure future supplies.

Although the production level of products such as piles, beams, and posts declined as demand for these fell, levels of licensed production steadily increased from the 1920s onwards, reaching a peak in the two decades from 1940 to 1960. This peak was due to wood shortages during World War II and the post-war timber shortages.

Since the 1960s timber production here has steadily decreased, but the demand for the types of timber products the area produces remains strong.

River red gum

Local river red gum forests - the most extensive and most useful of the forest types here - have been extensively harvested since the 1880s. Their timber has been used throughout Victoria for construction, rail sleepers, and harbour construction. During the last 50 years, about 75% of the State's red gum sawlogs have come from the study area.

The timber industry based on river red gum initially supplied the settlers with their firewood and building needs. The first red gum sawmill was established at Moama in 1856.

With the advent of river-boat transport and the rail-head at Echuca, the forests along the Murray River - particularly those located at Barmah and Gunbower Island - were heavily cut.

Cutting was uncontrolled and extremely wasteful. Even when forests were flooded, exploitation went on: tree-fellers stood on specially designed punts that were anchored to either side of the tree to be felled. This resulted in considerable waste, as stumps up to 3 m in height were occasionally left.

The river boats, powered by red gum firewood, dragged immense quantities of timber away from the forests, to be sawn at Echuca.

In addition, river boats transported sawn red gum to the rail-heads from sawmills located in the forests along the Murray River.

Felled trees were dragged to the river's edge by bullock teams, then attached to barges for transportation by steam tug, either up- or down-river, to the mill.

These barges were huge flat-bottomed craft with outriggers, and large logs were suspended from outriggers by chains (red gum logs do not float). A steam tug then towed up to three or four barges to the mill. Sometimes the operator let a barge float downstream with a large chain dragging from its stern to stop it from running aground. (The chain followed the deepest channels in the river.)

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The use of steam tugs and barges to transport the logs to the sawmills relied on the regular spring floods. Also, man-made canals called pontoon cuts were constructed so pontoons could be floated in to bring the logs to the river bank. These canals or pontoon cuts connected many of the shallow creeks, while through the Barmah Lakes there still exists a channel known as the steamer track, which connects with Cutting Creek.

Although the river transport system had seriously declined by the early 1900s, timber production in the forests along the Murray River continued, as the railroad system had already been extended to the areas previously served by the river boats. Bullock teams provided transport to the railhead.

In addition to sawlogs, river red gum was cut for hewn sleepers, but this production did not reach significant levels until the 1920s.

Red gum poles, piles, and beams were initially produced to construct wharves for the river boats, and production increased from 1865 to supply material for the Geelong and Melbourne harbour works. Since 1926 only minor quantities of these have been produced from the red gum forests.

Fencing materials have always been sought by farmers, and their production from red gum forests over the last century has always been significant.

Red gum poles were first used to support telegraph lines during the early 1900s and power transmission from about 1920.

With the introduction of the barrow saw (swing saw) in the 1950s for the production of sleepers, sleeper offcuts became available. These offcuts have been and are still in demand because of their suitability for landscaping and garden purposes.

The river red gum woodchip industry (produced using sawmill waste) commenced in 1979. These woodchips have found a ready market as a garden mulch and for landscaping. Currently production is 17,000 tonnes per year.

Charcoal production from river red gum timber has spasmodically taken place since the 1930s, but production has been generally low.

During the 1920s kino, a red gummy exudate rich in tannins, was produced from red gum. In 1928/29, some 2,300 kg of it was produced for use in the tanning industry.

Since settlement, the swamps away from the main river courses have provided a minor source of river red gum. Over the years, many of these swamps have been used to store irrigation water or as pondage for drainage water. This use has often resulted in the loss of productive areas of river red gum or, as is the case in Lake Mulwala, killed the

Coy's mill, Barham, 1911 - typical of the early sawmills on both sides of the river

Black box is popular with local farmers, for use as fence posts

stands by flooding or made them inaccessible.

Estimates suggest that, since timber utilization began in the 1860s, 2.5 million cubic metres of river red gum logs have been removed from the Barmah Forest.

Other durable species

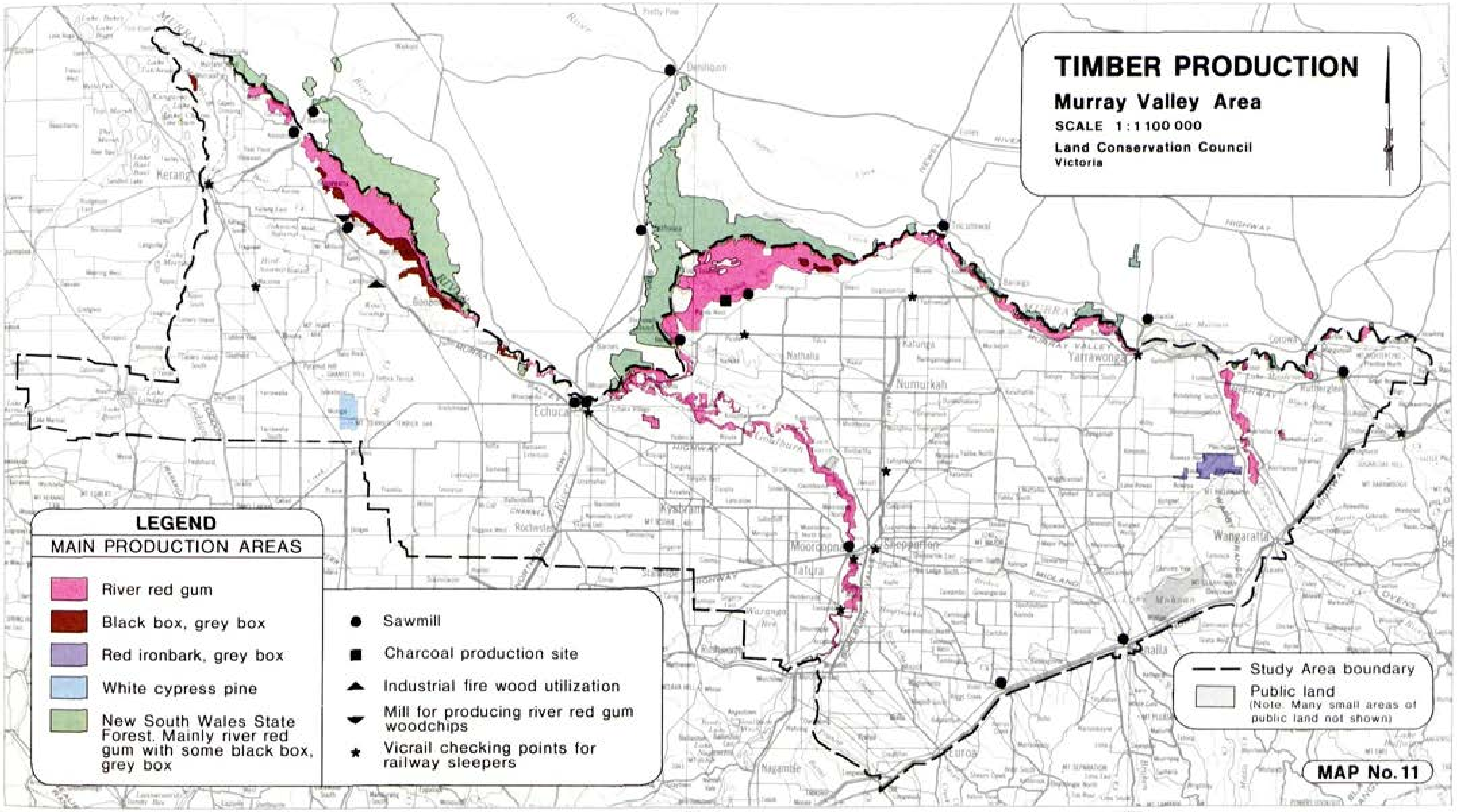
Forests of other durable species - of box, ironbark, stringybark, and white cypress pine - mainly grew on the riverine plains or the highland remnants when Europeans settled the area. They were initially utilized for fencing materials, firewood, and, in the case of white cypress pine, for house construction. Since settlement, clearing for agriculture and utilization for timber products has limited these forests mainly to public lands.

Such an area of public land is the Warby Range, where red stringybark and white cypress pine have been intensively milled while red box was used for durable fencing. Much of the Blakely's red gum has been cut for firewood. This has resulted in the present poorly formed coppice regrowth that occupies the Range.

The Killawarra Forest has also had a long history of timber production, being cut for red ironbark and grey box sleepers, fencing material, and poles. During World War II alien camps were located in the forest for the detention of Italian males who were not naturalized Australians. These people cut firewood and produced charcoal from the forest.

In the 1960s large quantities of grey box posts were cut from Killawarra for re-fencing work at Dookie Agricultural College, and sleeper-cutters utilized mainly red ironbark.

Terrick Terrick Forest has suffered similarly; its white cypress pine was frequently used in early times for house construction, often in the round form or sawn from flooring boards. The present regrowth white cypress pine forest there has been progressively thinned for round fence posts and rails since 1930: annual



TIMBER PRODUCTION
Murray Valley Area
SCALE 1:1 100 000
Land Conservation Council
Victoria
LEGEND
MAIN PRODUCTION AREAS
River red gum
Black box, grey box
Red ironbark, grey box
White cypress pine
New South Wales State Forest. Mainly river red gum with some black box, grey box
Sawmill
Charcoal production site
Industrial fire wood utilization
Mill for producing river red gum woodchips
Vicrail checking points for railway sleepers
Study Area boundary
Public land
(Note. Many small areas of public land not shown)
MAP No. 11
Kerang
Echuca
Numurkah
Yarrawonga
Shepparton
Mooroopna
Tatura
Wangaratta
Rutherglen
Corowa
Tocumwal
Deniliquin
Kyabram
Rochester
Nathalia
Katunga
Euroa
Nagambie
Benalla
MURRAY
HIGHWAY

production of some 5,000 such posts in the early 1960s has increased to 17,000 over the last 5 years. This increase reflects the demand for durable fencing materials and the general scarcity of timber in the surrounding cleared plains country.

New South Wales forests

River red gum forests across the river on New South Wales Crown land have had a similar history.

In the early settlement days they formed part of grazing runs or leases - in some cases, Improvement Leases. As the need for retaining forest land as such was realized, these areas were made Timber Reserves and finally, during the period 1914 to 1924, State Forests.

Exploitation of these New South Wales river red gum forests commenced in the latter half of last century. A shortage of durable hardwoods in Victoria, combined with the presence of a convenient natural system for water transport, resulted in the establishment of a milling industry - which rapidly grew as settlement proceeded. Mill logs were obtained mainly from areas immediately adjoining the river, because of the easier access and the superior nature of the trees there. Fellers operated on a basis of single-tree selection, without regard to good forestry practice. This type of exploitation continued up to the early 1900s.

The first attempt to manage the forests came in 1914, when Surveyor Harnett carried out topographical surveys of the main river red gum forest areas, including broad mapping of forest types. These surveys formed the basis for working plans prepared in 1918.

Estimates of 2,000 to 3,000 super feet Hoppus per acre merchantable volume (with a 300 to 350 super feet annual increment) were assumed, and the plans prescribed the removal of the merchantable volume over a period of 10 years. Fortunately, the milling industry was not expanded to consume the very high yield calculated. Despite this initial attempt at management, timber production

New South Wales forests supply some 60% of river red gum sawlogs cut locally was generally confined to the most convenient areas and the plans lapsed.

Selective logging, mainly under licence, continued up to 1947. In 1944 the Murray Management Survey was instituted, to carry out investigations necessary to introduce improved forest management here. The survey culminated in the preparation of a management plan for the river red gum forests, introduced in 1953. Besides prescribing the yield, the plan provided for the maintenance of adequate management records, the construction of improved access, and the logging of the management area by an order of working designed to achieve the maximum forestry benefit.

Today the river red gum forests that abut the northern bank of the Murray River produce significant quantities of timber and are managed by the Forestry Commission of New South Wales under its Murray Management Area Management Plan, which is currently being revised.

Current Timber Production

The forests

Responsibility for wood production from Victorian State forests rests with the Forests Commission. Timber products supplied to industry from within the study area include sawlogs, poles, piles, sleepers, bridge timbers, landscaping material, fencing material, and firewood.

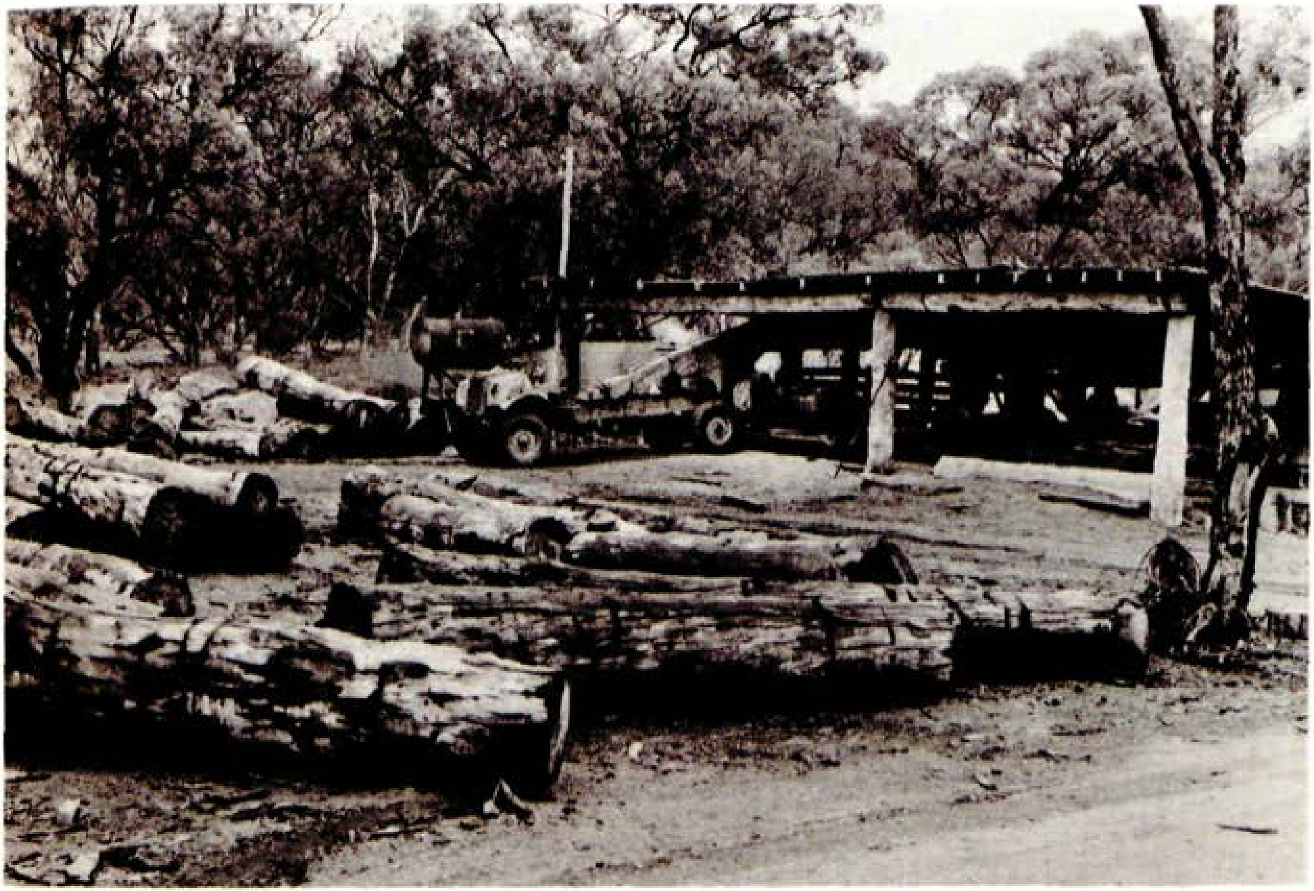
Most of the public land available for timber production is on the flood plain of the Murray River and its tributaries (see Map 11). The main forest areas are at Barmah and Gunbower, with smaller occurrences along the rest of the Murray and along the Goulburn and Ovens Rivers. River red gum is now the only species providing sawlogs, piles, and large-dimension bush-sawn timbers.

The stringybark forests of the Warby Range have also been intensively utilized, and most of that forest is now regrowth with little material presently of sawlog size. The box--ironbark forests at Killawarra (north of the Warby Range) are also predominantly regrowth, and present utilization is mainly for durable fencing materials.

White cypress pine occurs in isolated stands throughout the study area, but the only large stand on public land is on granite hills north of Mitiamo. This species is highly prized for its beauty and durability, and is now mainly used for durable farm timbers.

As little privately owned forest remains here, the forests on public land are locally important for the supply of timber products.

The natural durability of the main timber species present makes them suitable for such purposes as construction timbers, sleepers, and farm timbers, where durability and strength are required.



River red gum at the mill, Picola North

Production levels

Victorian State Forests in the study area supply a range of wood products, shown in Table 18.

The levels of production of the various products have altered over the years, in response to both demand and the capacity of the forest to supply. Regeneration has generally followed harvesting, and total growth undoubtedly exceeds harvesting rate. The lack of a market for small-sized material has, however meant that the thinnings necessary to concentrate growth on selected stems have not been carried out. There is therefore a shortfall - at least in the short term - of larger-sized trees suitable for piles, sawlogs, and sleepers. Demand for these products is presently much higher than the permitted harvesting rates.

Sawn timber

Sawlogs are obtained from river red gum. Most of the timber is used in the Melbourne area for specialist purposes - house stumps, fence posts, landscaping, and specialty furniture - or by the Victorian Railways as heavy construction timber and sleepers. Since 1970 the study area has produced some 90% of the annual total of red gum sawlogs harvested under licence from Victorian forests.

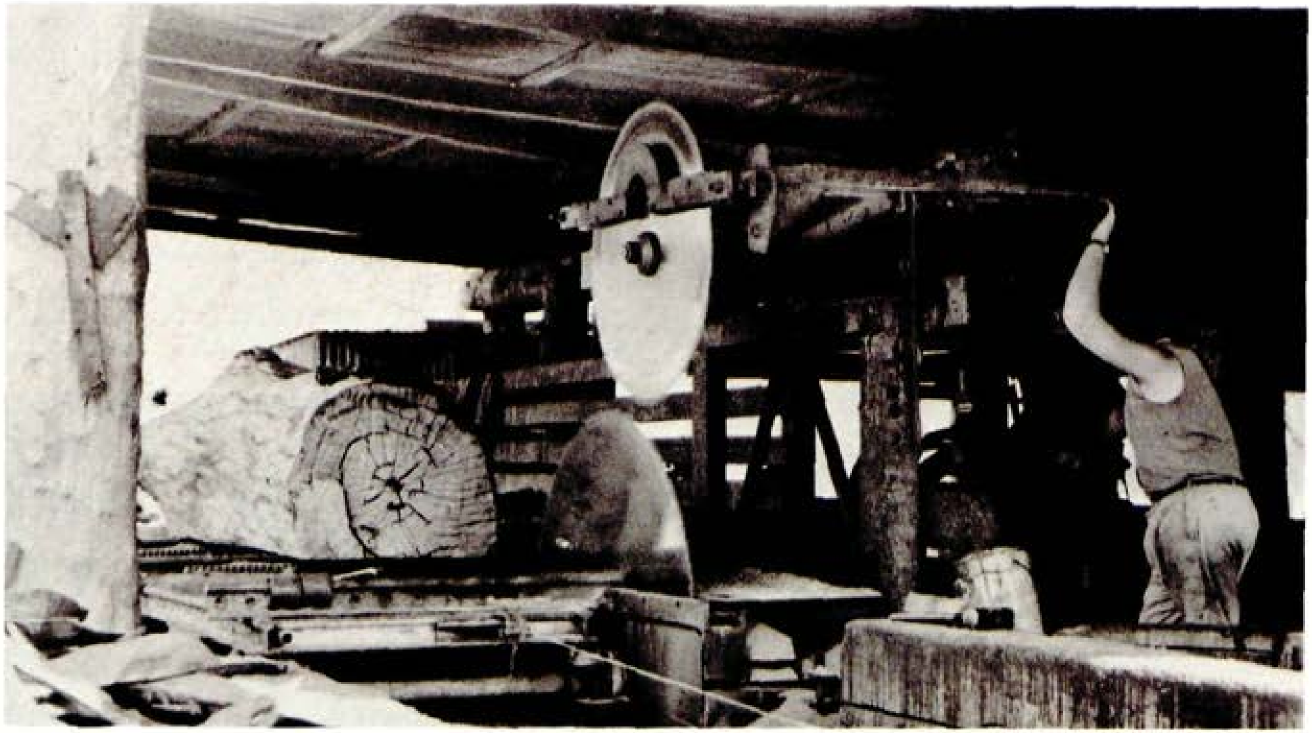
Table 18

AVERAGE ANNUAL OUTPUT OF WOOD PRODUCTS - VICTORIAN STATE FOREST, MURRAY VALLEY AREA (1977/78--1981/82)

Product	Quantity	Unit	Approximate percentage by species group			
			Red gum	Riverine box**	Box--ironbark	White cypress pine
Sawlogs	11,600	m^3	100%	-	-	-
Sleepers	66,400	number	100%	-	-	-
Piles, poles, and bridge timbers	4,800	lineal metre	81%	7%	10%	2%
Fencing materials	58,000	number	24%	36%	8%	32%
Firewood	10,300	m^3	83%	13%	4%	-
Sleeper offcuts	15,300	number	100%	-	-	-
Chips*	8,000	tonne	100%	-	-	-
Charcoal	200	tonne	100%	-	-	-

* Average for 3 years only

** Grey box, black box forests usually associated with the main river courses



Breaking down a river red gum sawlog using a twin or Canadian rig

The study area contains 10 sawmills, although the two located at Benalla and Violet Town draw supplies entirely from outside the area. The rest are located at Koondrook, Cohuna, Echuca (two), Barmah, Picola, Mooroopna, and Rutherglen, and most cut logs from both New South Wales and Victorian forests.

On a regional basis, encompassing the study area and the adjacent parts of New South Wales, the total annual supply of river red gum sawlogs is currently about 43,000 m^3, made up approximately as follows: 27% from State Forests and 4% from private land in Victoria; and 62% and 6% respectively from the adjacent State forest and private land in New South Wales.

Piles, poles, and bridge timbers

Large-dimension timber used in the round form is sold by the lineal metre. Piles are now only supplied from the Barmah Forest for Victorian ports and harbours. Local farmers use poles obtained from the area's forests in farm structures.

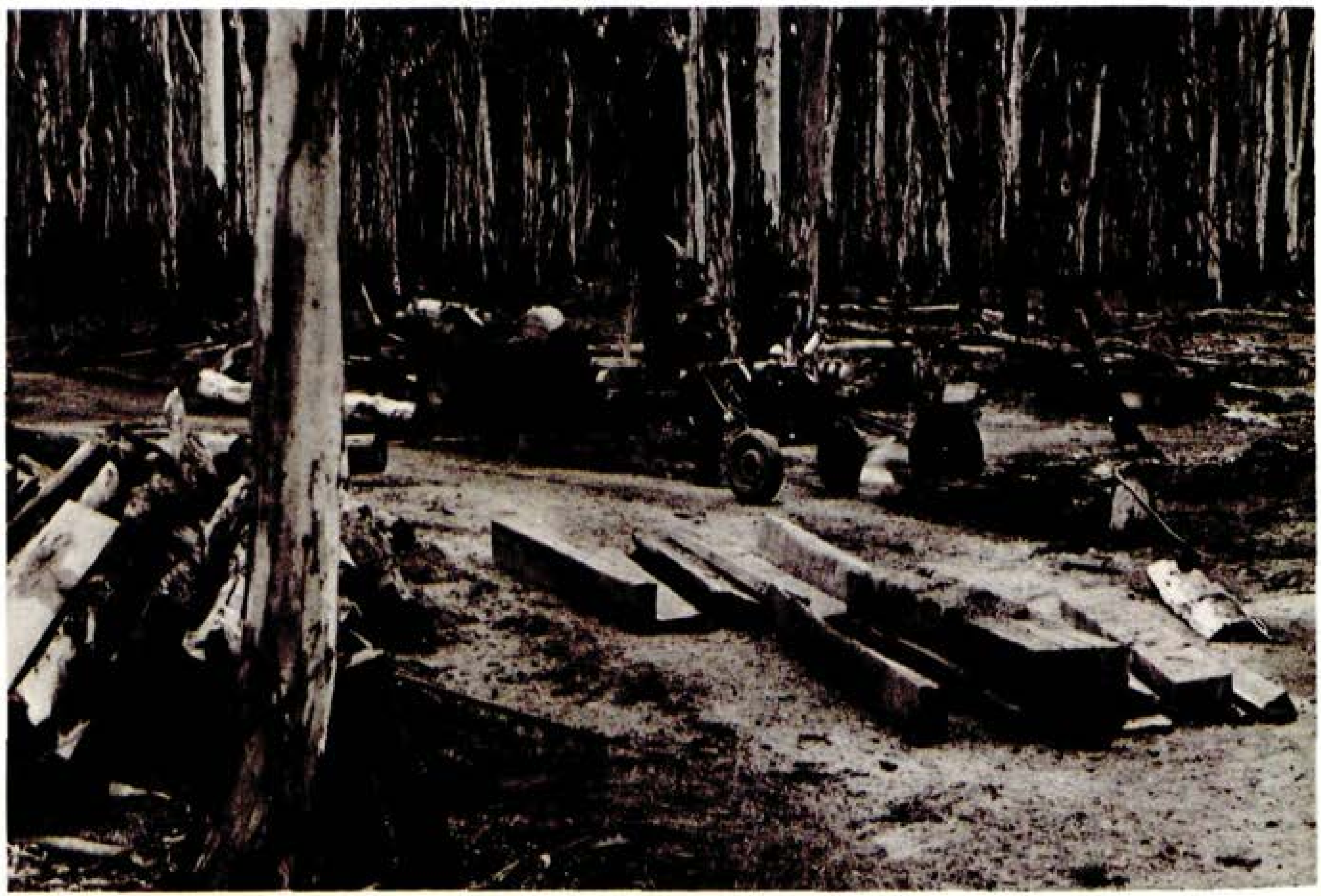
Local municipalities obtain timber for maintenance of the numerous timber bridges in the irrigation areas.

Railway sleepers

Railway sleepers impose continual demands on the durable-species forests of the region. River red gum is the only timber used at present, although other species such as black box, grey box, and red ironbark are suitable if trees of sufficient size are available. Sleepers are generally cut in the forest - from sawlog residues, poorer-quality trees, and thinnings in the denser stands. Some are produced from the sawmills in the region.

VicRail is virtually the sole market, and production is regulated by the allocation of fixed quotas to a number of licensed cutters.

On average, the total quantity obtained on a regional basis is about 176,000



Cutting river red gum sleepers with a barrow saw bush-sawn sleepers a year, of which 38% comes from public land in the study area. About 49% comes from public land in New South Wales, and the balance from freehold land in both States.

Annually over the period 1977/78 to 1981/82, the Murray Valley area has produced, on average, about half the sleepers harvested under licence from Victorian State Forests.

Several sleeper-cutters also produce fencing materials and heavy landscaping timbers.

Fencing materials

Demand in the region for durable fencing materials continues at about the level of production that the forests can supply. This demand reflects both the need for replacement fencing and the increasing intensity of local agriculture. Traditional preference favours strong durable timber over alternative materials. Virtually all the output is used in the region and a significant proportion is cut in the forest by the farmers themselves rather than by professional cutters.

Sleeper offcuts are also in demand, for use as stockyard timbers.

Firewood

Firewood is cut from fallen or dry timber, and licensed output remains steady

Firewood is mainly cut from forest residue - Gunbower Forest

at about 10,000 m^3 per annum. About 58% supplies domestic consumption, and is mainly gathered by householders. Currently the Kraft Foods factory at Leitchville is the only major user of firewood for industrial purposes.

Landscaping materials

Over the past decade, demand for durable species for landscaping materials has increased. This began as a market for sleeper offcuts and slabs and now includes chipped residues from sawmills and from thinning operations. Output

River red gum wood chips are popular - for use in landscaping and as garden mulch

from the study area in 1981/82 was 17,000 tonnes.

Charcoal

Charcoal is produced from dry river red gum residue found in abundance in the Gunbower and Barmah Forests. The demand (although unpredictable) has averaged 200 tonnes per annum over the last 5 years but is at present decreasing.

Charcoal, a major fuel source in developing countries, has the advantage over firewood of much-reduced weight per unit of energy output. In Australia at presend, it is used only in specialist industries as a source of carbon or in the production of certain filters.

Two commercial producers operate in the study area. One uses mobile steel kilns (which are set up on site) and the other has a fixed establishment near Picola.

Employment

The 1982 census recorded 174 people employed full-time and 67 people part-time in procuring or processing forest produce obtained from the Murray Valley study area. Approximately 40 more people are employed in local sawmills that obtain supplies from elsewhere.

Major products give rise to direct employment in the percentages: sawmilling 67%; sleeper-cutting 20%; and landscaping material 16%.

In general, constraints on supply allow little opportunity for expansion of employment, although the landscaping materials market is expanding.

Growth and Productivity

River red gum

The fast-growing river red gum is the most important commercial eucalypt timber species in the study area. It can produce tall straight-boled trees when growing in relatively dense stands, but has a tendency towards heavy branching and short bole length in open stands.

Water availability is the main criterion determining growth, and trees on good sites can grow in diameter at a rate of 1 cm per year. Tree height may exceed 50 m even in dense stands. In terms of volume production, the mean annual increment may be up to 6 m^3 per ha.

Sawlogs are usually produced from trees that are 100 years old or more. Production potential is assessed according to the estimated mature height of stands as follows:

Best (Site Quality I) :	30 m stand height
Average (Site Quality II) :	21--30 m stand height
Low (Site Quality III):	<21 m stand height

Generally, the future productivity of the river red gum forests depends on the provision of the appropriate flood regimes for the maintenance of their health and vitality.

Riverine box eucalypts

The box species usually grow in pure stands. Black box (*E. largiflorens*) occurs on the clay soils in the west of the study area, while grey box (*E. microcarpa*) can be found throughout. The largest stand of riverine box forest occupies the southern portion of Gunbower Island, and others also occur on the lower reaches of the Goulburn River. These comprise less than 10% of the utilizable forest area, but they supply most of the fencing materials.

Box--ironbark

Older trees of box eucalypts such as grey and yellow box and red ironbark can exceed 28 m in height, but most of the forest is currently regrowth following past utilization.

Blakely's red gum (*E. blakelyi*), which grows mainly on the granite hills of the Warby Range, is included in the box--ironbark type; in merchantable sizes it can produce similar timber products to those of the box eucalypts and has similar durability characteristics.

Diameter growth in box--ironbark forests can reach about 0.5 cm per annum on the better sites, but is often much less on the poorer sites or sites where multi-stemmed coppice growth is left unthinned.

White cypress pine

This naturally durable native conifer grows extremely slowly. Most of the white cypress pine at Terrick Terrick dates from 1885, when extensive germination followed a fire. Farm timbers have been produced from progressive thinning of the regeneration. In an open-grown stand these trees have reached about 50 cm in diameter (diameter growth of 0.5) cm per annum) and 13 m in height, while in a dense stand trees have reached only 8 cm in diameter (diameter growth of 0.08 cm per annum).

Another cypress pine - *Callitris preissii*, ssp. *murrayensis* - occurs, although less frequently, with white cypress pine at Terrick Terrick, and the timber properties of these two species show no apparent differences.

Private Commercial Forestry

Poplar plantations

The firm of Bryant and May has established some 320 ha of popular plantation on irrigated sites in the Cobrawonga area. Most of the 1,500 m^3 of wood produced annually is used to manufacture matchsticks. Poplar is generally unsuited to other uses, although the company is investigating its potential for use in the manufacture of cricket bats.

The company sells poplar seedlings and cuttings to local land-owners for use in shelter belts for stock and crops, including New Zealand gooseberries.

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17. AGRICULTURE

Primary production throughout the Murray Valley area encompasses a wide range of activities - from timber-milling to wine-making - and includes agricultural activities such as grazing, cropping, and fruit production.

Agriculture is the dominant land use here; its estimated annual value exceeds \$300 million. Map 12 indicates the locations of the various major agricultural pursuits. About 91% of the land in the area is privately owned and, except for that in the cities and towns, is generally used for agricultural production. Most of the private land is cleared, and grazing agistment or licences cover virtually all the reserved forest.

Soil type and the availability of irrigation largely determine the type of agricultural pursuits. With such a high proportion irrigated by gravity alone, the study area yields a diverse range of agricultural products that support a substantial decentralized population, both on farms and in the many towns throughout the area.

More than 7,000 farms produce a wide range of commodities from two main types of enterprise: dryland farming produces cereal crops, fat lambs and wool, and beef cattle; and irrigation agriculture produces dairy products, pome and stone fruits, citrus fruit, vines, various crops, and fat lambs and vealers.

Of the 14,126 km^2 of agricultural land in the area, 50.5% supports dryland farming, 33% irrigated dairy farms, 2% irrigated orchards, 0.5% dryland viticulture, and 14% low-irrigation-right mixed farming.

Dryland agriculture

Dryland farmers still depend on the traditional forms of agriculture that began more than 100 years ago. Cereals - wheat, barley, and oats - are the main crops while sheep, for both wool and fat lambs, and beef cattle are secondary farm enterprises. Land utilized for dryland farming needs regular applications of phosphate fertilizer in order to maintain productivity. The inclusion of subterranean clover in annual pastures enhances their grazing value and raises the nitrogen reserves of the soil.

The sub clover ley farming system was developed at the Rutherglen Research Institute.

Development of new technologies for cropping - such as minimum tillage and weed control - and the identification of new crops, such as lupins, have improved the profitability of dryland farming.

Irrigated agriculture

The forms of production from irrigated land depend on soil type and the amount of water available to the farm. These factors have determined farm size - especially in areas developed by successive settlement schemes.

Orchards occupy the better, lighter-textured soils with improved drainage.

Ayreshire cattle on irrigated pastures

They average 20 ha, and such properties have what is still termed a '2 in 1' water right: in the days of imperial measures, these farms received 2 acre-feet of water per acre of land. Those in the Goulburn Valley on the lighter sandy-loam-type soil grow peaches and apricots, since these crops need good drainage, while pears (which can better tolerate poor drainage) are grown on the somewhat heavier types of soils.

The heavier clayey soils are used for pasture production and cropping under irrigation. The most intensively farmed land in this category is used to produce perennial pasture for dairy cattle. Such farms average 40 ha, and, in imperial terms, have a 1 in 1 water right.

Larger farms, averaging 100 ha in size, have the lowest water right. These have a 1 in 2 or even 1 in 3 water right, and use their water for a range of enterprises, including irrigated crops and annual sub clover pastures. Such farmers use irrigation to extend the growing period of sub clover - from earlier in autumn to later in spring. Large areas of these properties usually carry dryland farming.

Farm Enterprises

Dairying

Dairying under irrigation is the most important agricultural industry here. More than 3,500 dairy farms carry a total of more than 350,000 milking cows. Gross value of production from this industry in 1980/81 was about $160 million, representing about one-third of the total Victorian dairy production. Tongala, Rochester, Cohuna, Tatura, Shepparton, and Cobram are noted dairying centres in the Murray Valley area.

The milk produced supplies the liquid-milk market or is processed in the many dairy factories. The area contains eight milk-processing factories (as well as a number of pasteurizing dairies and milk depots), which produce butter, cheeses, and different forms of dried milk products.

An average dairy farm runs 100 milking cows (plus replacement stock) on 40 ha of land, which usually carries perennial pastures of ryegrass, white clover, and paspalum. Annual production is generally about 140 kg of butterfat per cow.

Studies by the Victorian Department of Agriculture have shown that dairy farms in these irrigated areas of northern Victoria are among Australia's most productive and profitable.

Cropping

Cropping remains an important form of agricultural production in both dryland and irrigated farm areas.

On all dryland farms wheat is the chief crop grown. Soils and climate are generally suitable, so under reasonable growing conditions good yields are achieved in all areas, with the rich cropping soils around Dookie achieving the highest production.

Barley and oats are also grown on dryland cropping farms, and more recently lupins and peas have been included in rotations. These provide useful cash crops and increase the yield of subsequent cereal crops.

Ley farming systems are very important to dryland cropping farms. The sub clover and ryegrasses grown on the 'ley' phase are used mainly as fodder for sheep.

Irrigation greatly enhances the whole cropping spectrum. It can increase wheat yields threefold (up to 5 tonnes per ha), and can enable production of many other crops, such as sunflowers, lucerne, sorghum, millet, maize, and soybeans. These irrigated crops have the potential to produce yields greater than those currently obtained if current farming techniques can be improved.

Agricultural crops grown throughout the area have a total value of the order of $75 million annually.

Sheep

Production of sheep was one of the earliest agricultural pursuits in the area. In the pioneering days, the squatters

Sheep production is carried out in both dryland and irrigation farming areas

raised sheep on the extensive runs they had adopted.

Today, the sheep industry is much more intensive. It forms an important part of the rural environment in both dryland and irrigated farming enterprises, and produces both wool and prime lambs in association with cropping.

Sheep production under irrigation, or in the higher-rainfall zone in the east of the study area, utilizes crossbred ewes (Merino x Border Leicester) with meat-type rams (Dorset). The animals graze annual pastures of sub clover and rye-grass and produce top-quality prime lambs. The crossbred ewes also yield a valuable wool clip.

In the drier areas sheep enterprises are based on wool production from Merinos, with self-replacing flocks. Surplus wethers are sold for live exports.

The seep industry here returns more than $45 million to the area annually.

Beef

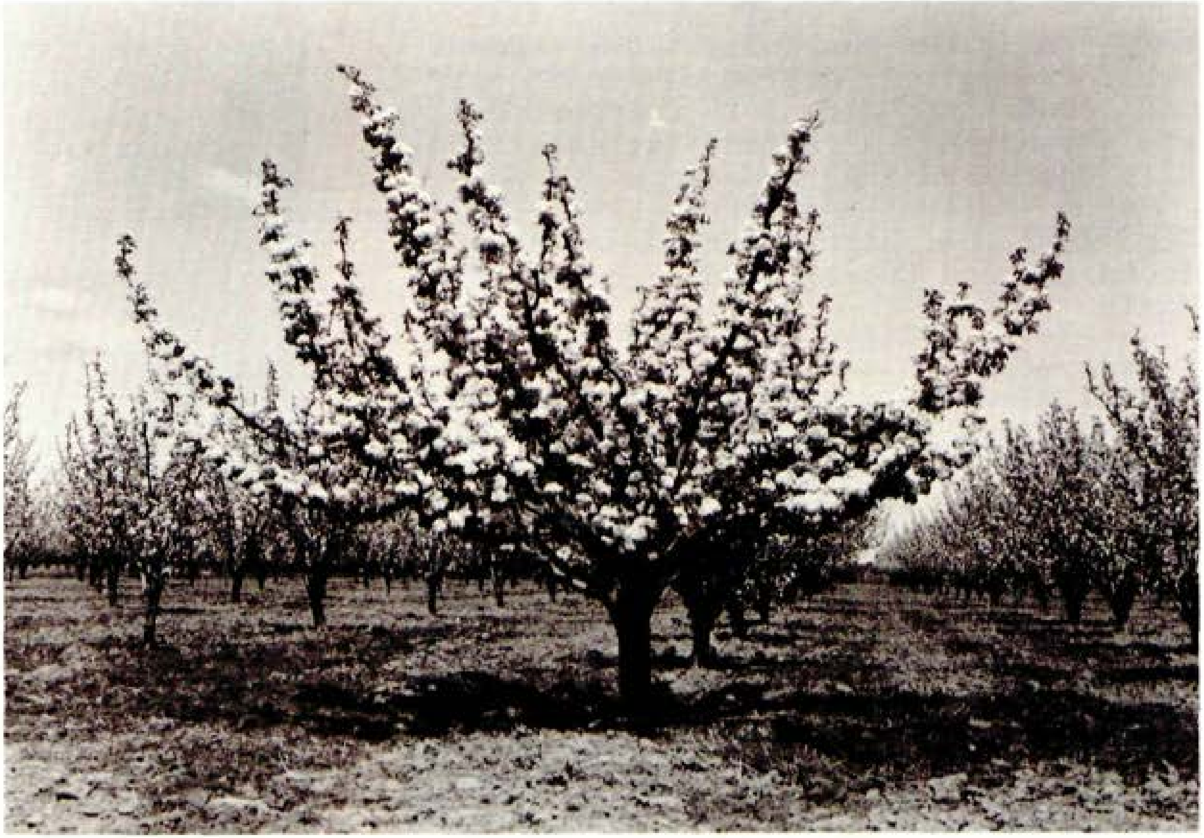
Similarly, beef production is carried out on both dryland and irrigated farms. Generally, beef production responds more favourably to profitable market trends than that of sheep, with farmers utilizing the vealers as a cash crop.

The value of the beef industry to the area varies considerably, but at present is about $20 million annually.

Fruit

Irrigated areas around Shepparton and Cobram are major districts for the production of pome and stone fruit, with some citrus and vine fruits being grown also.

The famous canning pear variety Williams Bon Cretien grows as well in and around



Pear orchard blossoming - Shepparton

the Goulburn Valley as anywhere in the world, while the district also produces clingstone peaches for canning and apricots, apples, and plums for processing.

Apple and pear varieties for marketing as fresh fruit in Australia and overseas are also grown in the area.

At present this important fruit industry is going through a very difficult readjustment period. Markets in Europe have virtually been closed to imports by the development of the European Economic Community. As a consequence, the number of growers in the industry has fallen from 850 to 500 in the last decade.

Growers are adjusting to this situation in two ways - by moving out of fruit production altogether, or by rearranging the mix of fruits so as to produce less canning fruit but more for the fresh fruit market. This has led to the closing of the Kyabram fruit-canning factory, while the remaining two - Ardmona Fruit Products in Mooroopna and Shepparton Preserving Company in Shepparton - are attempting to rationalize and diversify their canning production.

Some small but significant areas near Koondrook and Cobram produce citrus fruit.

Viticulture

While the Goulburn Valley produces some grapes, the best-known vine district in the study area is in the east, near Rutherglen. Vines were first planted there after the gold rushes in the mid 1800s, and the district has developed a well-deserved reputation for its full-bodied table wines and fortified spirits, especially liqueur muscats.

Picking pears at Ardmona

The potential of the irrigated districts to produce table grapes is still limited by the historical delineation of phylloxera infestations. In the late 1800s and early 1900s, the phylloxera aphid devastated vineyards throughout the area. Prohibitions were then introduced to prevent the spread of this insect - whether on grapes or on rooted vines. While these prohibitions remain, the development of table grapes in these districts is prevented by law.

Vegetables

A range of vegetables are planted annually in the study area, but the only one of economic importance is the tomato. More than 60% of Australia's entire processing-tomato crop is produced here. Traditionally, tomatoes were grown by transplanting seedlings and hand-harvesting, hence plantings were small (3--6ha). In recent years, however, a strong move to direct-seeding of tomato fields and machine harvesting has occurred.

The new techniques have enabled growers to plant areas of up to 40 ha, which has resulted in better financial returns.

Pigs

One-quarter of Victoria's pig-breeding herd is contained within the study area. The shires of Cohuna, Deakin, Rochester, Rodney, and Shepparton have pig populations among the highest in Victoria. With a move towards intensive production and a significant reduction of small enterprises in this industry has come a weakening of its traditional association with the dairy industries. Most pigs in the study area are fed cereal-based rations, with a minority fed dairy by-products.

Pigs produced in the study area had a gross value of $16.5 million in 1980/81.

Research Stations and Colleges

The Department of Agriculture has a number of agricultural research stations located in the area: the Irrigation Research Institute at Tatura, the Animal and Irrigation Pastures Institute at Kyabram, and the Rutherglen Research Institute, south-east of Rutherglen. During 1983, Dookie Agricultural College becomes the Dookie Campus of the Victorian College of Agriculture and Horticulture.

Irrigation Research Institute, Tatura

The Institute was originally established as a horticultural research station in 1937, to select new varieties of peaches and pears for the Goulburn Valley canning industry.

Research work included field trials to test pruning methods, soil management, timing of irrigation, and fertilizing inputs and weedicide requirements for orchards in the Goulburn Valley.

Following restructuring of the Department of Agriculture in 1976, the Horticultural Research Station became the Irrigation Research Institute, one of five research institutes in the Division of Plant Research.

The Institute occupies 42 ha of public land and employs a staff of 80. Current research emphasis is being placed on laboratory work and field instrumentation rather than field trials. Research activity is being directed into three areas: row and field crops, horticulture and irrigation technology, and salinity.

Animal and Irrigated Pastures Research Institute, Kyabram.

Occupying 250 ha of purchased freehold land and administered by the Department of Agriculture, the Institute undertakes research into animal production on irrigated land. It lies 1 km south of the town of Kyabram, in the centre of the Victorian irrigation areas. At present its research is concentrated on dairy production, as this is the major animal industry in irrigated areas.

The Institute commenced experimentation in 1959 on fertilizers for pastures and production of prime lambs. It has conducted research into water use, pasture species, soil amelioration, the use of superphosphate, sheep stocking rates, beef and dairy stocking rates, and bloat prevention. Other research has investigated tomatoes, row crops, field crops, and lucerne.

In 1979, the Institute restricted its research work to dairying, but this includes research into pasture production, crop production, and pasture and crop utilization by cows.

Dookie Agricultural College

The College occupies 2,448 ha of public land and encompasses a range of soil types and topographic features. Notable features include the frontage to the Broken River, wooded hills and a significant portion of Mount Major (380 m

Dookie Agricultural College

above sea level), and a 150-ha native eucalypt forest.

The College farm area has been developed to provide students with an opportunity to develop farm skills and an appreciation of the ongoing technological developments in agriculture. Activities at the College include a minimal-disease piggery of 240 sows, a Poll Hereford stud of 200 breeders, a Merino sheep flock, a crossbred sheep flock, an orchard of 8 ha, and a 4-ha vineyard. Gross income of the farm for the year ending June 1982 exceeded $460,500.

The land on which the College and its farm are located is assigned under the

Agricultural Education Act 1958 for agricultural education.

Rutherglen Research Institute

Situated 7 km south-east of Rutherglen, the Institute is the dryland cropping information centre for northern and north-eastern Victoria. It occupies 800 ha and employs a staff of between 65 and 70 people. Although it had its beginning as a viticultural college, the Institute is limiting its research in this field, which it will carry out in association with district vignerons.

The Institute conducts farming-system researcy involving the production of crops, pasture, and livestock, and their integration into a single farm unit.

Its research is primarily aimed at increasing the productivity of mixed farms situated on the neutral to acid soils,

Foden engine with chaff cutter and steam pipe to dampen hay, Boort 1920 where subterranean clover is the major pasture legume. It pioneered much of the early work on topdressing with superphosphate and the inclusion of clover leys in crop rotations.

Over a long period, the Institute has played a major part in altering agricultural use of the higher-rainfall parts of the wheat belt.

In recent years, it has been responsible for demonstrating the practicability of sowing crops without any seed-bed preparation - known as direct drilling - and for the development of techniques that enabled lupin-cropping to be established as a commercial enterprise.

The Institute currently lists 19 major research projects, including:

* improving lambing performance of sheep in north-eastern Victoria
* assessment of sheep carcass characteristics and their relation to production systems and marketing needs
* improved wheat production in north-eastern Victoria by tillage, rotations, and fertilizers
* improved pasture production in north-eastern Victoria
* the production of rape seed varieties with improved yield, oil-yield and quality, and field characteristics

Grazing on Public Land

Grazing of public land by domestic animals is a well-established historical practice and has been carried out in the study area since European settlement.

Earliest records of grazing by domestic animals on the public land are those of Edmund Curr. During the decade 1841--51, Curr (a squatter) regularly drove sheep from winter runs in southern Victoria to the luxuriant summer pastures of moira grass that developed in the Barmah Forest after the winter--spring flooding.

Since those days, forest grazing has gradually come under government control and has continued as an important adjunct to the local farming community, as it allows extra stock to be carried over the dry summer and autumn.

Grazing of public land is either by licence or agistment permit.

Licensed grazing involves a rental (being set for a specified period), based on the carrying capacity of the area and charged on a per-hectare basis. There is a minimum licence fee. The licence may specify other conditions pertaining to the grazing use.

In agisted grazing, the public land managing authority regulates the number of stock permitted to graze on a given area according to the condition of the ground

Cattle grazing in reserved forest - Cobram

vegetation. Rent is paid on a per-head basis over a specified period.

Grazing on reserved forest is controlled by the Forests Commission. Grazing on other Crown land is controlled by the Department of Crown Lands and Survey.

Virtually all of the reserved forest in the study area, except the Warby Range, is grazed. Grazing is carried out under licence or by agistment and mainly involves cattle, sheep, and horses.

In addition, many of the smaller blocks of other Crown land managed by the Department of Crown Lands and Survey have grazing licences over them.

No licensee depends completely on public land for his livelihood. Forest grazing may be considered to be of value to the farmer, as it supplements production from his freehold property. It is particularly valuable during droughts, when food on the farm is in short supply. The best management usually involves grazing forests adjacent to the licensees' freehold land, as is the case along the Ovens River.

Throughout the study area the stocking rates vary according to the quality of the site, season, and market trends.

Map 12 shows the major areas of reserved forest currently held under grazing licence or agistment. They consist mainly of river red gum forests and box forests (the notable exception being the callitris forests at Mount Terrick Terrick and the red ironbark--box forests at Killawarra).

Licensed grazing, reserved forest

Annually renewable occupation licences authorize grazing on some 36,000 ha of reserved forest, encompassing various forest types. Rental, paid on a per-hectare basis, depends on the carrying capacity of the land. There is a minimum licence fee.

During 1982, 291 grazing licences covered some 36,000 ha of reserved forest, on which 256 individual licensees grazed cattle, sheep, and horses. Rentals ranged from $0.48 to $2.66 per ha, with the minimum licence fee being $25.00. Total rental from these licences amounted to $46,000 in 1982.

Most of the licence areas are small. Of the 291 licences, 39% covered less than 20 ha, 20% between 20 and 50 ha, and 23% between 50 and 150 ha. Only 2% of the licences covered areas greater than 1,000 ha.

Licensees use their areas regularly and have fenced most of them, which usually adjoin licensees' freehold property.

The main forest types grazed under licence are the river red gum forests along the Ovens, Goulburn, and Murray Rivers, the black and grey box forests adjoining these, and the box--ironbark forests at Killawarra, where the whole block is grazed by sheep.

In the Cohuna area, the forests adjacent to the irrigated dairy farms are grazed by dried-off dairy cows.

On other Crown land

The Department of Crown Lands and Survey generally issues three forms of licences for grazing on other Crown land.

The first type (section 130 grazing licences) cover small to large blocks of Crown land. These have a minimum fee of $50.00, and an estimated 300--400 apply within the Murray Valley study area.

Licences of the second type - water-frontage licences - cover Crown stream frontages and are issued to adjoining land-owners. These license them to occupy Crown land, enabling them to save fencing costs and give stock access to water. Minimum fee for these ranges between $25 and $50 depending on the area. At least 1,000 of these licences apply in the Murray Valley study area.

Unused-road licences (the third form) are issued to adjoining land-owners to cover roads declared unused by the Shires. These save land-owners the cost of fencing and give limited grazing. The minimum fee for these also ranges between $25 and $50, depending on the area. It is estimated that as many as 2,000 of them apply in the Murray Valley study area.

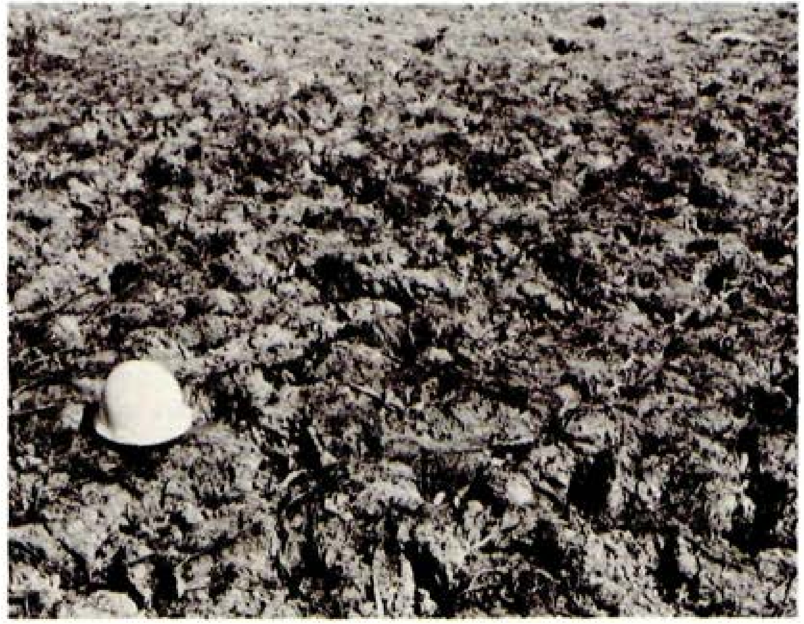
Cultivation on grazing licences can only be permitted by the Minister of Lands if its purpose is to control vermin or noxious weeds, but can be permitted more widely on frontage or unused-road licences.

Agisted grazing

Currently, 50 stock-owners agist some 2,000 cattle on 45,000 ha of reserved forest in the study area, comprising 15 agistment areas located around Gunbower, Barmah, Cobram, Boosey, and Mount Terrick Terrick. Nine of these sites adjoin fenced areas within the 2,500-ha callitris--box forest at Mount Terrick Terrick.

Currently, the stocking rate is only one-third of the level attained prior to the slump in beef cattle prices that occurred during the 1970s.

The agisters usually have farms near the forest, but not necessarily abutting the agisted public land, as is the case with licenced grazing. The largest agistment area - 22,260 ha - forms the bulk of the Barmah Forest. Annual stocking is determined by a committee of Forests Commission personnel and local graziers, and the Forests Commission employs a herdsman.



Cattle hooves can cause pugging of the soil - Benwell forest

Agistment in the Barmah is restricted to persons who live in the Shire of Nathalia while in the Gunbower Forest it is restricted to persons who live within a 25-km radius of the forest.

The Department of Crown Lands and Survey was recently given the power to issue agistment permits over other Crown land. Although low at present, the number of these in the study area is increasing.

Impact of grazing

Relatively little is known about the impact that grazing by introduced stock has on the natural vegetation in the Murray Valley area.

It is known that grazing animals such as cattle are selective feeders, and therefore have the potential to influence the floristics of the area grazed. In some parts of the public land, this selective grazing has probably initiated a change in the understorey community - from one dominated by perennial summer-growing indigenous species to one dominated by annual alien species. Changes in ground flora depend on the effective stocking rate and the severity of the season.

If grazing affects the composition of the understorey flora it may also have an effect on the ground-dwelling fauna- through the alteration of the habitat.

Grazing may also aid the establishment of alien plants through the reduction of competition from indigenous species, localized nutrient enrichment, creation of bare gound, and the transportation of seeds.

It is also known that grazing pressure is not necessarily distributed evenly. Even with low stocking numbers, localized heavy grazing may occur in areas such as those near water points. Introduced stock such as cattle and sheep have a greater capacity than the soft-footed indigenous animals to compact or cut up the soil surface with their hooves. In areas of localized heavy grazing, this may contribute to soil erosion.

While grazing in riverine forests may benefit the regeneration of river red gum (by reducing moisture competition), in woodlands it may (in association with rabbit infestations) retard the regeneration of trees such as *Callitris* and *Casuarina* spp.

Grazing of the public land in the Murray Valley area is often used as a fire-management tool. It reduces the fire hazard - through removal of the standing bio-mass that would become fuel for a summer bushfire.

The impact of grazing on the vegetation, soil, native wildlife, and recreation may be reduced by maintaining a light stocking rate, to ensure that the available forage is undergrazed.

18. APICULTURE

The apiculture industry depends on the introduced honey bee, *Apis mellifera*. This social insect collects and stores quantities of plant nectar as a carbohydrate food source. The excess is harvested as honey. In the process, the bees also collect pollen on specially adapted hairs on their rear legs. Pollen is a protein food that they store, along with nectar, for feeding. The pollination activity of honey bees, especially in relation to agriculture and horticultural crops, is probably more important than their commercial value as producers of honey.

Public lands of greatest importance to the apiculture industry in the area are the reserved forests located along the Murray, Ovens, and Goulburn Rivers. These contain river red gum stands that average one heavy summer flowering every 4 years.

Other areas of reserved forest, containing box--ironbark--stringybark eucalypts (as at Killawarra and the Warby Range), have importance for the industry because of their species diversity and the resulting varieties of honey produced. The Warby Range and Killawarra forests are also valued for overwintering, as they are generally warmer and more accessible in winter than the river red gum areas.

Throughout the Murray Valley area, roadside verges, stream frontages, and small blocks of Crown land carry native vegetation. These also provide important sources of nectar and pollen for the apiarists.

Commercial bee-keeping is a 'migratory' industry. Operators truck their hives to areas of high nectar yield, following the honey flows of different eucalypts. They also travel to overwintering sites, where the bees can build up their stocks of pollen. Although they are mobile in terms of access to honey flows throughout Victoria, individual apiarists tend to operate in certain parts of the study area.

Some 80 apiarists regularly operate more than 23,000 hives in the study area, but these numbers could increase greatly in seasons when prospects are greater here than in other parts of the State.

The bulk of Victorian honey is sold to large processors, who clarify and pack it for export and for the home market.

Most bee-keepers also maintain a local trade in their own areas. About half the annual Australian production is exported, mainly to the United Kingdom, but the finest honeys - such as that of river red gum - are almost entirely consumed on the home market.

Apiarists also harvest quantities of beeswax, a product with many uses, including cosmetic and polish manufacture.

Honey valued at more than half a million dollars and beeswax worth around $34,000 are produced here annually. This is the value of direct production within the area and does not take account of production elsewhere following build-up and preparation of bees in the study area.

It is estimated that about 5--10% of Victoria's honey products come from the study area. This proportion is extremely variable, however, and could be significantly higher in years when heavy flowering occurs.

Important plant species

Eucalypts are the most important honey-producing species, but others - which do not produce high nectar yields, or on their own produce a poor-quality honey - can be particularly important for brood rearing. These include wattles, she-oaks, sweet bursaria, and lignum. The following species are the main eucalypt honey flora and are listed in order of importance.

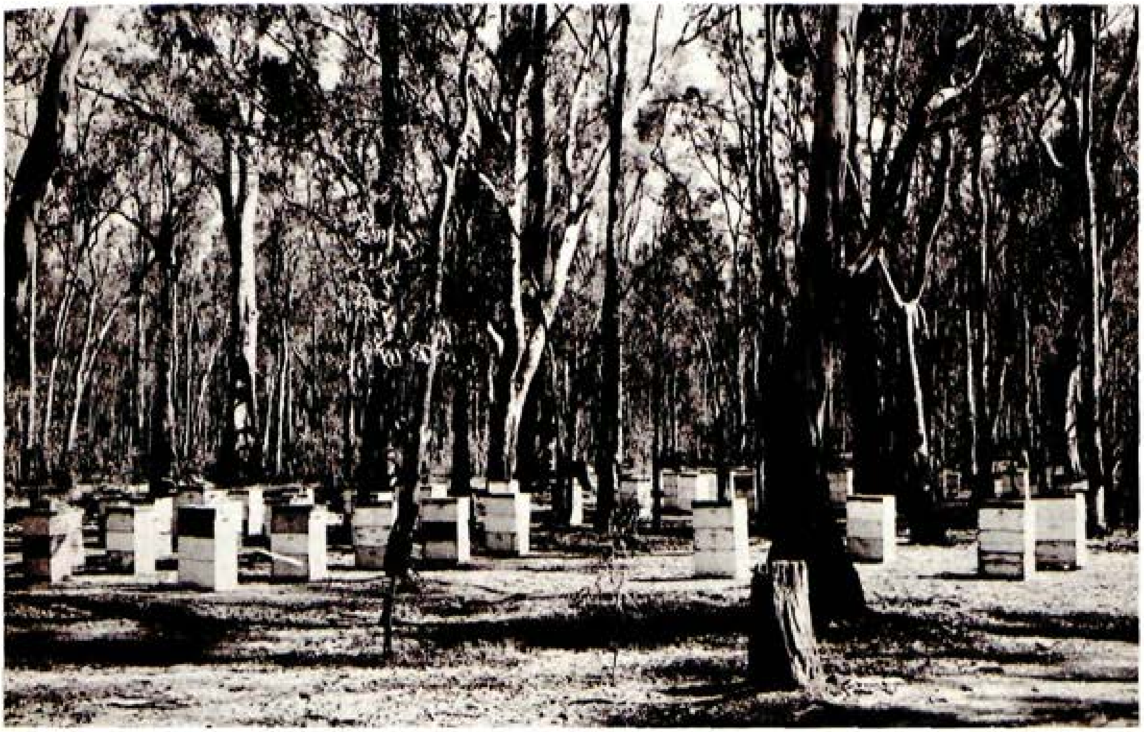
River red gum (*Eucalyptus camaldulensis*) is a valuable tree for the bee-keeper. It often secretes nectar very profusely and is one of the heaviest yielders. It yields a straw-coloured honey, not quite so dense as that from yellow box, and with a very good flavour. It produces pollen in great quantities, and this makes it extremely valuable when grown in pollen-deficient areas. Average honey yields of 27 kg per hive per year are obtained.

Grey box (*E. microcarpa*) produces honey of excellent-flavour, amber coloured when pure. It also produces large amounts of cream-coloured pollen, which is important to the industry, as this is the only available source at the season's end - that is, around autumn. Average annual honey yields are about 14 kg per hive.

Blakely's red gum (*E. blakelyi*), also known as hill gum by bee-keepers in the area, produces a good honey with average yields of 9--14 kg per hive per year.

Yellow box (*E. melliodora*) regularly yields nectar to produce one of the best-quality honeys available. Bees do not collect its pollen, however, and would soon deteriorate without access to an alternative pollen source.

Red ironbark (*E. sideroxylon*) yields copious quantities of nectar to produce first-grade honey, but (like yellow box) produces little pollen. Average annual honey yields are about 20 kg per hive.



Beehives situated in reserved forest, Gunbower Island State Forest

Black box (*E. largiflorens*) produces a good-quality honey with a medium flavour and medium amounts of cream-coloured pollen. Honey yields average 27 kg per hive per year.

Red box (*E. polyanthemos*) produces a good-quality honey, but nectar flows are unreliable. Virtually no pollen is yielded. Average honey yields of 2 kg per hive per year are obtained.

Red stringybark (*E. macrorhyncha*) varies in both nectar and pollen yield. It produces a medium-grade honey, with average annual yields of 5 kg per hive.

Long-leaf box (*E. goniocalyx*) produces a medium- to dark-coloured honey of reasonable flavour and is a prolific yielder of pollen. Bees winter well on it. Average honey yields of 2 kg per hive per year are obtained.

White box (*E. albens*) yields profuse amounts of nectar and produces a first-class honey of light colour and mild flavour. It is not a reliable yielder of pollen.

On agricultural and horticultural land, lucerne, seed crops, and various clovers are important sources of nectar and pollen. Declared noxious weeds such as Patterson's curse, thistles, and blackberries are also important sources. A potential disadvantage in utilizing any of these plants lies in the application of pesticides - to protect the former group and kill the latter - that can rapidly decimate a whole apiary.

Licensed bee-keeping on public land

On private forested and agricultural land, siting of hives is by arrangement with the land-owner.

Licensing of bee sites in reserved forest is carried out by the Forests Commission. The reserved forest is divided up into a system of licensed sites - either temporary or permanent.

A permanent site has its centre marked in the field and generates a licensed bee range of 1.6-km (1-mile) radius. The rental charged for a permanent bee-farm and range licence depends on the number of hectares of reserved forest within the circle. At June 1982, 81 of the 91 permanent sites were held under licence.

A temporary bee-farm and range licence covers an area of 0.8-km (½-mile) radius and is renewable each quarter on payment of a flat-rate charge.

Few temporary sites were held under licence at June 1982, but during a good flowering season an estimated 100 temporary sites could be licensed. The middle sections of the Barmah and Gunbower Island State Forest - for reasons of limited access (flooding) or limited water (during droughts) - are suited to temporary rather than permanent bee-farm and range licences.

Sites are located in reserved forest so that minimal overlap of licensed bee ranges occurs.

Substantially more than half of the reserved forest in the study area is available for honey production (see Map 12), and in 1982 the Forests Commission received $3,814 in revenue from licensing permanent and temporary sites.

The Department of Crown Lands and Survey operates a similar system of licences on other Crown land. It is estimated that this Department licenses about 20 temporary sites and 12 permanent sites in the study area.

The number of licenced sites does not reflect the use of public land for apiculture, for bees sited on private property work the adjacent public land. It has been estimated that, for every site on public land, up to a dozen bee-keepers could be using this land from private property.

Reference

Goodman, R.D. (1973). 'Honey Flora of Victoria.' (Government Printer: Melbourne.)

19. MINERAL AND STONE PRODUCTION

The term 'mineral', as defined in the *Mines Act* (1958), includes metals, gems, and precious stones, either as ores or in their native states: bauxite, gypsum, magnesite, coal, pigments, and other similar materials. In this report, it also includes gold. 'Mining' is defined as the extraction of any mineral or minerals from the ground or from tailings and is carried out under the conditions of a Miner's Right claim, or mining lease.

'Stone', as defined in the *Extractive Industries Act* (1966), is a general term for sand, gravel, limestone, sandstone, slate, basalt, granite, clay, soil, etc. 'Extractive industry' is defined as the extraction of any stone and is carried out under the conditions of an extractive industry licence or lease. 'Quarrying' is a term generally used for the extraction of stone. Mineral and stone information is included in the geological map (Map 4).

Minerals

The activities of mining companies can be divided into two categories - mining and exploration. Mining (which excludes quarrying) in the study area is carried out on a small scale and is confined entirely to the mining of gypsum in the far west. All other current activity associated with minerals here is of an exploratory nature.

Over the last 3 years, local exploration activity has increased. Much of the Murray Valley area is under licence for exploration: at the beginning of November 1982, 18 exploration licences were current there and a further five had been applied for.

The main company involved in the area is CRA Exploration, which is currently searching for coal, gold, and diamonds (see Table 19).

Map 13 shows the locations of these exploration licences. Most of the companies originally applied to search for uranium, but because of the current State Labour Government policy this mineral has been excised from the licences.

Coal

As previously noted, much of the region is being actively prospected for coal.

Table 19 TENEMENTS ISSUED BY THE DEPARTMENT OF MINERALS

Type	Lessee	Mineral or stone	Status	Parish	Area (ha)	Owner
Mining lease						
329-1	Northern Gypsum	Gypsum	Expires 13/9/87	Boort	15.7	Crown
596	Smith & Smith	"	" 12/11/84	Terrick Terrick West	2.3	Shire of Gordon
978	Northern Gypsum	"	Application	Boort	13.7	Crown
984	Northern Gypsum	"	Application	Terrick Terrick West	12	Crown
988	Smith & Smith	"	Application	Terrick Terrick West	5	Shire of Gordon
Tailing licence						
4260 (removal) (Southern Consols)	Shire of Rutherglen	Gravel	Expires 31/1/84	Lilliput	1	Crown
Extractive industry lease						
36	Manson & Son	Granite	Renewal App.	Terrick Terrick West	28	Crown
208	Rochester Shire	Chert	Expires 12/4/86	Nanneela	20	Crown

* Most exploration licences include some public lands

Information from existing bore holes in north-eastern Victoria shows that almost the entire Murray Valley area west of Shepparton contains sediments that may supply economic quantities of coal. Sediments of fresh-water origin that are

AND ENERGY ON THE PUBLIC LAND, MURRAY VALLEY AREA (AS AT 28/10/82)

Production (1980/81 unless otherwise stated)	Mineral exploration licences*			
	No.	Lessee	Status	Area (km^2)
	781	CRA	Expires 30/7/83	528
	795	"	" "	792
	796	"	" "	528
15,667 tonnes	797	"	" "	396
	807	"	" "	660
	808	"	" "	347
	809	"	" "	678
	810	"	" "	726
	811	"	" "	462
	822	"	" 19/6/83	66
	823	"	" "	198
	885	"	" "	66
	953	"	Application	462
706 m^3 (Apr.'78 --Dec.'81)	972	"	Expires 3/7/83	66
	991	Freeport	" 27/5/83	726
	1062	CRA	" 30/7/83	275
	1063	"	" 22/10/83	792
	1064	"	" "	392
	1083	"	Application	792
	1165	Mineral Management	Expires 1/4/83	330
90 tonnes	1225	Duval Mining & Picon Expl.	Application	396
	1264	CRA	"	792
122,400 tonnes	1273	"	"	132

highly carbonaceous and/or contain fossil wood fragments are likely to contain coal deposits. An exception is a prominent sub-surface ridge that runs in a north-west direction from Kamarooka through Mitiamo, Mount Terrick Terrick, and Pyramid Hill, to Mount Hope. This zone comprises granitic intrusions of Ordovician age and is likely to prove unprospective for coal (see Map 14).

Diamonds

Minor occurrences of diamonds in alluvial sediments have previously been reported north of Beechworth and within the study area south-east of Rutherglen. In addition, much of the Murray Valley is being explored for diamonds, either as buried *in situ* occurrences associated with basic igneous intrusive rocks or as buried alluvial deposits.

Gold

The most important gold-producing area here lies in a belt of country running north-west from Chiltern to Rutherglen. Numerous auriferous quartz reefs occur throughout the Ordovician sediments, but the majority have proved narrow and of relatively low grade (7.65 g per tonne). The real importance appears to lie in the alluvial gold (and tin) deposits to be found here.

Mining of both reefs and shallow leads commenced in the late 1850s, and several leads were exploited. These included the Lancashire Lead (4 miles east of Chiltern), the main Chiltern Valley Lead, the Barambogie Lead (lying immediately to the south-east of the railway line that runs through Chiltern Township), the Indigo Lead (located between Chiltern and Rutherglen), and the Prentice Lead (to the east of Rutherglen). The geological map (Map 4) shows the extent of the Chiltern Valley, Indigo, and Prentice leads.

Many thousands of ounces of gold have been produced from this field, which remains highly prospective, especially for alluvial deposits.

Two other minor alluvial fields occur - one straddling the Hume Highway just south of Benalla, and the other at Tamleugh North.

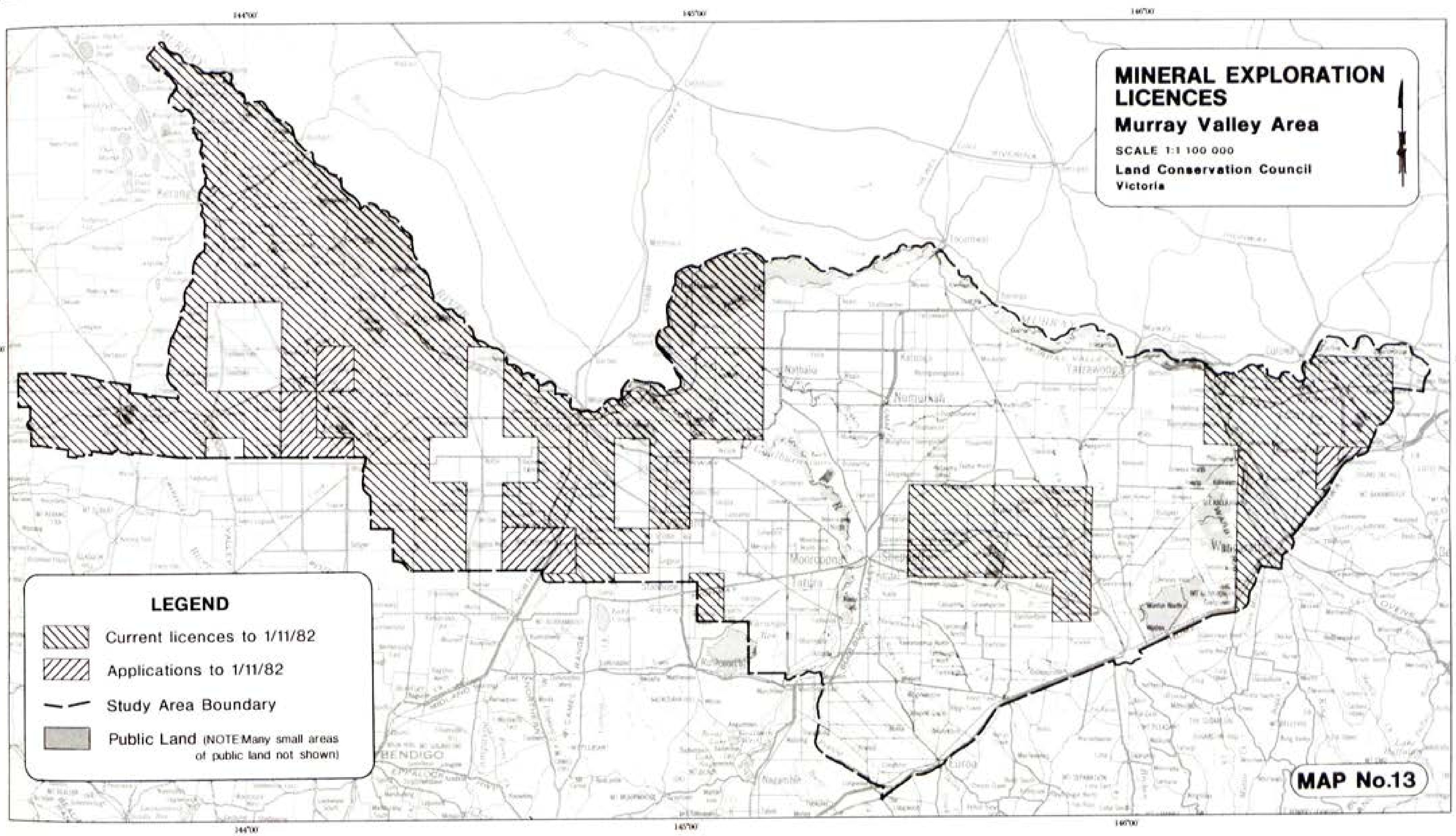
Many of the mullock dumps from the deep lead mining around Rutherglen, a number of which are on public land, have had tailings licences over them from time to time. Often, the material is extracted for road gravel. Indeed, one current tailing licence allows removal of material for road purposes (see Table 19).

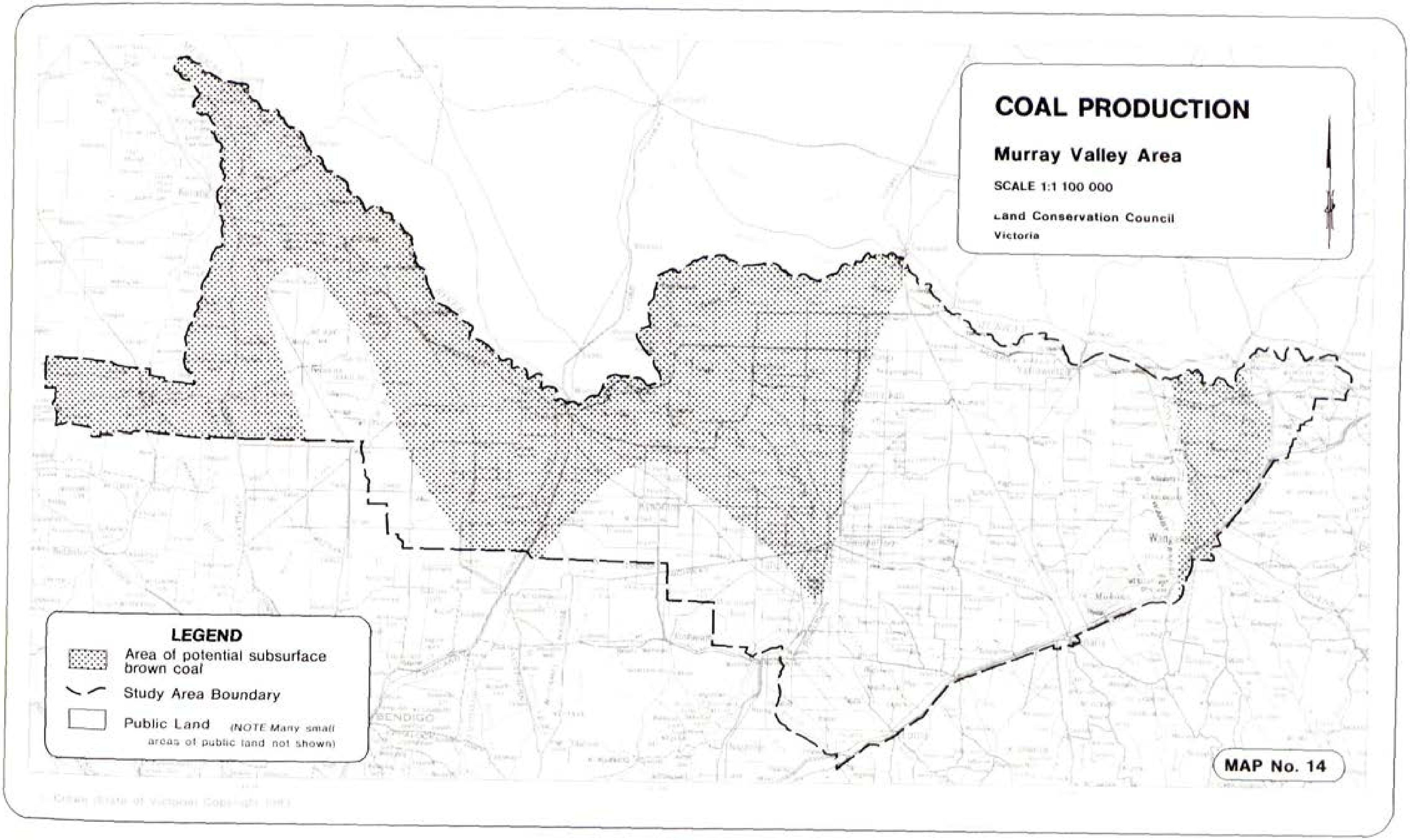
Fluorite

This mineral has been reported in minor amounts throughout the Warby Range. Two localities (1.5 km west of Mount Warby and 1.5 km north of The Willows) possibly contain economic quantities. The fluorite typically occurs within quartz veins, which may be up to 10 m wide. At the Mount Warby locality, the quartz veining is estimated to cover an area of about 1 sq. km.

Gypsum

Numerous gypsum deposits occur throughout the north-west of the State. Within the study area such deposits occur on Crown land near Boort and Terrick Terrick, where one mining lease is current


MINERAL EXPLORATION LICENCES
Murray Valley Area
SCALE 1:1 100 000
Land Conservation Council
Victoria
LEGEND
Current licences to 1/11/82
Applications to 1/11/82
Study Area Boundary
Public Land (NOTE:Many small areas of public land not shown)
MAP No.13


COAL PRODUCTION
Murray Valley Area
SCALE 1:1 100 000
Land Conservation Council
Victoria
LEGEND
Area of potential subsurface brown coal
Study Area Boundary
Public Land
(NOTE Many small areas of public land not shown)
BENDIGO
MAP No. 14

and two others have been applied for. At Terrick Terrick West, also, a mining lease and a mining lease application to extract gypsum from municipal land are current.

Iron and manganese

Limonite and associated manganese oxide occur on the north side of Mount Major near Dookie. The body has a variable width and, according to estimates, probably contains some thousands of tonnes of limonite at the surface. As has been shown, however, it does not extend under the surface to any appreciable depth. Assays show iron values between 35 and 50%, while manganese - which occurs as a series of incrustations - is relatively impure. Host rocks include tuffs and cherty shales, which are intimately associated with altered lavas. Such a geological environment would be highly prospective for the well-known pyritic--copper ore bodies. An exploration licence is currently held over the whole area by Freeport of Australia Inc (No. 991).

Kaolinite

Several small occurrences of kaolinite occur throughout the area, with at least two having been recorded on Crown land - west of Nalinga on the Midland Highway, and on Mount Terrick Terrick, south-west of Pyramid Hill. The latter deposit has been derived from the weathering of Devonian granites.

Phosphate

Near Killawarra, 14 km north-west of Wangaratta, a small occurrence of wavellite (hydrated aluminous phosphate) is associated with faulted Upper Ordovician sediments.

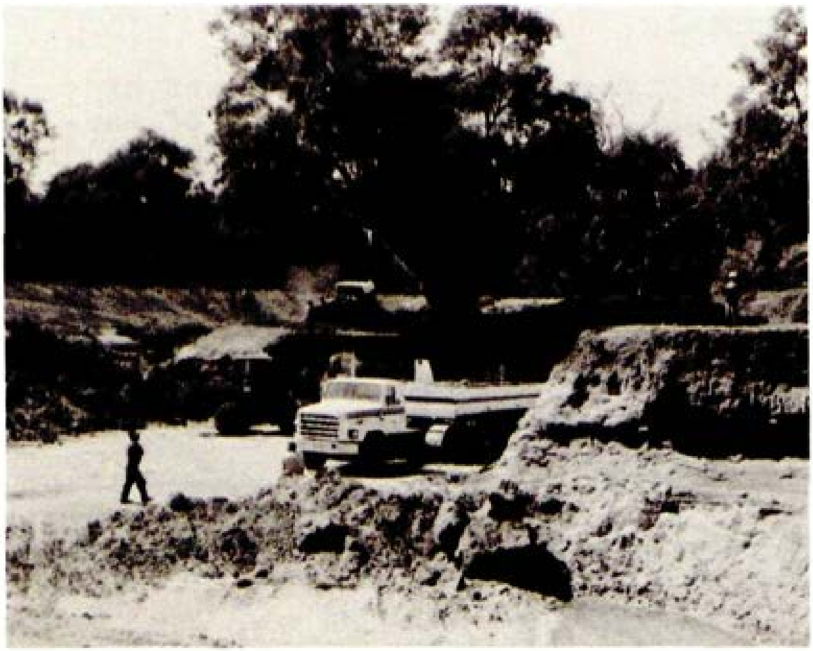
Tin

Alluvial tin, probably derived from nearby granitoid rocks, commonly occurs in association with alluvial gold around Chiltern and Rutherglen. Although cassiterite is but a minor by-product of gold-mining in the area, the Chiltern district has produced a significant tonnage of tin ore.

Stone

Stone is required throughout the region for roading, filling, and various construction projects. Because of the extensive clayey sediments in the Murray Valley area, many Shires experience difficulties in obtaining enough stone with properties suitable for construction purposes. As little Crown land remains here, most quarrying activity occurs on private land: more than 60 commercial quarrying operations under extractive industry licences occupy private land in the study area. The main materials extracted include granite, sand, mine tailings, and gravel.

Extraction of stone from the Crown lands is currently around 286,000 m^3 annually.



Sand pit - Murrabit forest

This figure is made up of stone extracted by the Shires from public lands, and production from the two commercial quarries operating under extractive industry lease on public land (see Tables 19 and 20).

Extractive industries are subject to the provisions of the *Extractive Industries Act* 1966 on Crown land and private land and to those of the *Forests Act* in reserved forest.

The Department of Minerals and Energy issues permits to search for stone as defined under the *Extractive Industries Act*. For purposes of commercial quarrying, the Department issues leases on Crown land and licences on private land.

Municipal bodies and the Country Roads Board make non-commercial extractions and therefore are not subject to leasing or licensing under this *Act*. They are, however, subject to licensing under the *Forests Act* if extractions take place in reserved forest. (Extractions of less than 2 m are regulated by the *Soil Conservation & Land Utilization Act* 1958 and the *Land Act* 1958.)

Extraction from streams (a special case) requires consultation with State Rivers and Water Supply Commission, Fisheries and Wildlife Division, Soil Conservation Authority, and River Improvement Trust (if established). Current guidelines allow stream extraction to be permitted only if such extraction is desirable for stream management. In areas of limited material where recharge is low or absent (such as in the lower Goulburn River) it is seldom permitted.

Sand extraction from beaches on the left bank of the Murray River is the responsibility of the relevant New South Wales authority.

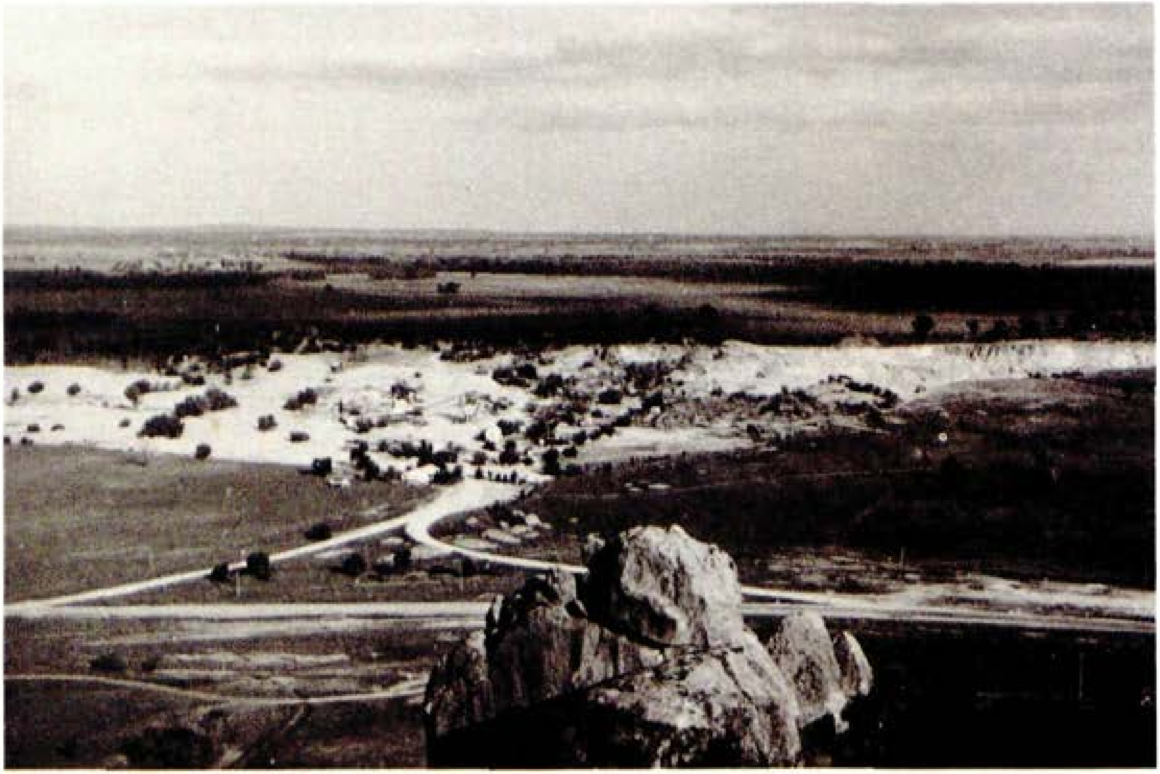
Parts of the study area offer potential for further stone quarrying and extraction, especially where the highlands, or isolated outliers of bedrock, occur in the area. Briefly, such localities include the Cambrian dolerites and gabbros

Table 20

SUMMARY OF STONE EXTRACTION FROM CROWN LAND
BY SHIRES

Shire	Public land	Details
Euroa	Gravel pit next to Hume Highway	Approximately 30% of the Shire's supply comes from this pit. Total Shire production for 1981/82 was 28,600 m^3.
Kerang	Two localities in the State Forests of Guttram and Benwell	Sand extraction for the Shire comes from these two pits, which contain the only known sand deposits in the Shire east of the Loddon River suitable for road construction. Production from these pits in 1981/82 was 9,500 m^3, representing 12.65% of total gravel and sand used by the Shire.
Rutherglen	Two localities occur on Crown land	The Shire uses mine tailings from Great Southern and Wallace Consols. Total production from these for 1981/82 was 5,000 m^3. The Shire estimates that for 1982/83 6,000 m^3 will come from Crown land and 28,000 m^3 from private land.
Wangaratta	Boorhaman North pit, Wilsons pit, Nicklaur pit	The Shire operates three pits within the Murray Valley area on Crown land. Total production in 1981/82 was 4,023 m^3.
All shires		Total 47,523 m^3

Note: The remaining 13 shires in the study area currently do not extract stone from public lands.



Quarry at Pyramid Hill - viewed from Pyramid Hill itself

on and around Mount Major. These rocks would be suitable for crushed aggregate.

Medium-grained granite has been quarried from the eastern side of the Warby Range near the Taminick Gap road, and has been used for the construction of churches in Wangaratta and Glenrowan. At present, just outside the study area at Glenrowan, it is being quarried and crushed on public land.

Sand and gravel deposits are widespread, and in many instances are suitable for extraction. An example is the fossil sand dune located on the eastern edge of Lake Mokoan.

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20. WATER UTILIZATION

Historical Development

European settlement in the area commenced in the 1840s, when squatters took up large tracts of land to raise sheep. After the gold fever of the 1850s had abated, the land was 'unlocked' by *Land Acts* designed to encourage settlement, and increasing areas of pastoral land were taken up for dryland farming. In years of average rainfall the area could sustain this form of agriculture, but unreliable rainfall and frequent drought meant that many farmers suffered serious hardships.

Good rains fell between 1870 and 1876, and so settlement expanded rapidly. More land in the area was taken up for farming, and landholders were fairly prosperous until the long drought from 1877 to 1881, which brought disaster.

The Victorian government responded to the crisis by passing the *Water Conservation Act* 1883, which provided for the establishment of Irrigation Trusts. In the 1880s and '90s many such Trusts were formed in the Loddon and Goulburn districts, but it became clear in the 1900s that they could not cope with the necessary construction of storage and diversion works. The main problem was one of finance, as in the wet years land-owners made no demand for water and, consequently, no payments. In the dry years demand for water and willingness to pay for it were high, but very little water was available.

In 1881, John Garden of Cohuna had demonstrated the feasibility of irrigation by watering 900 acres of wheat and grass from the Barr Creek near Cohuna. His crop of 20--40 bushels an acre was outstanding for the time, the average district yield being 2 bushels, and it earned him the title 'Pioneer of Irrigation'.

Not until 1889, however, when the Victorian government completed work on the Goulburn Weir, did irrigation become feasible in the Goulburn Valley.

Storing more than 25,000 ML and built of concrete, faced with massive granite blocks, the weir is still in service today, having withstood 90 years of Goulburn River floods. Raising the summer river level 14.6 m allows the water to be diverted by gravity in two directions - eastwards to the Shepparton area and westwards to Waranga Reservoir.

In 1905 the government established the State Rivers and Water Supply Commission. The Commission consolidated the Trust areas into Irrigation Districts and extended diversion from the Murray after 1907 by erecting pumping plants at Koondrook and Cohuna. Irrigation expanded accordingly, although the lack of major water storages restricted these developments.

From 1913 to 1933 the Commission was the statutory Closer Settlement Authority for irrigation areas in Victoria, and during this time the Rochester, Shepparton, and Tongala areas were settled. With the expansion of settlement, and an increasing dependence on irrigation, it was realized that additional storage capacity was needed. This led to the construction of River Murray Commission storages - including Torrumbarry Weir (1924), Hume Reservoir (1931), and Yarrawonga Weir (1939). Water from these storages greatly increased the area of the Murray Valley that could be irrigated.

Construction of Eildon Dam was completed in 1955 and resulted in a doubling of Victoria's water storage capacity. Further additional storage capacity was still needed, however.

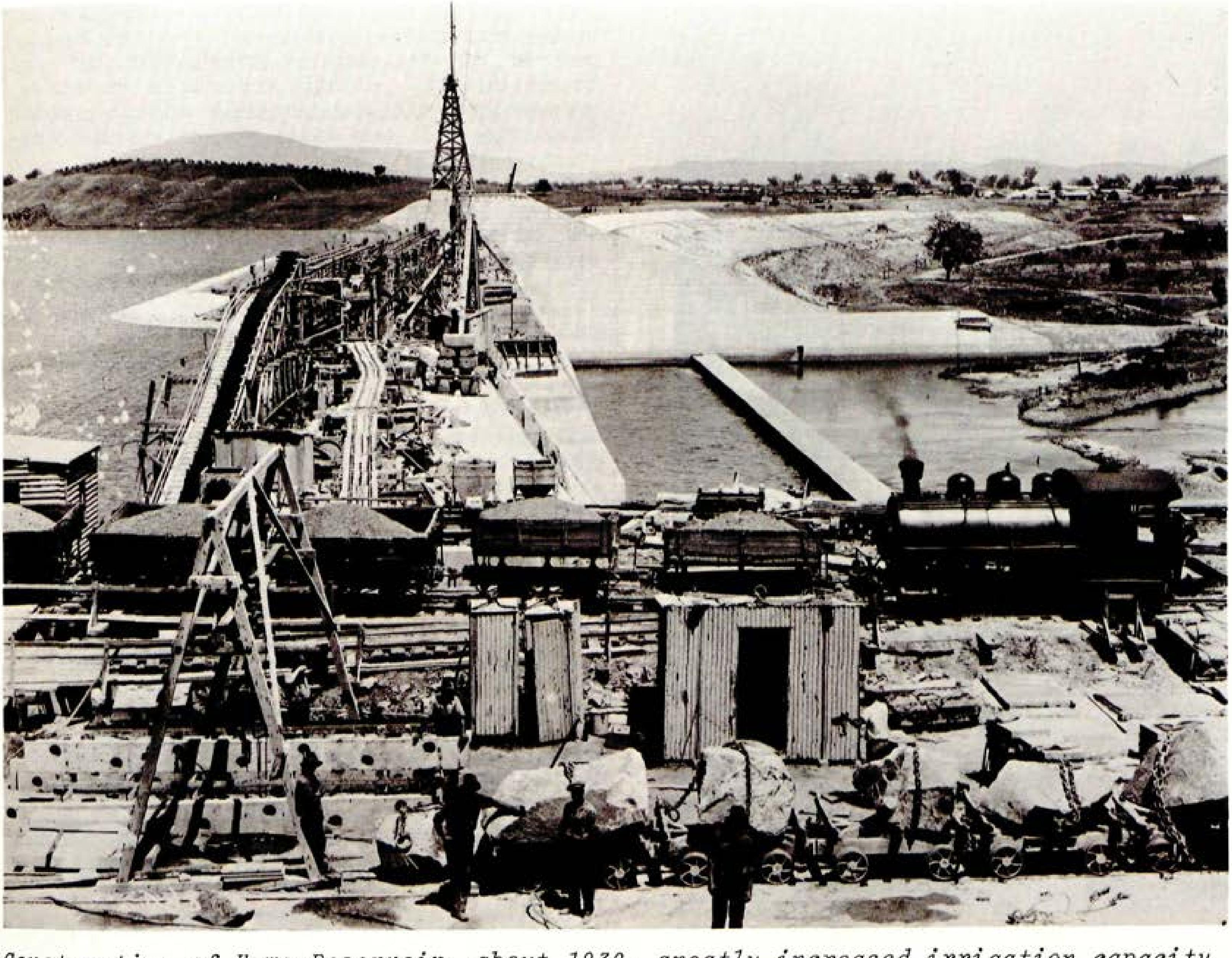
Since the 1950s, the main expansion in irrigation has stemmed from intensification of water use and the development of a 120,000-ha irrigation district around Cobram and Numurkah. By 1955 work on the main supply channels was completed.

When irrigation began, no thought was given to proper water management. Land was 'wild flooded', with channels often criss-crossing highly permeable soils derived from prior stream-beds. The irrigation system was poorly designed, and drainage of used water was not considered. Consequently, underground water tables rose and concentrations of salt reached plant root zones. Salinity was first noticed around Cohuna in the early 1900s and developed rapidly around Kerang from 1908.

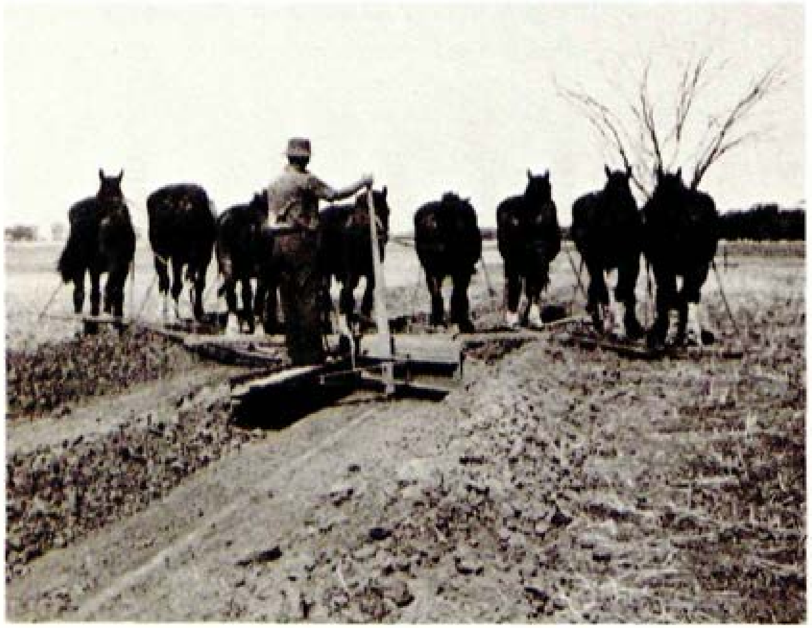
The construction of surface drains began in Rochester in 1917, and considerable construction was also carried out in the Shires of Deakin, Tongala, Stanhope, and Rodney between 1920 and 1930, and around Kerang and Cohuna in 1933--36. The extension of the surface drainage system continues today.

River Murray Commission

As the Murray River is a major source of water for irrigation in Victoria, New South Wales, and South Australia, there has always been a need for co-operation between the three States. In 1951, the federal government and the three State governments established the River Murray Commission. Initially, its main function was to ensure sufficient water for



Construction of Hume Reservoir, about 1930, greatly increased irrigation capacity



Making a new farm channel, with the help of 8 horses - Numurkah area, about 1946

navigation, but the storage and allocation of water for irrigation and domestic use have now become its major concerns.

Its activities are mainly confined to control of the river and storages in accordance with the *River Murray Water Act*, 1915. For major works, the detailed design, construction, maintenance, and staffing are carried out by the appropriate construction authority in each State, each acting, in effect, as the Commission's agent. In Victoria, the State Rivers and Water Supply Commission assumes this function.

Water is apportioned between the States under two different arrangements, depending on the amount available for distribution. South Australia receives an assured minimum monthly supply, while Victoria and New South Wales retain the right, at all times, to make use of waters of tributaries within their borders as they see fit, subject to the requirement that South Australia's full entitlement is provided.

Irrigation

Irrigation is the controlled application of water to the land in order to increase agricultural production. The amount applied varies with the need to supplement rainfall in order to maintain plant growth. Removal of excess water from irrigated land is also essential to maintain peak agricultural production. Improved drainage of both surface and groundwater is an essential part of land management in irrigation districts.

Goulburn--Murray Irrigation System

The Murray Valley area contains the bulk of this system, which includes the Murray Valley, Cohuna, Koondrook, Shepparton, Rochester, and Tragowel Plains Irrigation Areas, and parts of the Kerang, Third Lake, Rodney, Tongala, Calivil, and Boort Irrigation Areas and of the Campaspe Irrigation District.

It also includes parts of the East Loddon and West Loddon Waterworks Districts.

The Goulburn--Murray Irrigation System is Australia's largest, irrigating more than 425,000 hectares annually.

The Goulburn--Murray Irrigation District was constituted in 1959 and defined under section 62 and schedule 3A of the *Water Act* 1958. In broad outline, it stretches in a semi-circle inland from the Murray River between Swan Hill and Yarrawonga, with its southern boundary running through Boort, Rushworth, and Murchison. Main sources of its water supply are the Murray and that river's largest Victorian tributary, the Goulburn.

It contains some of the nation's richest farmlands, which produce a range of commodities including dairy goods, soft fruit, fat lambs, beef, and vegetables. The farms depend on irrigation to overcome the effects of limited rainfall, variable river flow, and drought.

In the north, the District receives irrigation water from the Murray, which is stored and regulated at Dartmouth Dam, Lake Hume, Yarrawonga Weir, and Torrumbarry Weir.

Water from Yarrawonga Weir (or Lake Mulwala) is diverted and distributed by gravity to irrigators around Cobram, and to the rest of the Murray Valley Irrigation Area via the Yarrawonga Main Channel. Torrumbarry Weir supplies water by gravity to the Cohuna, Kerang, Koondrook, and Third Lake Area via a natural drainage system, which includes Kow Swamp and Gunbower and Pyramid Creeks.

Between the Yarrawonga and Torrumbarry Weirs, the flow of the Murray decreases with distance downstream because of the requirements for irrigation on both sides of the river.

Lake Eildon supplies more than half of the water for the Goulburn--Murray irrigators. It can store enough water for more than one irrigation season, thereby minimizing the effects of prolonged drought.

Torrumbarry Weir (a trestle weir) can be taken out of the water for maintenance

On release, water from Lake Eildon flows down the Goulburn River to the Goulburn Weir. From there it is transferred by gravity - eastwards via the East Goulburn Main Channel (completed in 1910 and substantially enlarged in 1958) or westwards to Waranga Reservoir via the Stuart Murray and Cattanach Canals (completed in 1904 and 1956 respectively). From Waranga Reservoir, water travels westwards via the Waranga Western Main Channel, which extends some 230 miles to beyond Birchip.

Apart from construction of a number of small weirs in the 1880s, the first step taken towards the conservation and use of water resources of the Ovens, Loddon, Broken, and Campaspe River systems was the completion of Laanecoorie Reservoir on the Loddon in 1891. Other Loddon River storages, completed later, were Cairn Curran Reservoir in 1956 and Tullaroop Reservoir in 1959. These provide an assured supply of irrigation water to diverters along the Loddon River as well as supplementing supplies to irrigators in the extreme west of the area.

A further five storages were completed during the 1960s and early 1970s. Lake Eppalock, completed in 1962, supplies water to diverters on the Campaspe River and supplements irrigation in the south.

Lake Mokoan and Lake Nillahcootie store the waters of the Broken River system, and Lake Buffalo and Lake William Hovell those of the Ovens River system.

Irrigation methods

Pastures are generally irrigated by flooding: farmers allow the water to flow across the field by opening outlets from the irrigation channels located at its highest boundary.

The adoption of laser-levelling techniques for large tracts of irrigable land in the area has corrected previous faults due to lack of uniformity of application (caused by uneven grades), and to under-drainage.

Orchards, market gardens, and vineyards are usually furrow-irrigated: water from the irrigation channel is directed down furrows between the rows of trees.

Increased salinity and high watertables have resulted in many orchardists adopting tile drainage to control groundwater levels. Sprinkler irrigation, either overhead or under-tree, allows better control of deep percolation and economy of water use, but it is costly to install.

Modern low-flow systems of irrigation are also used in orchards. These are trickle, microjet, or minisprinkle systems, and offer better efficiency of water management than traditional sprinkler methods.

Charges made to farmers for irrigation water cover the operation, maintenance, and management costs of the system used.

Throughout the area, many drainage schemes have been constructed in order to reduce the frequency and extent of flooding (Jubilee Swamp about 1960)

Drainage

Historically, the provision of drainage systems in most irrigation areas lagged behind the installation of supply systems, and the backlog has yet to be overcome.

Initial co-ordinated drainage schemes here carried operational surpluses only, and natural drainage patterns handled the surface run-off problem.

More recently, however, additional drains have been built throughout much of the irrigated areas to carry surplus water away, thereby helping to control the water tables and maintain the viability of properties.

The very low-relief landscape and natural flood patterns of the local rivers and streams make it very difficult to design and operate a surface drainage system capable of handling all significant flood events. In the eastern part of the Goulburn--Murray Irrigation District, however, co-ordinated drainage capacity has been greatly enlarged in order to cope with significant flooding.

In some places, such as Kerang, groundwater levels have risen to such an extent that artificial drainage - principally for groundwater control - may be necessary.

Disposal of the groundwater depends on its quality. Good-quality groundwater

Table 21

WATER DELIVERED IN IRRIGATION AREAS (1980/81)

District	Water delivered (ML)
Murray System	
Murray Valley	348,910
Cohuna	222,234
Koondrook	108,204
Kerang	53,000*
Third Lake	3,000*
	700,000
Goulburn--Campaspe--Loddon Systems	
Shepparton	236,397
Rodney	350,000*
Tongala	156,000
Rochester	237,947
Campaspe	30,000*
Calivil	16,000*
Tragowel	148,209
Boort	40,000*
East--West Loddon	2,000*
	1,200,000
Total	1,900,000

* Because part of the District lies outside the study area, the figure given is an estimate derived from the amount of water known to have been delivered throughout the whole District.

can be re-used for irrigation, blended with higher-quality water for farm use, or discharged into the system for use downstream. If quality is poor then other disposal methods become necessary. These include on-farm evaporation ponds, on-farm storage with discharge in flood periods, community evaporation ponds, and community off-river storage with release in flood periods.

Funds spent on irrigation drainage maintenance are raised from the irrigators the drainage system services, the extent of maintenance being determined each year in consultation with local advisory boards.

Current Utilization

Surface water

The estimated surface-water utilization for irrigation in the Irrigation Areas totalled 1,900,000 ML during 1980/81 (see Table 21). This comprised 700,000 ML supplied from the Murray System and 1,200,000 ML from the Goulburn--Loddon System.

In addition to this 1,900,000 ML, private irrigation schemes in the study area use some 100,000 ML of water annually (as shown in Table 22). Most of these schemes are operated by individual landowners, who pump water directly from watercourses under licences or permits issued by the State Rivers and Water Supply Commission. Many of the land-

Table 22

AUTHORIZED ANNUAL WATER USE OUTSIDE IRRIGATION AREAS

Source	Irrigation	Domestic & stock	Miscell-aneous	Total
Murray River and Lakes	64,745	552	735	66,032
Ovens River Basin	4,654	68	450	5,172
Broken River Basin	19,015	119	-	19,134
Goulburn River Basin	9,402	242	646	10,290
Campaspe River Basin	1,706	75	-	1,781
Loddon River Basin	3,964	150	4	4,118
Total	103,486	1,206	1,835	106,527

owners also have licences to site their pumps, pipelines, and channels on public land.

The significance of irrigation here can be gauged from the fact that in 1980/81 the Murray Valley District consumed 50% of the State's irrigation water.

Urban water supply

Appendix 6 lists the local water authorities, constituted under the *Water Act* 1959, that serve urban centres in the area.

The populations that these Waterworks Trusts serve vary in size from 130 persons at Devenish to 24,250 at Shepparton. The sources of water vary, ranging from reservoirs that impound water from pastured and forested catchments to pumps that take water directly from the Murray River and Water Commission irrigation channels. No domestic water is obtained from bores. Annual urban water consumption in the study area amounts to 45,000 ML.

Local storages consist of excavated basins, sandpipes, elevated storages,

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or (as at Echuca) underground tanks. Storage capacity reflects the population served. Consumption per head of population ranges from approximately 0.2 ML to 0.3 ML annually.

All of the urban authorities chlorinate their water supplies, and the majority filter the water prior to use. The Boort and Shire of Deakin Waterworks Trusts also fluoridate their water.

The State Rivers and Water Supply Commission is responsible for the financial and technical supervision of the activities of these water supply authorities.

Groundwater

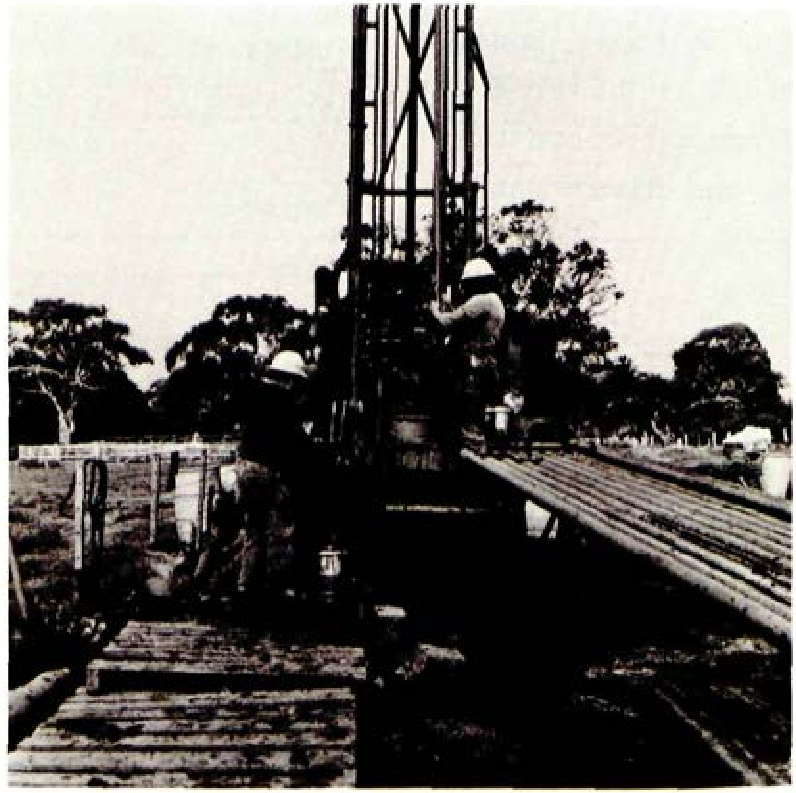
The area has substantial reserves of groundwater of varying salinities, contained in both the shallow and deep aquifers (see Map 7).

As at August 1982, it had a total annual licensed groundwater usage of 98,331 ML and contained 593 licensed bores and 398 irrigation bores (see Map 15).

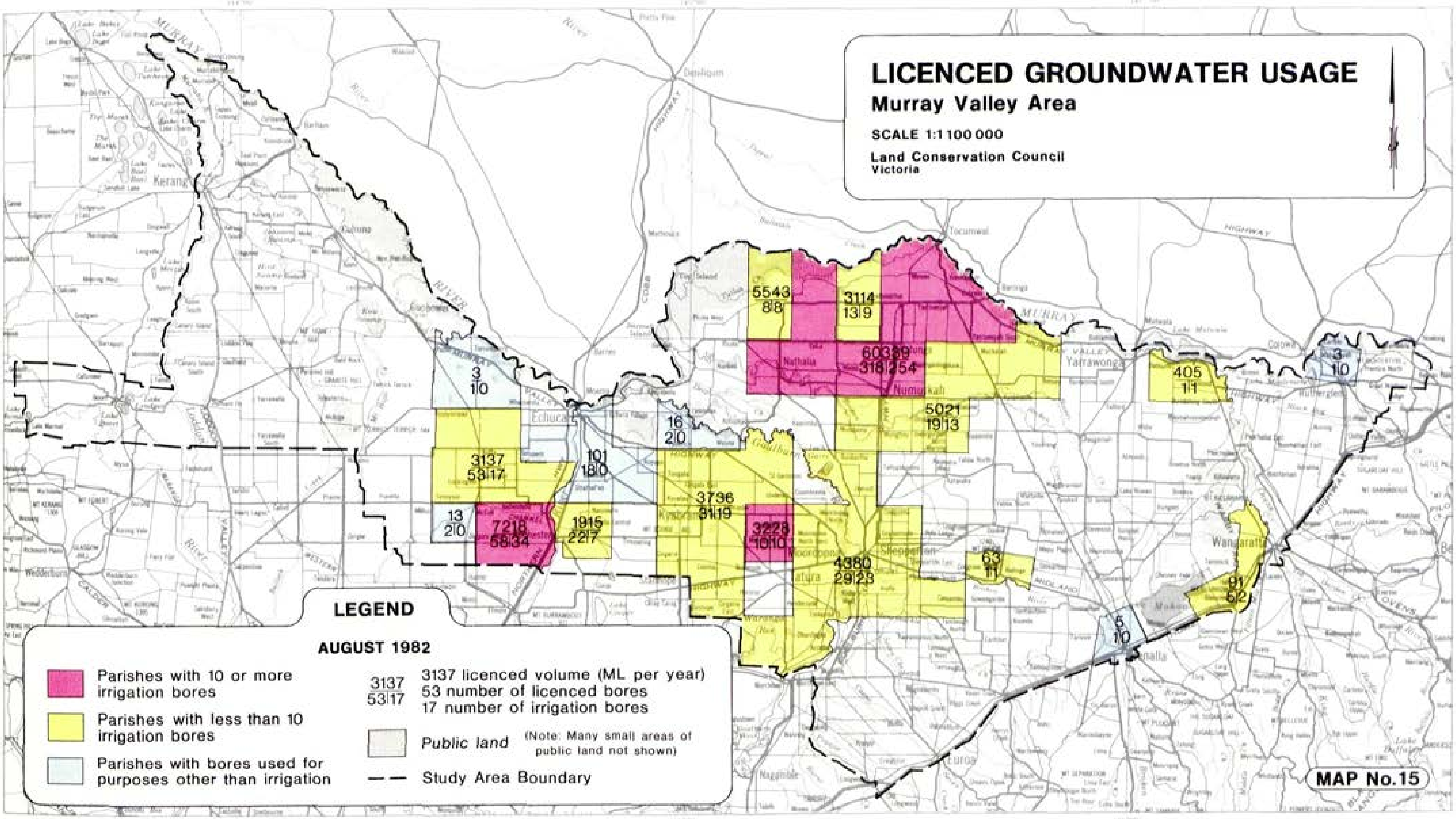
Groundwater is used for irrigation, for stock, and for domestic purposes. Bores in the Shepparton Formation aquifers provide groundwater for all three uses, while the deep aquifer in the Rochester area supplies water for irrigation at a rate of about 2,300 ML per annum.

The potential for use of the shallow aquifers generally increases from west to east across the region, and yields from irrigation bores range from 10 to 50 L per second. The highest concentration of shallow irrigation bores occurs in the Murray Valley and Rodney Irrigation Areas.

Bores in the consolidated rocks supply 1 L or less per second, and this usually restricts their use to stock and domestic purposes.



Drilling for groundwater - Murray Valley area


LICENCED GROUNDWATER USAGE
Murray Valley Area
SCALE 1:1 100 000
Land Conservation Council
Victoria
LEGEND
AUGUST 1982
Parishes with 10 or more irrigation bores
Parishes with less than 10 irrigation bores
Parishes with bores used for purposes other than irrigation
3137
53|17
3137 licenced volume (ML per year)
53 number of licenced bores
17 number of irrigation bores
Public land
(Note: Many small areas of public land not shown)
Study Area Boundary
MAP No.15
MURRAY
RIVER
Kerang
Echuca
Nathalia
Numurkah
Yarrawonga
Rutherglen
Wangaratta
Shepparton
Tatura
Mooroopna
Kyabram
Tocumwal
Deniliquin
Cobram
Euroa
Benalla
Wedderburn

Future Utilization

Surface water

Over the years, the construction of new storages has enabled continuous increases in water usage, but further increases are likely to be small, as surface resources are now highly regulated and almost fully committed. Throughout the study area, diversions have been authorized up to the capacity of most streams.

The Parliamentary Public Works Committee is currently holding an inquiry into future water allocations for all purposes in northern Victoria, which includes the Murray Valley area. Completion of the Dartmouth Reservoir will make an additional 600,000 ML per annum available for allocation to Victorian needs.

The Committee's Progress Report No. 1 (February 1982) acknowledged that, of this 600,000 ML, some 270,000 ML per annum had already been allocated. This left a volume of approximately 330,000 ML annually available for future allocation. Of that 330,000 ML, the Committee has recommended these allocations:

* 45,450 ML for future urban and industrial water supply in northern towns supplied from the River Murray and its tributaries

* 25,000 ML (interim) set aside in the interests of conservation of native flora and fauna

Many channels carrying water for irrigation and other purposes cross the area

* 65,000 ML (interim) for irrigation by private diversion, subject to the prescriptions nominated by the State Rivers and Water Supply Commission concerning appropriate drainage arrangements

In regard to concern expressed about the effects the operation of the Dartmouth Reservoir could have on the river red gum forest at Barmah, the Committee stated:

'The whole question of River Murray regulation and the associated problems of forest management are currently under detailed examination at two levels: through the River Murray Commission and within Victoria by a Joint Working Committee of officers of the Forests Commission and the State Rivers and Water Supply Commission. The Committee will give its appreciation of the problem and possibly make recommendations in a later Progress Report.'

After Dartmouth's completion, the only opportunity for further major development and increase of regulated water supplies to the Murray Valley area would come from the mid Goulburn, Ovens, or Kiewa Rivers. This would, however, require the construction of additional storage capacity.

Groundwater

For irrigation purposes, the best potential for shallow groundwater occurs in the Murray Valley and Rodney Irrigation Areas. Water tables still remain high there, despite the locally intensive pumping.

The Strathmerton and Ovens Valley Areas offer good prospects for the development of the deep aquifer: the groundwater is of good quality and, as yet, is virtually untapped.

For stock and domestic purposes, many areas contain small to moderate amounts of groundwater that is presently underutilized. The main factor limiting use of this water is its salinity.

River Improvement

The *River Improvement Act* 1958 provides for river improvement and maintenance works to be carried out and enables the constitution of river improvement districts under the control of a single authority.

Apart from such works, it also makes provision for carrying out drainage works and for rating lands within the district that such works benefit.

Works include the use of structures to reduce flooding and erosion, the removal of weeds and silt, and re-grading of the river bed. Fallen timber may be removed from rivers or alternatively placed against their banks to control erosion.

Four River Improvement Trusts operate in the study area: Black Dog Creek, Broken River, Bullock Creek, and the Ovens--King Rivers (see Map 16).

The ultimate purpose of works undertaken by Trusts is to maintain or increase the productivity of land adjoining rivers - by reducing flooding and erosion, and by improving drainage.

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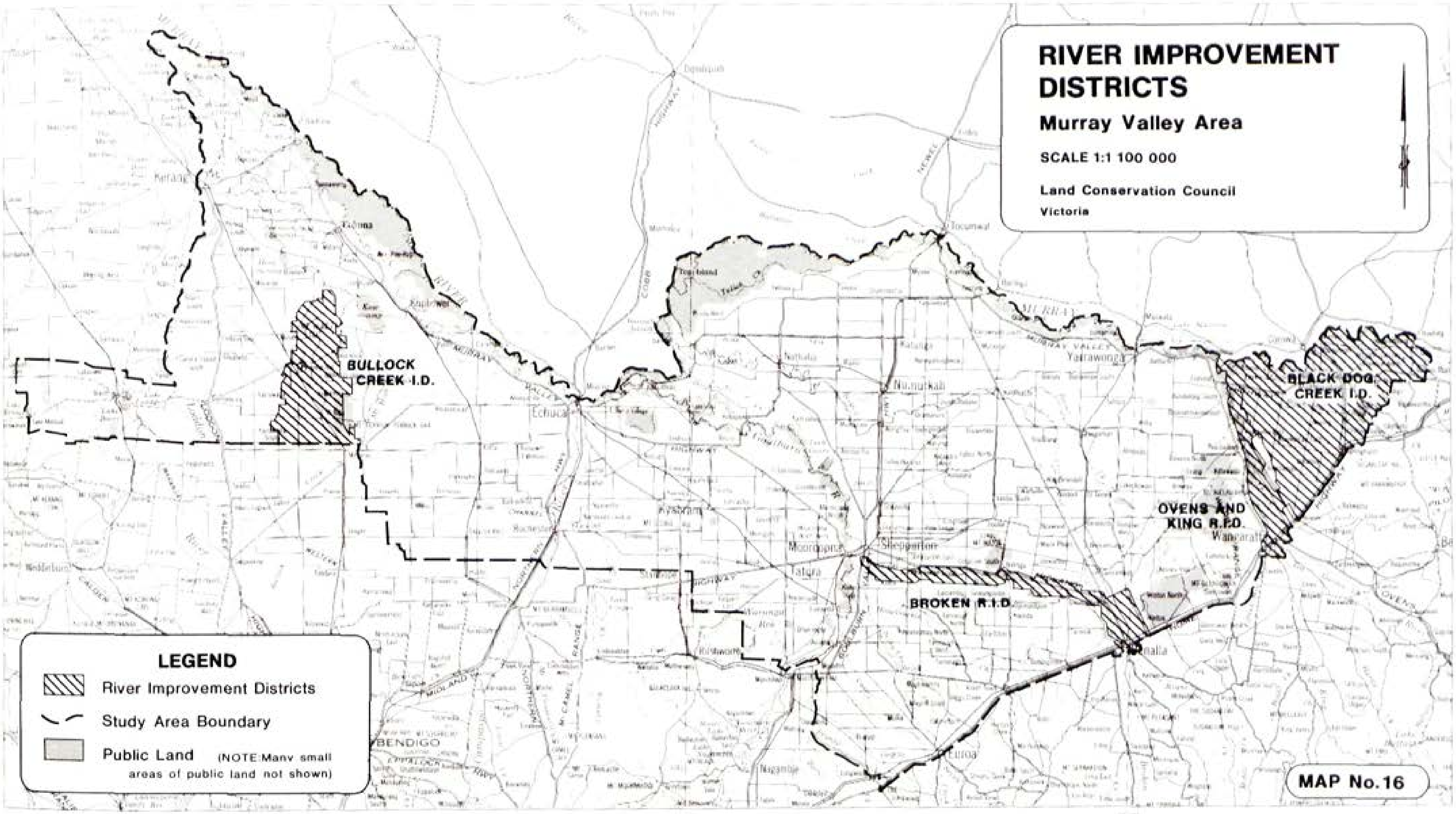
RIVER IMPROVEMENT DISTRICTS
Murray Valley Area
SCALE 1:1 100 000
Land Conservation Council
Victoria
BULLOCK CREEK I.D.
BLACK DOG CREEK I.D.
OVENS AND KING R.I.D.
BROKEN R.I.D.
LEGEND
River Improvement Districts
Study Area Boundary
Public Land (NOTE:Many small areas of public land not shown)
MAP No.16
Kerang
Echuca
Yarrawonga
Shepparton
Mooroopna
Tatura
Numurkah
Wangaratta
Benalla
Euroa
Nagambie
Rushworth
Kyabram
Rochester
BENDIGO
Tocumwal
MURRAY
RIVER

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21. UTILITIES

Often, the utilities and services essential to modern community living are located on public land. They may include facilities for transport, communications, navigation, power supply, waste disposal, or airstrips. This chapter describes the major utilities in the study area and attempts to assess future requirements in certain fields.

Waste disposal

Disposal of the waste produced by urban communities can be a problem for municipal authorities. The selection of new disposal sites can be difficult; in many cases, little suitable land remains near towns and conflict may arise between waste disposal and the recreational and conservation pressures for the same areas.

The illegal dumping of rubbish on public land is of widespread concern, and even the licensed tips have caused problems with fire risk, windblown material, and unsightliness.

Throughout the study area, the authorities mainly dispose of solid waste by the landfill method - using natural depressions or old excavations.

Generally, the tips serving the towns occupy either freehold land or public land specifically reserved or licensed for waste disposal. A number of townships use licensed tips on public land.

Sewage-treatment works processing both domestic and industrial waste operate for 16 of the major population centres of the study area, which does not contain any schemes under construction at present. Disposal of the effluent from these systems is generally through irrigation works, although a number of sewerage authorities discharge effluent into swamps or rivers.

Land vested in sewerage authorities is not 'public land', according to the *Land Conservation Act*, 1970. Appendix 7 gives further details on the sewerage authorities.

Electricity supply

The State Electricity Commission of Victoria supplies electricity from the State high-tension grid network. Two single-circuit 220-kV lines cross the study area; one connects the Bendigo, Shepparton, and Glenrowan terminal stations and the other the stations at Mildura, Kerang, and Bendigo. The easements for both of these transmission lines mainly occupy private land. On the Glenrowan--Shepparton line, the easement passes through portion of the Dookie Agricultural College.

A number of medium-voltage 66-kV transmission lines radiate from the Kerang and Shepparton terminal stations, supplying electricity to zone substations. Further distribution of electricity throughout the area, and to the consumers, occurs via a substantial network of 22-kV and 127-kV distribution lines.

Most of these sub-transmission and distribution lines run in road reserves, although some of them are in easements - usually on private land.

Construction of power lines along the easements of existing road reserves ensures ready access for maintenance vehicles. In some cases, however, it may require the destruction of some roadside vegetation to meet the easement widths that the Commission desires.

Supply of natural gas

The Gas and Fuel Corporation of Victoria has responsibility for a 300-mm-diameter pipeline conveying natural gas from the Woolert compressing station to Albury. At Euroa, a 200-mm-diameter pipeline branches off to supply Shepparton, Mooroopna, and Tatura. Easements for these pipelines traverse mainly freehold land, and cross public land in the vicinity of Lake Mokoan and Kialla West. At this stage there are no specific plans for extending these pipeline easements.

Road transport

The Country Roads Board has the responsibility for constructing and maintaining the State's major road systems. In the Murray Valley area, these include the Hume (which forms part of the national highway system and is funded by the Commonwealth government), Murray Valley, Loddon Valley, Midland, and Goulburn Valley Highways.

Some routes, defined as 'roads' by the C.R.B. and forming further links between settlements, come under the control of the relevant municipalities. Others are the responsibility of the municipalities and the Forests Commission - within their respective areas of control.

Road reserves often contain significant remnants of the original vegetation, particularly where they pass through agricultural country, and often make an important contribution to the local landscape.

Apart from some improvements to existing alignments, there are no plans for the construction of major highways in the study area. Long-term proposals for the Hume Highway, however, include by-passes and deviations around Euroa, Violet Town, Benalla, and Wangaratta, as part of the development ofa dual carriageway from the outskirts of Melbourne to Wodonga.

Airports

Four major aerodromes owned by the respective municipalities and licensed by the Commonwealth Department of Transport are located at Benalla, Echuca, Kerang, and Shepparton. In addition, a number of authorized landing strips are scattered throughout.

Rail transport

The Murray Valley area is well served by the VicRail network. Lines run from Bendigo to Kerang, Bendigo to Echuca, and Mangalore to Cobram, with branches to Numurkah, Picola, and Katamatite. The Melbourne--Sydney lines, broad- and standard-gauge, pass through Mangalore, Euroa, Benalla, and Wangaratta, with branches to Peechelba, Yarrawonga and Wahgunyah.

Recently the Kerang--Koondrook, Cohuna--Diggora West, and Girgarree--Stanhope lines have all been closed. The land these lines occupied remains the responsibility of the Railway Construction and Property Board.

Institutional use

Victoria's Department of Community Welfare Services administers the Dhurringle Prison, located north of Dhurringle. This is classified as a minimum-security establishment for short-term prisoners and has a self-contained farm, orchard, and cannery that provide work for the inmates.

Military use

The Australian Army has no recognized or proclaimed training areas here. Low-level adventure-type training does take place, however, on the public land. This requires prior approval from the responsible managing authority and is unlikely to pose a threat to public safety or cause major inconvenience.

It is expected that the increasing number of units being stationed at Albury--Wodonga will lead to more frequent use of public land abutting the Murray River for adventure-type training.

Communications

A number of government instrumentalities and commercial broadcasters operate and maintain communication and transmission facilities on leased public land at Mount Major.

Other uses

Public utilities and institutions occupy land for schools, cemeteries, trignometrical stations, public buildings, and municipal depots. Small areas of public land are continually required for such uses.

22. LAND USE RELATIONS

Preceding chapters of this report have described the natural resources of the study area and discussed the existing and potential utilization of resources on public land. Hazards associated with these uses have also been considered.

Groups with a wide range of interests are making growing demands for resources on public land. In such a situation the interaction of various uses becomes an important issue that must be considered before decisions can be made on the allocation of that land. This chapter examines the nature of the interactions.

Land use compatibility

Each type of land use requires a certain set of resources for its operation, and these have been discussed in relevant chapters. In many cases the resources required overlap in both time and space, thus providing a source of potential conflict. Moreover, the operation of each will have a series of direct and indirect effects on most other uses. These effects may be considered as:

* beneficial - resulting in an increase in another activity or activities (complementary uses)
* harmful - resulting in a decrease in another activity or activities (competitive uses)
* negligible - having no effect in either direction (supplementary uses)

The nature of these effects will determine the degree of compatibility between two or more land uses, and hence their ability to be combined in order to obtain the best combination of uses on a land management unit. In practice, several ameliorating factors operate, which include the following.

* Activities occur at different levels of intensity. (Incompatibility between two activities at a high intensity may be reduced if the operations of one become less intensive.)
* Some activities occur for a short period, thus restricting their effects and allowing other activities to continue in intervening periods.
* Often an activity only occurs in a small part of a wider area, thus localizing its effect. (This enables other activities to continue in the general area.)

* Compatibility between uses in an area changes over time as the once-harmful effects of one activity are lessened.

* Prevailing social attitudes towards the tolerance of harmful intereffects may change. (In some cases improved technology helps change these attitudes.)

* Skilful management techniques can reduce possible competitive effects of an activity on others.

Land use flexibility refers to the degree to which any one activity precludes (by its operation) other activities' utilization of a given resource. Flexible uses include those having either negligible or beneficial effects on others.

The following sections give a general outline of relations between broad land use categories in the study area. This report does not deal with relations between various activities or aspects within each major category of use, although the same principles would apply. Those between various forms of recreation, however, are briefly considered.

Agriculture

Clearing of land for agricultural production has benefited some native animals by increasing the area of grassland and forest margins, while farm dams and irrigation works may have extended the range of some amphibians, reptiles, and birds. Nevertheless, agriculture is normally incompatible with most aspects of nature conservation, since most species are severely reduced in number or even eliminated by the removal of their habitat and the introduction of alien plants and animals.

On the other hand, agricultural activities have in many cases added visual variety to the landscape; for example, the irrigated orchards around Cobram, especially when in bloom, provide a contrast with the adjacent river red gum forests.

Agriculture can affect water production, as the conversion from forest to grassland can alter the volume and timing of run-off, which in turn may lead to increases in total water yield, turbidity, and salinity, as well as a reduction in summer stream flow.

Irrigation can affect water tables, as the successive waterings over the years can lead to the rise of the water table, which in turn leads to the accumulation of salts at the root and ground level. Pollution may also result from injudicious use of fertilizers and pesticides or from the concentration of stock near watercourses.

Forest grazing can conflict with nature conservation because of the disturbance to the environment caused by stock grazing and watering, and the introduction of alien plants. It is also competitive with some forms of recreation that require natural environments and, by reducing native ground flora that provide nectar and pollen for honey bees, it can compete with apiculture.

Apiculture

Since the bees serve the useful function of cross-pollination, apiculture may complement agriculture.

It relies largely on the native flora and so is supplementary to timber production, recreation, water production, and some aspects of nature conservation. Bees do compete with native fauna for nectar and pollen, but the significance of this competition and its ecological effects remain largely unknown.

Timber production

This is a relatively flexible land use, particularly when carried out at a low intensity. It is compatible with forest grazing, honey production, and all but the strictest forms of nature conservation. It can benefit some forms of outdoor recreation by providing access tracks for walking and pleasure driving.

Harvesting operations can immediately degrade vegetation, fauna, and landscape values. Most effects are temporary, but some could be long-term. Tree-felling becomes more noticeable as the size of the area increases and when most or all of the trees in the stand are cut.

Increasing the levels of hardwood production decreases its compatibility with other uses, such as nature conservation, apiculture, and many forms of recreation. Intensive practices may favour certain commercially valuable species, remove trees containing sites for animal nesting, limit the size to which trees are allowed to grow, intensify harvesting activities, and require the increased use of fire.

Hardwood timber production in certain parts of the study area competes with recreational activities requiring solitude. It could also be considered to be in competition with agricultural production on those areas of forested public land that have potential for agricultural development.

Water conservation

The production and utilization of water is an important use of public land. To some extent it is competitive with agriculture, timber production, mining, and recreation (depending on the intensity of these uses, the management techniques employed, and the intended use of the water).

The hydrology of the surface drainage system in most of the study area has been significantly altered by use of water within and outside the area, as well as by artificial drainage of the lower lands. While this management of water is a necessary part of land management for food and fibre production, it can affect the value of wetlands for wildlife habitat and the health and vigour of some of the river red gum forests.

Activities such as logging, road-making, quarrying, clearing, and grazing can cause soil disturbance and reduce absorption by the soil, leading to increases in surface run-off, stream turbidity, peak flows, siltation, and erosion.

As well as contributing to the quality and quantity of stream flows, public land also contributes to the quality and quantity of the groundwater. Recharge of underground water supplies can be decreased if run-off is increased by clearing vegetation.

In many cases, activities using parts of catchments away from storage areas do not pose a substantial threat to either water quality or yield. The use of land as a catchment is therefore normally complementary with nature conservation and, to varying degrees, with other activities.

Water storages increase the opportunities for some forms of recreation, such as lakeside picnicking and water-based activities.

Storages, however, can adversely affect nature conservation. Inundation by water obviously destroys the original habitat, and the storage may alter flow regimes, affect water temperature and oxygen content, and consequently affect aquatic and riparian vegetation and wildlife habitats downstream.

On the other hand, storages also create an aquatic habitat, supporting fish and waterfowl.

Compatibility between water utilization and nature conservation can be enhanced by the design of structures and operation procedures that cater for the effective distribution and drainage of irrigation water.

Nature conservation

This is generally compatible with a wide range of uses, such as water production, apiculture, and low-intensity recreation. It tends to compete with any activity that radically changes the natural vegetation, such as mining, agriculture, urban development, or intensive forestry.

Excessive use for recreation is a problem in some areas of value for nature conservation, because these areas are often used primarily as leisure resources. The other aims of parks and reserves (biological conservation, landscape preservation, and research opportunities) can therefore be threatened.

Areas set aside specifically for reference must be managed to exclude activities other than particular forms of scientific study. This use is complementary with nature conservation and water production only.

Outdoor recreation

Outdoor recreation encompasses a wide range of activities. Their relations with other uses vary according to their type and intensity.

Some sports such as golf, horse-racing, and archery require their own specialized areas and are therefore incompatible with most other uses. Most recreational activities are relatively flexible, however, and can be accommodated in areas managed primarily for other uses.

A single land use in a particular area may conflict with one type of recreation and yet complement another. For example an abandoned quarry may mar a panoramic view yet provide an ideal site for gem fossicking or riding trail-bikes. Similarly, forestry tracks may reduce the value of an area for bushwalkers seeking natural surroundings, but make it more accessible for picnicking and pleasure driving.

Some pursuits such as adventure driving, fishing, and bushwalking can become self-competitive, especially at high usage rates.

Certain water-based activities such as water-skiing may be incompatible with nature conservation. Such conflict can sometimes be alleviated by zoning certain sections of the water body for specific activities.

Urban and industrial uses

Urban areas contain a multitude of different activities that collectively are competitive in space with most non-urban uses, including agriculture, timber production, apiculture, water conservation, mining, and many forms of outdoor recreation. Moreover, the presence of urban areas - by intensifying the utilization of, or requirement for, most resources - undoubtedly compounds the competition between many activities in adjacent areas of public land.

Extractive industries

Mining, quarrying, and shallow gravel extraction can be competitive with most forms of land use through site disturbance, roading, and pollution. Competition is usually localized, however, and its degree depends on the type and scale of operation. Underground mining does not usually involve as much site disturbance as open-cut mining or surface stripping, but dumping of waste material such as mine tailings may still conflict with other uses.

Many conflicts between extractive industries and landscape are localized, but they may be serious where values are high or the operations obvious. On the other hand, some quarries provide the opportunity to study the local natural history, and open sites for the collection of fossils and gemstones.

Exhausted quarries and open-cut mines are often useful for water supply or rubbish disposal, or as sites for such recreation as trail-bike-riding.

Public utilities and transport

Generally the provision of these services requires allocation of small areas of land only, but in most cases this represents an inflexible use.

Due to growing recreational pressures and more interest in nature conservation at a local level, waste-disposal problems are increasing. Most disposal sites are generally regarded as unsightly, sometimes produce offensive odours, and, if not carefully managed, may have detrimental effects on other uses such as water production.

Cleared easements for transmission lines or gas or water pipes compete with vegetation and some wildlife habitats, and may be unattractive. Likewise, the *measures taken to reduce the risk of* fire along transmission lines may conflict with other uses. Again, telecommunication facilities on peaks or ridges can conflict with scenic and other values, especially when constructed in attractive or remote landscapes.

These services and most others are generally considered essential. However, a measure of compatibility with other land uses can be achieved by careful siting, location, and design to minimize the conflicts.

PART IV

BLOCK DESCRIPTIONS

BLOCK DESCRIPTIONS

In this part of the report, the study area has been divided into six blocks. For each block, the location and land tenure, the nature of the land, present uses, capability for various uses, the present condition of the land, and likely land-use hazards are described.

A consistent format of headings and subheadings has been used, to help the reader compare specific information for various blocks. Some sections deal only with the public land. These include vegetation, recreation, and wood production. A key diagram at the beginning of each description gives the approximate location of that block in the study area while Map 2 shows greater detail for all blocks.

'Capability' refers to the suitability of public land for various uses. Assessment is based on a number of considerations, including the inherent characteristics of the land, its proximity to centres of population, the level of accessibility within it, the relative scarcity of the type of land, and the hazards associated with the various uses.

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

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1. GUNBOWER

A. General

1. Land tenure and location

Gunbower block occupies some 290,000 ha in the far west and north-west of the area. Approximately 27,000 ha is public land, mainly comprising the Gunbower Island State Forest (19,500 ha), Guttram and Benwell areas of reserved forest (1,850 ha), Kow Swamp (2,750 ha), the Tragowel Swamp Wildlife Reserve (200 ha), Hird Swamp Wildlife Reserve (270 he), and Johnson Swamp Wildlife Reserve (300 ha). The remainder comprises various stream frontages and reserved and unreserved Crown lands.

2. New South Wales Crown land

Significant areas of New South Wales Crown land abut this block. They are mostly State Forest, have a total area of some 34,400 ha, and are known as Campbells Island, Koondrook, and Perricoota Forests.

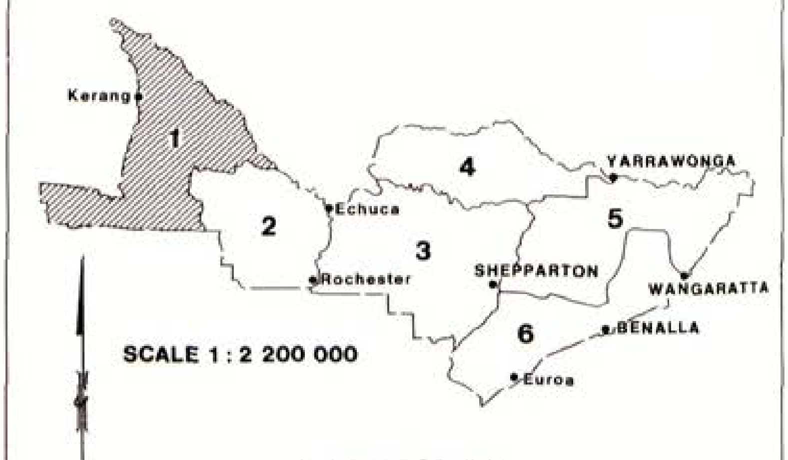
These lands serve many purposes, including timber production, grazing, flood mitigation, honey production, and recreation. They contain similar forest types, and would have similar conservation values, to those on the Victorian public land that abuts the Murray River.

B. Nature of the Land

1. Climate

Climate here can be described as semi-arid and is generally uniform throughout.

Average annual rainfall is less than 400 mm and ranges from 400 mm at Boort to 350 mm at Murrabit. It tends to dec-



1. GUNBOWER

rease from south to north. Considerable variations in monthly and yearly rainfall occur over the block, due mainly to summer storms.

In general, temperatures are similar throughout. Summers are hot and winters mild, with a mean annual maximum temperature of some 22°C and a mean annual minimum of some 9.5°C.

Average annual evaporation is usually three times average annual rainfall. The area experiences a few frosts: about 8 severe and 21 light frosts annually.

2. Geology and geomorphology

The block is dominated by riverine plains of Quaternary age. The youngest alluvial deposits of clay, sand, and gravel occur within the flood plains of the present-day streams, principally the Murray and Loddon Rivers. The surfaces of these river terraces are commonly marked by scrolls and oxbow lakes, broad areas of anastamosing channels, fine ephemeral channels, and low-lying areas subject to sheet flooding.

Away from the present-day drainage channels, and unrelated to them, are alluvial plains deposited by an older drainage system. Sandy levee banks of these former streams can still be traced at the surface of the plains.

Swampy areas and lakes are scattered over the alluvial plains. Associated with many of these are crescent-shaped dunes known as lunettes.

The Quaternary sediments overlie Tertiary alluvial deposits in the east of the block, and Late Tertiary marine sands in the west. Exposures of the marine deposits occur near Boort.

3. Soils

The most common soil type throughout the block is the grey-brown sodic uniform clay with gilgai micro-relief. In the slightly better-drained positions of the plain, red-brown sodic duplex soils occur but these are of minor importance.

In the far south-west, red calcareous sodic duplex soils predominate in the uneven mallee plain. Yellow sodic duplex soils occur in the depressions.

Other minor components include the silty gradational soils with hard-setting surfaces on the Murray River flood plains, the sandy red duplex soils on prior stream levees in the north-east, and the calcareous clay soils on the lunettes in the northern half and the extreme south-west.

4. Vegetation

In the riverine forests along the Murray, particular Gunbower Forest, river red gum predominates in a mosaic of open forest III and open forest II (sometimes grading into woodland II or III). The

Black box forest - Benjeroop Forest, north of Kerang

taller forests are characteristic of well-watered sites towards the Murray River, particularly in the downstream sections. (Due to the Cadell Tilt, a slope runs along the length of Gunbower Island.)

In the less frequently flooded sections, particularly to the south-east of the Island and along Gunbower Creek, an open forest II of black box replaces river red gum.

In addition, some small grassy plains (either too wet or too dry for tree growth) and swamp vegetation occur within the Gunbower Forest. Down-river from Gunbower Island, river red gum open forest II and III are the major vegetation types (Benwell and Guttram Forests).

Along the Loddon River, open forest II of river red gum predominates, with black box in less frequently flooded situations.

On the creek systems, black box open forest I and woodland I predominate, except where land use practices (in particular those related to water regulation) have induced a change to swamp, grassland, saltbush, or lignum communities. Although chenopods and lignum are characteristically components, extensive changes have occurred in the distribution of these species and the floristics of the chenopod content of the vegetation.

The side branches of the Loddon River system can support river red gum and black box in woodland I formation; however, changes in the water tables have altered the relative composition. The upper Gunbower Creek and lagoon system support a mosaic of black box, swamp, lignum, and saltbush. The effects of use for irrigation purposes have killed many trees, which may persist only on the top of some banks.

Surrounding the lakes, saltbush and lignum predominate, with swamp vegetation (rushes and reeds) or grassland in the

Kerang--Kow Swamp regions, and limited fringes of black box and river red gum fringe the lakes.

The remaining public land mainly carries saltbush or volunteer pasture (mostly of

Saltbush with grass in a salt-affected area along the Loddon River near Appin

introduced species). Around Boort, some small pockets of mallee vegetation (predominantly *E. dumosa*), with some yellow gum (*E. leucoxylon*), remain.

5. Fauna

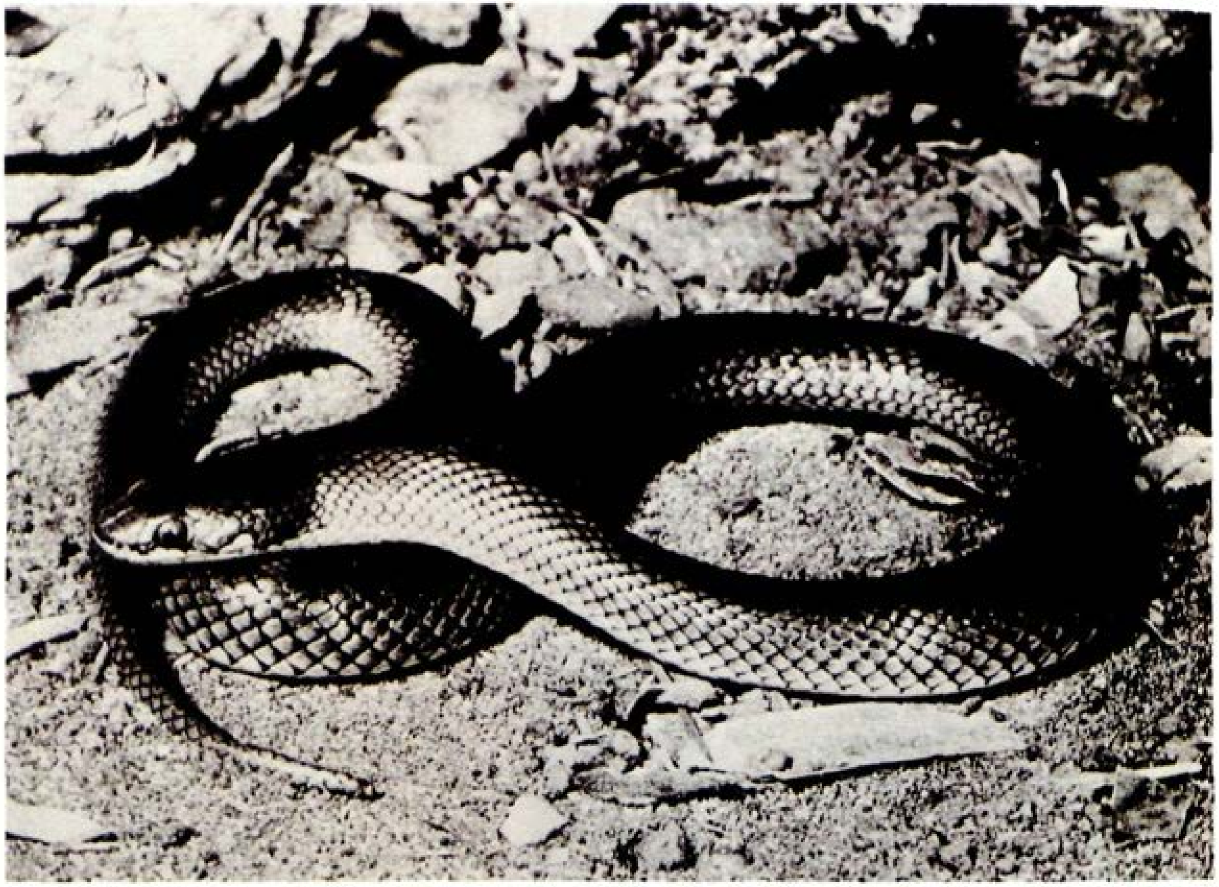
Gunbower block supports 17 species of native mammals. Many of these - such as the feathertail glider, yellow-footed antechinus, and sugar glider - are confined to the forested areas along the Murray River. Others - such as the brushtail possum, eastern grey kangaroo, and white-striped mastiff-bat - are more widespread throughout the block.

The house mouse, fox, brown hare, and European rabbit are the commonest introduced mammals.

The block contains the highest number of native bird species: 177 have been recorded. Those recorded only in this block include the little bittern, blue-billed duck, stubble quail, Baillon's crake, spotless crake, painted snipe, gull-billed tern, blue-winged parrot, variegated and white-winged fairy wrens, inland thornbill, striped honeyeater, and orange chat.

Reptiles known here total 24 species. Four of these - the hooded scaly-foot, curl snake, and two skinks (*Merietia grey* and *Morethia adelaidensis*) - are found only in this block. The other 20 include the bearded dragon, snake-eyed skink, and stump-tailed lizard. Nine

The curl snake (Suta suta) *occurs on the cracking clay soils in this block*



species of amphibians have been recorded - including Peron's tree frog, the barking frog, and the burrowing frog.

Appendices 2 and 3 list the fauna of the study area, showing the habitats in which they occur (Appendix 2) and their distribution and abundance in each block (Appendix 3). For descriptions of habitats, the reader should refer to Chapter 11.

C. Present Use and Capabilities

1. Nature conservation

While all the forested public land has at least moderate to high capability for nature conservation, some areas are more important than others. For instance, the river red gum and black box areas in the Gunbower Island State Forest are very important breeding and living habitat for many species of birds and native animals. Also the Forest provides good examples of the river red gum and black box forest and woodland types.

The Tragowel Swamp, Hird Swamp, and Johnson Swamp Wildlife Reserves are also important breeding areas for species of waterfowl such as duck.

In general, most of the public land is accessible and has in many cases been altered in some way by man's activities. Despite this, much of it still retains some conservation significance.

2. Recreation

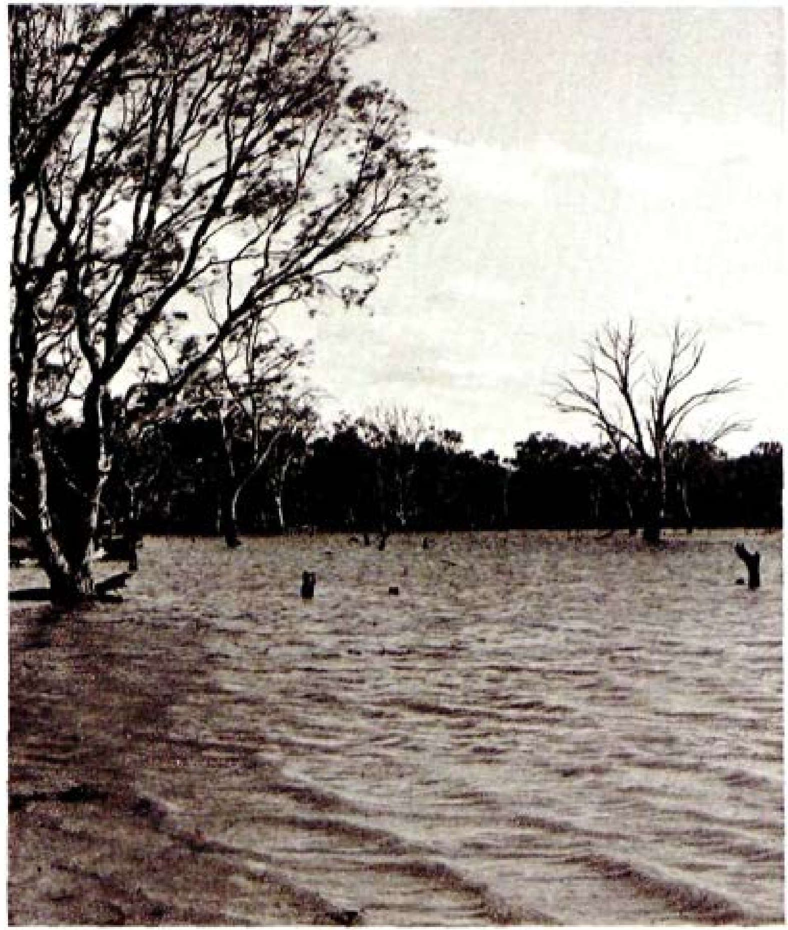
Gunbower Island State Forest is the main recreation resource here. Comprising mainly stands of river red gum and black box, the Forest with its many wetlands, creeks, and effluents provides excellent recreation opportunities, and is popular for fishing, camping, and hunting, where permitted. The convoluted course of the Murray provides many fishing spots. Wildlife, particularly waterfowl, are plentiful.

The most popular spots are along the Murray and at Torrumbarry Weir, where a formal caravan park is located. The Forests Commission maintains an extensive system of fireplaces and picnic tables.

Cohuna Scout Group has a camp within the Forest.

Access within the Forest is good and includes the River Track, which provides a scenic drive from Koondrook to Torrumbarry Weir.

Tragowel, Hird, and Johnson Swamp Wildlife Reserves are of interest for bird-



Lake Marmal is popular for a number of water-based recreation activities

Arbuthnot's sawmill - Koondrook

watching and Hird and Johnson Swamps are popular waterfowl-hunting areas.

Kow Swamp, Lake Boort, and Lake Marmal are popular for water sports and fishing.

3. Timber production

The main areas of timber production are the Gunbower Island State Forest and the Guttram and Benwell areas of reserved forest. These have generally high capability for timber production, especially the river red gum stands if the appropriate flood regimes necessary to maintain the health and vitality of stands are provided.

River red gum is mainly cut for sawlogs and rail sleepers and other minor forest products such as firewood, posts, and piles. Two sawmills - one at Koondrook and the other at Cohuna - draw river red gum sawlogs from the Gunbower Island State Forest. Sawlog parcels are periodically sold from the Guttram and Benwell reserved forest areas.

Twelve cutters are licensed to cut rail sleepers from these forests.

Grey and black box are generally cut to supply fencing materials, firewood, and short poles.

The Kraft factory at Leitchville utilizes quantities of firewood from the Gunbower Forest for industrial purposes.

The sawmill at Cohuna utilizes residue to produce red gum woodchips, which are sold as garden mulch.

4. Agriculture and apiculture

Most of the public land has low agricultural capability, mainly due to its flood characteristics. Most is grazed under some form of licence or, as in part of the Gunbower Island State Forest, under agistment.

The river red gum and box forests have a high capability for honey production.

5. Water

This block lies within the Loddon River drainage basin. Its western border is the Loddon River, while the Barr, Pyramid, Kinypanial, Pennyroyal, and Calivil Creeks traverse the area.

The Tragowel Plains, Kerang, Koondrook, Third Lake, Boort, Cohuna, and Calivil Irrigation Areas lie within or partly within the block, which also contains parts of the West and East Loddon Waterworks Districts, mainly around Boort. Water delivered to the Irrigation Areas and Waterworks Districts in 1980/81 was of the order of 592,000 ML. Small quantities are also authorized for use outside the irrigation areas. This water comes from the Loddon and Murray Rivers.

Most of the public land is used for flood mitigation purposes. In addition, numerous levees, pumping stations, pipelines, and channels (including natural drainage lines) are located on public land.

Three local water authorities - the Boort, Cohuna, and Kerang Waterworks Trusts - are constituted under the *Water Act* 1959. The block contains the western part of Bullock Creek Improvement District.

6. Mineral and stone production

Exploration for brown coal is currently being undertaken here. Gypsum is being mined from public land near Boort. Most stone extraction in the block occurs on private land, but the Shires of Kerang and Cohuna obtain sand and gravel from pits located in the Guttram, Benwell, and Gunbower Forests.

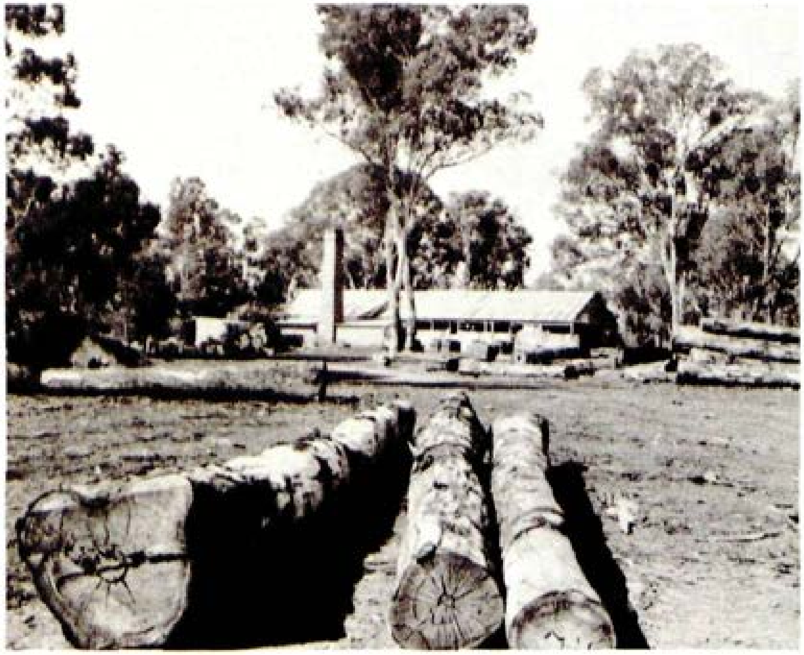
D. Hazards and Conflicts

Wildfire is always a major hazard. Although the forests on public land- such as the Gunbower Island, Guttram, and Benwell areas - do not have such a high fire risk as some others in the State, and in general access is good, wildfires remain a threat to life, property, and timber resources, and do, of course, affect wildlife and flora values.

While soil erosion is not a common feature on the public land, a moderate hazard for water erosion applies on the gently sloping Mallee plain, which, at present, may only be expressed as minor erosion of vehicular tracks. River and stream-bank erosion can be a problem along the watercourses. The potential for wind erosion of the sandy lunettes and the light topsoil of the Mallee plain is high.

Both vermin and noxious weeds are present on public land, but neither constitutes a significant hazard at present.

All of the major rivers and streams, such as the Murray and Loddon Rivers and Calivil Creek, are subject to flooding. Although winter--spring floods are nec-



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Both vermin and noxious weeds are present on public land, but neither constitutes a significant hazard at present.

All of the major rivers and streams, such as the Murray and Loddon Rivers and Calivil Creek, are subject to flooding. Although winter--spring floods are necessary to maintain the adjacent river red gum forests, flooding of agricultural land is a major hazard. Flooding of a magnitude that causes some inconvenience to the landholders near streams occurs frequently. More serious flooding, resulting in considerable property damage and community disruption, is a less frequent but not uncommon phenomenon, especially along the Lower Loddon River.

A major hazard to the health and vitality of the riverine forests along the Murray such as at Gunbower Island is the alteration of the natural flood regime due to water impoundment and diversion for irrigation and water supply purposes. This alteration has resulted in floods being less frequent, shorter in duration, and reduced in extent. Unless the appropriate flood regimes necessary to maintain the health and vitality of the riverine forests are provided, it is expected that the operation of the Dartmouth Dam will aggravate this situation.

Efforts to overcome these effects of the altered flood pattern may conflict with the water supply and management commitments to water-users both along and downstream of the Murray River.

Conflict may arise over the use and management of the many wetlands in the block for nature conservation, wildlife habitat, water supply, flood mitigation, and drainage. Management of water forms a necessary part of land management for food and fibre products and flood mitigation, but can affect the value of wetlands for nature conservation and wildlife habitat.

Opinions differ about the effect of grazing on public land and the maintenance of the ground flora. It is often claimed that grazing causes a reduction in the diversity of the ground flora species and domination of the site by one or more exotic or native species. Others claim that grazing is of economic importance and a necessary fire management tool for the type of forests in the block.

In some areas grazing, with proper management and stocking, may not conflict with other values.

On areas of public land where recreation use is high, such as Gunbower Island Forest, inevitably conflict with other uses will arise. Thus, some recreational activities may be inappropriate in prime water-bird habitats, camping and using recreational vehicles such as trail-bikes may be incompatible, and the heavy use of some river-bank areas may result in bank erosion.

2. PATHO

A. General

1. Land tenure and location

Patho block occupies some 194,000 ha in the middle west of the area. Approximately 5,500 ha is public land, comprising the Terrick Terrick State Forest (2,600 ha), reserved forest and frontage along the Murray River, and frontages along the Bullock and Mount Hope Creeks and the Campaspe River. The remainder comprises various small blocks of reserved and unreserved Crown lands - such as the granite outcrops at Pyramid Hill and Mount Hope.

2. New South Wales Crown land

A number of small areas of New South Wales Crown land abut this block. They are mostly State Forest with a number of Crown land reserves, and have an area of some 380 ha. The main ones are the Benarca and Moama State Forests.

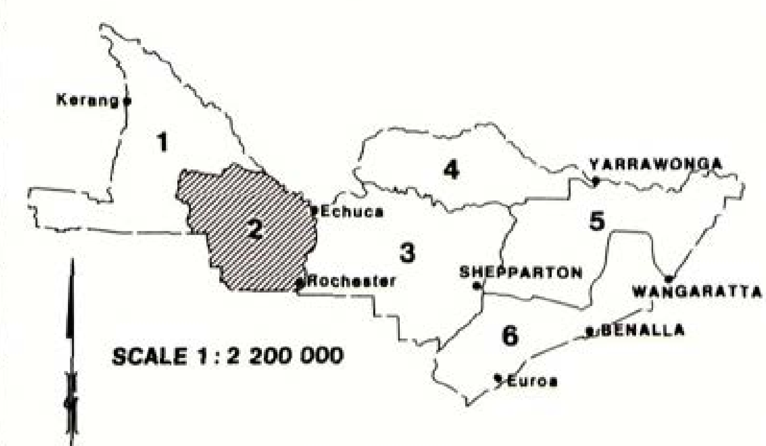
These lands serve many purposes, including timber production, grazing, flood mitigation, honey production, and recreation. They contain similar forest types, and would have similar conservation values, to those on the Victorian public land that abuts the Murray River.

B. Nature of the Land

1. Climate

Climate here can be described as semi-arid and is generally uniform throughout.

Average annual rainfall is less than 400 mm in the north-west of the block, and more than 400 mm in the south-west. It



2. PATHO

ranges from 451 mm at Rochester to 394 mm at Patho West. The summer and autumn rainfall is more erratic than that in winter and spring.

In general, temperatures are similar throughout. Summers are hot and winters mild, with a mean annual maximum temperature of some 22°C and a mean annual minimum of 8.9°C.

2. Geology and geomorphology

Riverine plains of Quaternary age dominate the block, with the youngest alluvial deposits of clay, sand, and gravel present within the flood plains of the modern streams. Older alluvial sediments make up the plains away from the present-day drainage channels. These were deposited by an earlier drainage system, traces of which can still be seen on the plains.

In the west of the block, outliers of Palaeozoic granite and minor contact metamorphosed sediments protrude through the plains, from Mitiamo through Mount Terrick Terrick to Pyramid Hill and Mount Hope.

3. Soils

Extensive areas have grey brown calcareous sodic uniform clay soils, with red-brown duplex soils occurring on slightly better-drained positions. Sections of the plain associated with old prior stream systems have well-drained red duplex soils on the levees, merging into red or yellow sodic duplex soils.

The Mount Terrick Terrick area, on the western boundary, has variable depths of coarse sands prominent. Red duplex soils with deep coarse sandy topsoils occur on the slopes and yellow duplex soils are found in the drainage depressions coming off the range.

Silty gradational soils with hard-setting topsoils occur along the Murray and Campaspe River flood plains in association with the river red gum forests.

4. Vegetation

A zone of river red gum open forest II and III adjoins the Murray River, with some fringes of grey box and black box open forest II. A small area carries yellow box open forest II near Wharparilla North. Some swamps and grasslands occur, often reflecting local land-use patterns. The remaining vegetation along the Campaspe River is predominantly river red gum open forest II, with some volunteer grasslands.

Along the creeks, black box woodland I or swamp communities predominate. The Gunbower lagoon system extends into this block (mostly saltbush, lignum, volunteer grassland, or swamp, with some river red gum and black box).

The Terrick Terrick Forest (2,900 ha) is mostly an open forest I of white cypress pine (*Callitris columnellaris*). Yellow box and grey box accompany the white cypress pine, but have been thinned out by silvicultural treatment. Some small pockets of 'granite outcrop' vegetation (scrub) also occur within the forest. Granite outcrop vegetation at Mount Hope and Pyramid Hill is dominated by the wattle, *Acacia deanei* ssp. *paucijuga*, with other sclerophyllous species (such as rock correa, wedge-leaf hop-bush, and nodding blue-lily) in an open shrubland formation.

Some of the small blocks support a black box woodland or river red gum open forest--woodland II, but volunteer grassland, lignum, or saltbush are most typical. A relic of grey box woodland with white cypress pine grows at Doherty Pines Flora Reserve near Rochester.

5. Fauna

The paucity of native vegetation remaining is reflected in the faunal composition. Only 12 species of native mammals have been recorded in the block, most of which are rare or uncommon: Only the widespread common brushtail possum and water-rat are recorded frequently.

Birds of 110 species have been recorded here; the rarer species among them include plumed whistling-duck, black falcon, Gilberts whistler, grey-crowned babbler, and singing honeyeater. Common birds in the block, such as galah and Richard's pipit, are those usually associated with the grasslands of the agricultural areas.

White cypress pine plantation - Terrick Terrick State Forest

In contrast to the other vertebrate groups, reptiles are well repreented here, largely as a result of favourable habitats provided by the rock outcrops. Species such as the eastern spiny-tailed gecko, large striped skink, Bougainville's skink, Cunningham's skink, and short-tailed snake utilize these outcrops, while the carpet snake and bandy bandy are also known in Patho block. Ten

Pyramid Hill golf club is located at the foot of Pyramid Hill

species of amphibians, all widespread in the study area, are recorded here.

Appendices 2 and 3 list the fauna of the study area, showing the habitats in which they occur (Appendix 2) and their distribution and abundance in each block (Appendix 3). For descriptions of habitats, the reader should refer to Chapter 11.

C. Present Use and Capabilities

1. Nature conservation

While all the forested land has at least a moderate capability for nature conservation, some areas are more important than others. For instance, the Terrick Terrick State Forest contains Mount Terrick Terrick, which forms a significant geological feature, and supports the largest area of white cypress pine forest and woodland formation in Victoria. Other geological formations of significance include Mount Hope and Pyramid Hill.

In general, most of the public land is very accessible and has in many cases been altered in some way by man's activities. Despite this, much of it still retains some conservation significane.

2. Recreation

The main recreation resource in Patho block is the Terrick Terrick State Forest. With its granite boulders and box and white cypress pine vegetation, it

White cypress pine fence posts are cut from the Terrick Terrick State Forest

provides interesting recreation experiences. Recreation development here is retarded by the lack of natural water. The Terricks Rocks Reserve is popular with picnickers. Trail-bike-riding is also popular.

Mount Terrick Terrick, Mount Hope, and Pyramid Hill all provide scenic views of the surrounding plain country. They also are of geological interest. Some small areas of river red gum forests adjoin the River Murray, but the recreation usage is relatively low.

A number of small recreation reserves cater for organized sports such as football, cricket, and tennis.

3. Timber production

Capability for timber production is generally low. The white cypress pine and box forests at Terrick Terrick produce durable timbers used for fencing material and short poles. Owing to the slow growth rate, it will be many years before this area produces white cypress pine sawlogs in any quantity.

Small areas of river red gum along the Murray River produce small quantities of sawlogs and rail sleepers, as well as fencing material and firewood.

4. Agriculture and apiculture

Most of the public land has low agricultural potential. Most is grazed under some form of licence or, as in the Terrick Terrick State Forest, under agistment.

The river red gum and box forests have a high capability for honey production.

5. Water

Most of the block lies within the Loddon River Drainage Basin; the remainder contains virtually all of the Campaspe River Drainage Basin. It contains the Rochester Irrigation Area, and part of the Campaspe Irrigation District.

Water delivered for irrigation in 1980/81 was of the order of 268,000 ML, and further small quantities were authorized for usage outside the Irrigation Areas and District. This water was supplied from the Murray and Campaspe Rivers.

Some levees, pumping stations, pipelines, and channels are located on the public land.

One local water authority is constituted under the *Water Act* 1959: the Rochester Waterworks Trust. The block also contains the eastern part of the Bullock Creek Improvement District.

6. Mineral and stone production

Exploration for brown coal is currently being undertaken east of the Terrick Terrick Range. Gypsum is being mined from public land in the Parish of Terrick Terrick West, and a small deposit of kaolinite occurs at Mount Terrick Terrick.

Granite is quarried from public land at Pyramid Hill, and there is potential for further hard rock quarries in the Terrick Terrick Range.

D. Hazards and Conflicts

Wildfires are always a major hazard. Although the forests on the public land (such as at Terrick Terrick) do not have such a high fire risk as some others in the State, and in general access is good, wildfires remain a threat to life, property, and timber resources, and do, of course, affect wildlife and flora values.

While soil erosion is not a common feature on the public land, a severe hazard of sheet erosion applies on the slopes of the Mount Terrick Terrick granitic area, and a moderate hazard for gully erosion in the lower depressions. The area also has a moderate potential for wind erosion if the sandy topsoil is left exposed. River and stream-bank erosion can be a problem along the watercourses.

Dryland and irrigation salting are not serious hazards in this block.

Both vermin and noxious weeds are present on public land, but neither constitutes a significant hazard at present.

All of the rivers and streams are subject to flooding. Flooding of a magnitude that causes some inconvenience to landholders near streams occurs quite frequently. More serious flooding, resulting in considerable property damage and community disruption, is a less frequent but not uncommon phenomenon. The area located near the junction of the Murray and Campaspe Rivers is particularly flood-prone.

Opinions differ about the effect of grazing on public land and the maintenance of the ground flora. It is often claimed that grazing causes a reduction in the diversity of the ground flora species and domination of the site by one or more exotic or native species. Others claim that grazing is of economic importance and a necessary fire management tool for the type of forests in the block. In some areas grazing, with proper management and stocking, may not conflict with other values.

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3. GOULBURN

A. General

1. Land tenure and location

Goulburn block occupies some 355,000 ha in the centre of the area. Approximately 16,000 ha is public land, mainly comprising the reserved forest that abuts the Goulburn River (12,000 ha), the Beattie Drainage Depression (400 ha), the Kanyapella Drainage Basin (2,500 ha), and a part of the Waranga Reservoir and part of Green Lake. The rest makes up various stream frontages and reserved and unreserved Crown lands.

2. *New South Wales Crown land*

Areas of New South Wales Crown land that abut this block are mostly State Forest, with a number of small Crown land reserves, and have a total area of some 3,200 ha. The main one is the Bama State Forest, north of Kanyapella.

These lands serve many purposes, including timber production, grazing, flood mitigation, honey production, and recreation. They contain similar forest types, and would have similar conservation values, to those on the Victorian public land that abuts the Murray River.

B. Nature of the Land

1. Climate

Climate in this block can be described as temperate, hot summer.

Average annual rainfall is mostly less than 500 mm and ranges from 513 mm at Shepparton to 437 mm at Echuca. It tends to decrease from south-west to north-east through the block. Winter rainfall is slightly higher than summer rainfall.

3. GOULBURN

In general, temperatures are similar throughout. Summers are hot and winters mild, with a mean annual maximum temperature of 22°C and a mean annual minimum of some 9°C.

The annual evaporation is of the order of 1,400 mm, which is three times the annual average rainfall.

2. Geology and geomorphology

Alluvial clay, sand, and gravel of Quaternary age outcrop as flat plains over most of the block. The youngest sediments occur in the channels and terraces of the present-day streams. Above this level the alluvial plains have been deposited by an older drainage system, traces of which can still be seen on the plains.

Clay lake-bed deposits together with associated lunettes occur in the west. A large relict lake-bed is represented by a subcircular depression to the east and north-east of Echuca.

Source-bordering dunes derived from deflation of dry stream-beds are scattered along present-day and pre-existing stream courses.

In the south of the block, Palaeozoic bedrock outcrops as low north-trending ridges protruding into the plain, and as outliers cut off from the Central Highlands. Sediments of Ordovician and Siluro-Devonian age are represented, together with Cambrian greenstones and sediments.

3. Soils

Red sodic duplex soils predominate here, with only minor occurrences of silty gradational duplex soils along the flood plains of the Goulburn River. Gilgaied clay soils are present in the northern sector, together with isolated occurrences of uniform sandy profiles on old lunettes. In the south, stony red gradational soils and reddish brown uniform clay soils are associated with the Cambrian basalt hills. Also in the south, shallow stony gradational soils and red sodic duplex soils occur on the gentle slopes of the Palaeozoic sediments.

4. Vegetation

The Murray--Goulburn flood plain region mostly carries open forest--woodland II--III of river red gum, with some fragments of grey box open forest II, swamp, and grassland (usually volunteer). Kanyapella basin is predominantly river red gum open forest--woodland II, with areas of box (black and yellow), volunteer pastures (with some tree regeneration), and swampland.

Vegetation around other watercourses is mostly river red gum open forest II, with some patches of grey box of similar formation. The last two vegetation types occupy the remaining treed public

Open forest--woodland I of black box and grey box near Wyuna

land, with some yellow box and black box to the east, but the majority of the small patches carry volunteer pastures.

5. Fauna

Goulburn block supports 33 species of mammals. The rare squirrel glider occurs extensively along the Goulburn River, at far greater densities than it is known elsewhere in the study area. Other arboreal mammals include the sugar glider, feathertail glider, common brushtail possum, and common ringtail possum. The brush-tailed phascogale, fat-tailed dunnart, and yellow-footed antechinus are also present, and 23 species of bats have been recorded.

A total of 136 native birds have been recorded in this block. A number of them are restricted or unusual ones, including the intermediate egret, glossy ibis, plumed whistling-duck, white-bellied sea-eagle, common sandpiper, barking owl, dollarbird, white-bellied cuckoo-shrike, and yellow-faced honeyeater.

The most notable among the 17 species of reptile known to occur in the block is a northerly record of White's skink. All of the 12 species of amphibians recorded in the study area occur in this block, including the rare giant bullfrog.

Appendices 2 and 3 list the fauna of the study area, showing the habitats in which they occur (Appendix 2) and their distribution and abundance in each block (Appendix 3). For descriptions of habitats, the reader should refer to Chapter 11.

C. Present Use and Capabilities

1. Nature conservation

While all the forested land has at least moderate to high capability for nature conservation, some areas are more important than others. Loch Garry provides important breeding areas and habitat for waterfowl. The Kanyapella Drainage Basin is also important for nature study (with special regard to the breeding habits of native birds in an artificially controlled environment).

Forested areas along the Goulburn are important for nature conservation - not only for native animals and birds, but also for river red gum and box forest and woodland types.

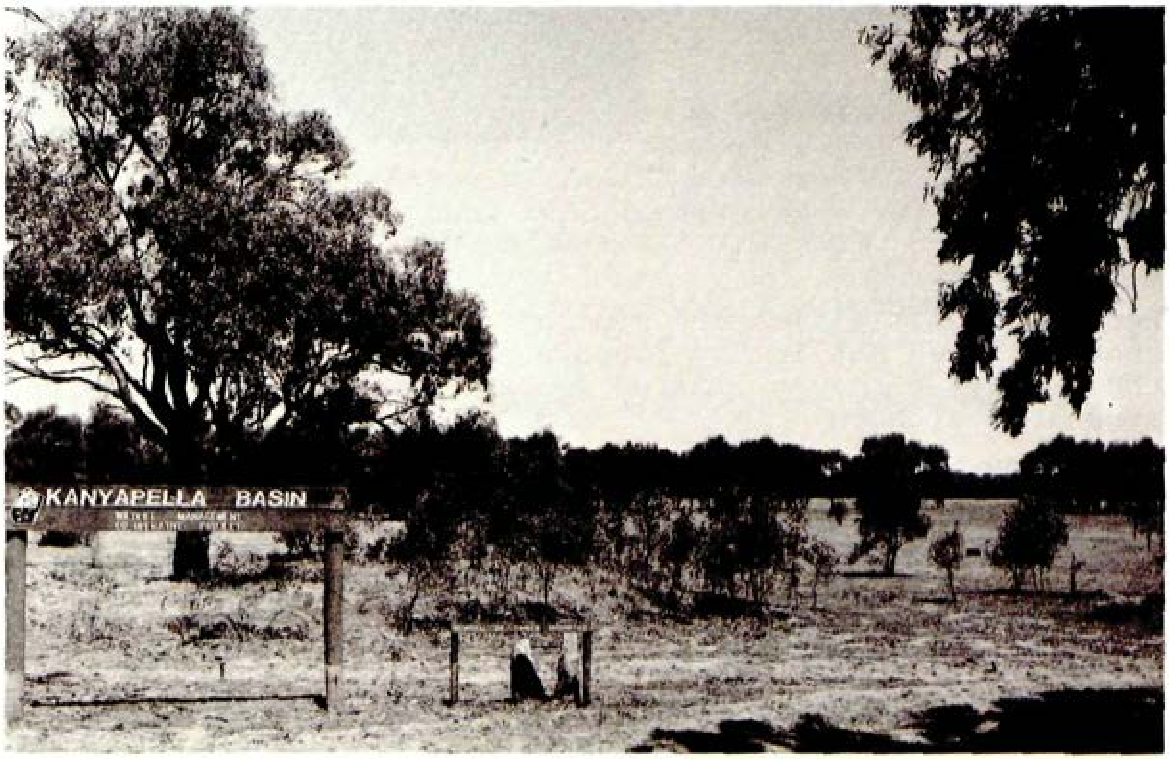
Many of the small parcels of public land carry examples of the native vegetation that occupied the riverine plains before European settlement. These have high floristic significance.

In general, most of the public land is accessible and has in many cases been altered in some way by man's activities. Despite this, much of it still retains some conservation significance.

2. Recreation

Forests that abut the Goulburn River are the main recreation resource here.

They receive less recreational use than similar forests along the Murray, but do cater for some of the recreational needs of people living in the area.



Kanyapella Basin, where a wildlife management co-operative project is currently in progress

Echuca racecourse lies on public land south-east of Echuca

Recreation activities are similar to those carried out in the forests along the Murray, although limited access hampers some of them.

Popular areas for camping along the Goulburn are Bangarang Park, Yambuna Bridge, and Ashes Bridge.

Loch Garry is popular for fishing, picnicking, and duck-hunting.

The Gemmill Waterfowl Reserve (34.4 ha), Shepparton Flora and Fauna Reserve (62.73 ha), and Shepparton Urban Waterworks Trust Area (21.04 ha), all Forests Commission section 50 reserves, are located along the Goulburn near Shepparton. The Echuca Village section 50 reserve (12 ha) adjoins the City of Echuca.

The City of Echuca offers a wealth of historical interest, especially for those interested in early Australian history.

A co-operative wildlife management project - carried out by the State Rivers and Water Supply Commission and the Fisheries and Wildlife Division - gives Kanyapella Basin recreational interest. The project is mainly concerned with waterfowl management through the use of an artificially controlled wildlife habitat.

A number of small recreation reserves cater for organized sports such as football, cricket, and tennis.

3. Timber production

The river red gum forests have medium to high capability for timber production.

One sawmill cuts small quantities of sawlogs from these forests, while five sleeper-cutters cut from the same area. Minor forest produce such as fencing material, firewood, short poles, and posts are also produced.

4. Agriculture and apiculture

Most of the public land has low agricultural capability, mainly due to its flood characteristics. Most is grazed under some form of licence.

The public land carrying river red gum that straddles the Goulburn River has a high capability for honey production.

5. Water

Most of the block lies within the Goulburn River Basin; the remaining eastern portion lies within the Broken River Basin. It contains the Shepparton Irrigation Area and parts of the Tongala and Rodney Irrigation Areas.

Some 742,000 ML of water was delivered to these Irrigation Areas in 1980/81, and a further 10,000 ML was authorized for usage outside the Irrigation Areas. Most of this was supplied from the Goulburn River.

Most of the public land adjoining the Goulburn and Murray Rivers is used for flood mitigation purposes. In addition, numerous levees, pumping stations, pipelines, and channels are located on public land.

Seven local water authorities are constituted under the *Water Act* 1959: the Shire of Deakin, Shepparton Urban, Mooroopna, Echuca, Merrigum, Tatura, and Kyabram Waterworks Trusts.

The block contains the western part of the Broken River Improvement District.

6. Mineral and stone production

Exploration for brown coal is currently being undertaken in the western part of the block, north of the highland front. Sediments prospective for coal are Tertiary in age, and underlie Quaternary alluvium of the riverine plains.

Most of the stone extraction takes place on private land, but the Shire of Rochester operates a hard rock quarry on public land in the Parish of Nannella. Cherts of Cambrian age are quarried from this site.

D. Hazards and Conflicts

Wildfires are always a major hazard. Although the forests on the public land, such as those abutting the Goulburn River, do not have such a high fire risk as some others in the State, wildfires remain a threat to life, property, and timber resources, and do, of course, affect wildlife and flora values.

While soil erosion is not a common feature on the public land, a moderate hazard of sheet and gully erosion affects the slopes on Palaeozoic sediments and Cambrian rocks. The sandy lunettes and source-bordering dunes also face a moderate potential for wind erosion. Small areas of dryland salting occur in depressions in the northern end of the Camel Range.

Irrigation salting has the potential to become serious if the measures taken to alleviate it are discontinued.

Both vermin and noxious weeds are present on public land, but neither constitutes a significant hazard at present.

All of the major rivers and streams, such as the Goulburn River, are subject to flooding. Although winter--spring floods are necessary to maintain the adjacent river red gum forests, the flooding of agricultural land is a major hazard. Flooding of a magnitude that causes some inconvenience to the landholders near streams occurs frequently. More serious flooding, resulting in considerable disruption, is a less frequent but not uncommon phenomenon. Flood problems in the lower Goulburn area are thought to be exacerbated by the presence of some protection levee banks.

A major hazard to the health and vitality of the riverine forests along the Goulburn River is the alteration of the natural flood regime due to water impoundment and diversion for irrigation and water supply purposes. This alteration has resulted in floods being less frequent, shorter in duration, and reduced in extent. Consequently it is expected that the health and vigour of the forest could decline and regeneration would be uncertain.

Efforts to overcome these effects of the altered flood pattern may conflict with the water supply and management commitments to water-users along the Goulburn River.

Conflict may arise over the use and management of the many wetlands in the block for nature conservation of wildlife habitat, water supply, flood mitigation, and drainage. Management of water forms a necessary part of land management for food and fibre production and flood mitigation, but can affect the value of wetlands for nature conservation and wildlife habitat.

Reeds growing in a drainage line

Opinions differ about the effect of grazing on public land and the maintenance of the ground flora. It is often claimed that grazing causes a reduction in the diversity of the ground flora species and domination of the site by one or more exotic or native species.

Others claim that grazing is of economic importance and a necessary fire management tool for the type of forests in the block. In some areas grazing, with proper management and stocking, may not conflict with other values.

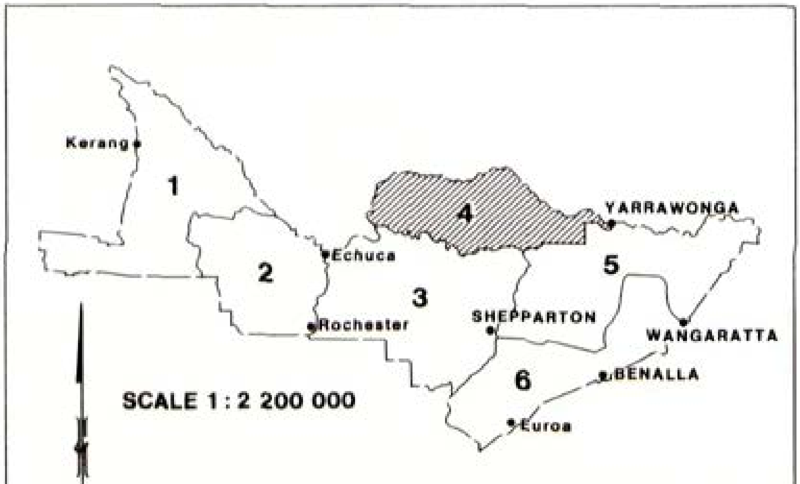
On areas of public land where recreation use is high, such as the popular recreation areas along the Goulburn River, inevitably conflict with other uses will arise. Thus, some recreational activities may be inappropriate in prime waterbird habitats, camping and using recreational vehicles such as trail-bikes may be incompatible, and the heavy use of some river-bank areas may result in bank erosion.

4. BARMAH

A. General

1. Land tenure and location

Barmah block occupies approximately 193,000 ha in the northern part of the area. Some 39,000 ha is public land, mainly comprising the Barmah State Forest (29,000 ha) and the reserved forest along the Murray River from Ulupna Island to Yarrawonga (7,200 ha). The rest consists of various stream frontages and reserved and unreserved Crown lands.



4. BARMAH

2. New South Wales Crown land

Significant areas of New South Wales Crown land abut this block. They are mostly State Forest and have a total area of some 41,000 ha. They are known as Moira, Gulpa Island, Millewa, Thornley, Woperana, Barooga, Cootadidda, Boomanoomana, and Mulwala Forests.

These lands serve many purposes, including timber production, grazing, flood mitigation, honey production, and recreation. They contain similar forest types, and would have similar conservation values, to those on the Victorian public land that abuts the Murray River.

B. Nature of the Land

1. Climate

Climate in this block can be described as temperate, hot summer.

Average annual rainfall is generally less than 500 mm, ranging from 444 mm at Nathalia to 473 mm at Cobram. It tends to decrease from east to west.

In general, temperatures are similar throughout. Summers are hot and winters mild, with a mean annual maximum temperature of some 22°C and a mean annual minimum of some 9°C. Summer and autumn are relatively hot. Days with a maximum temperature of 32°C or more occur 30 to 40 times a year. Severe frosts are limited to 8 weeks in June, July, and August and usually total 6--8 each year.

The annual evaporation in the block is approximately 1,375 mm.

2. Geology and geomorphology

Alluvial plains of Quaternary age make up the entire block. This alluvium has been differentiated into two units, the youngest of which comprises clay, sand, and gravel deposited by the present-day stream system, mostly along the Murray River in the north and west and the Broken Creek in the south.

The largest expanse of this unit occurs in the Barmah Forest, which is subject to frequent flooding by the Murray River.

Above the level of present-day stream terraces are alluvial deposits laid down by an older drainage system. Levee banks associated with these old stream courses are still visible on the surface of the plains.

Source-bordering dunes derived from deflation of dry stream-beds are scattered along present-day and pre-existing stream courses.

3. Soils

Barmah Forest is a uniform area of Murray River flood plain; the soils vary little from the silty gradational profile with a mottled clay subsoil and a bleached hard-setting topsoil. In the remainder of the block, reddish brown to yellow sodic duplex soils predominate, with grey sodic uniform clays in poorly drained areas and uniform profiles on old dune formation and some river levees.

4. Vegetation

The Barmah Forest is largely vegetated by river red gum open forest II--III. Areas of grey box and yellow box open forest II occupy sand ridges in the east, and pockets of black box grow in the south-west. Where prolonged inundation prevents tree growth, extensive areas support grassland and swamp. Some smaller treeless areas occur on dry sand ridges.

In the remaining riverine forests (Ulupna Island--Yarrawonga) red gum open forest III predominates. Broken Creek also supports remnants of river red gum open forest III. In addition, pockets of black box open forest occur - for example, at Nathalia and near Barmah.

5. Fauna

Of the 30 species of mammals, including 12 bats, known in Barmah block, the most

Many species of birds use the Barmah Forest for breeding

notable are the brush-tailed phascogale, squirrel glider, and sugar glider. The eastern grey kangaroo, platypus, yellow-footed antechinus, and common ringtail possum are common and widespread in Barmah State Forest.

A total of 129 native birds have been recorded here. The emu, white-bellied sea-eagle, brown quail, superb parrot, azure kingfisher, and leaden fly-catcher are a few of the more notable birds known in Barmah State Forest. The Forest is an important breeding area for a number of aquatic birds, such as ibis and duck species.

Only 13 species of reptile are known in this block, including the three Victorian tortoises and some of the commoner skinks. Eight species of amphibians, all widespread in the study area, have been recorded here.

Appendices 2 and 3 list the fauna of the study area, showing the habitats in which they occur (Appendix 2) and their distribution and abundance in each block (Appendix 3). For descriptions of habitats, the reader should refer to Chapter 11.

C. Present Use and Capabilities

1. Nature conservation

The most significant area for nature conservation is the Barmah Forest. This contains possibly the best examples of

Ulupna Island flora and fauna reserve in river red gum woodland

the development of river red gum as a forest species on the flood plains of the Murray River. It consists mainly of river red gum stands, with yellow box on the sand hills and black box in the less frequently flooded areas. The Forest also contains many watercourses, swamps, and grassy plains.

It is an important area for wildlife, particularly water birds. A variety of other birds and mammals inhabit or breed in the Forest. It has a relatively high population of eastern grey kangaroos by comparison with other Victorian forest areas. In addition, it provides important habitat for fish, amphibians and reptiles.

The Forest supports breeding populations of numerous water bird species; small resident populations breed regularly, but numbers swell during floods. Further, it provides extensive habitat for duck-breeding. Of 12 species noted in the area, most are good game species. In addition, the Forest is located at a major junction of the flyways of migratory ducks. Duck-hunters regard it as of paramount importance for the maintenance of viable duck populations.

Ulupna Island, a Public Purposes (Flora and Fauna) Reserve north of Strathmerton, was proclaimed in 1969, as a result of local interest and a wish to preserve the area's floristic and scenic value.

A total of 178 species of plants have been recorded in the reserve, which has suffered remarkably little from the effects of over-grazing or timber-cutting.

Many of the small parcels of public land carry examples of the native vegetation that occupied the riverine plain before European settlement. These areas have high floristic and faunal significance.

In general, most of the public land is accessible and has in many cases been altered in some way by man's activities. Despite this, much of it still retains important nature conservation values.

2. Recreation

The main recreational resource here (the Barmah State Forest) consists mainly of river red gum forests and associated wetlands, and provides many recreation experiences. Camping, hunting, bird-watching, pleasure driving, and horse-riding are all popular activities and usage level is relatively high.

The Barmah Forest is also important for nature study, as it provides a breeding habitat for kangaroos, emus, eight varieties of bats, and many species of waterfowl. Wild duck and ibis are common.

The Forest contains a wealth of Aboriginal relics and relics of European use and association.

The forests along the Murray from Ulupna Island to Yarrawonga are also popular for recreation, supporting activities such as camping, swimming, hunting, and fishing. Sandy beaches on this stretch of the Murray River are very popular locations for a variety of recreation activities.

The Ulupna Island Flora and Fauna Reserve, north of Strathmerton, provides opportunities for the study of flora and fauna.

3. Timber production

Most of the forests here are river red gum types and have a high capability for

Harvesting river red gum sawlogs in the New South Wales forests timber production if the appropriate flood regimes necessary to maintain the heath and vitality of these stands are provided.

Sawlogs from this block - mainly from Barmah Forest - are processed at four mills, located at Echuca, Barmah, Picola North, and Mulwala. In addition, 12 sleeper-cutters draw supplies from both the Barmah Forest and the forests adjoining the Ulupna Island--Yarrawonga stretch of the Murray River.

Other forest products such as fencing material, firewood, short poles, and charcoal are also produced.

4. Agriculture and apiculture

A large proportion of the public land has low agricultural capability, mainly due to its susceptibility to flooding.

Most is grazed under some form of licence, or, as in the Barmah Forest, under agistment. Its capability to support forest grazing is high, due to the grassy understorey of the river red gum and box forest types. Grazing usually takes place over summer and autumn, although the areas carry reduced numbers of stock in the winter and spring. This reduction in numbers reflects the loss of feed due to flooding.

The public land carrying river red gum and box forests has a high capability for honey production.

Sleepers being cut using a barrow saw

5. Water

The block lies within the Broken River Drainage Basin and contains all of the Murray River Irrigation Area.

Some 349,000 ML of water was delivered to this Irrigation Area in 1980/81. Significant quantities were also authorized for usage outside the Irrigation Area, the water coming from the Murray River.

Most of the public land is used for flood mitigation purposes, the Barmah Forest being a major part of the natural flood-control reservoir. In addition, numerous levees, pumping stations, pipelines, and channels are located on public land.

Three local water authorities are constituted under the *Water Act* 1959: the Shire of Nathalia, Shire of Numurkah, and Cobram Waterworks Trusts.

6. Mineral and stone production

Exploration for brown coal is currently being undertaken in the western part of the block. Underlying the Quaternary alluvium are Tertiary sediments that are prospective for coal.

D. Hazards and Conflicts

Wildfires are always a major hazard. Although the forests on public land such as the Barmah State Forest do not have such a high fire risk as some others in the State, and access is generally good, wildfires remain a threat to life, property, and timber recourses, and can have a devastating effect on wildlife and floral values.

While soil erosion is not a common feature on the public land, water erosion of tracks may occur in localized areas and river and stream-bank erosion can be a problem along the watercourses.

A severe hazard of wind erosion threatens the source-bordering dunes and sandy lunettes if the native vegetation is removed and the sandy topsoil is left in an exposed condition.

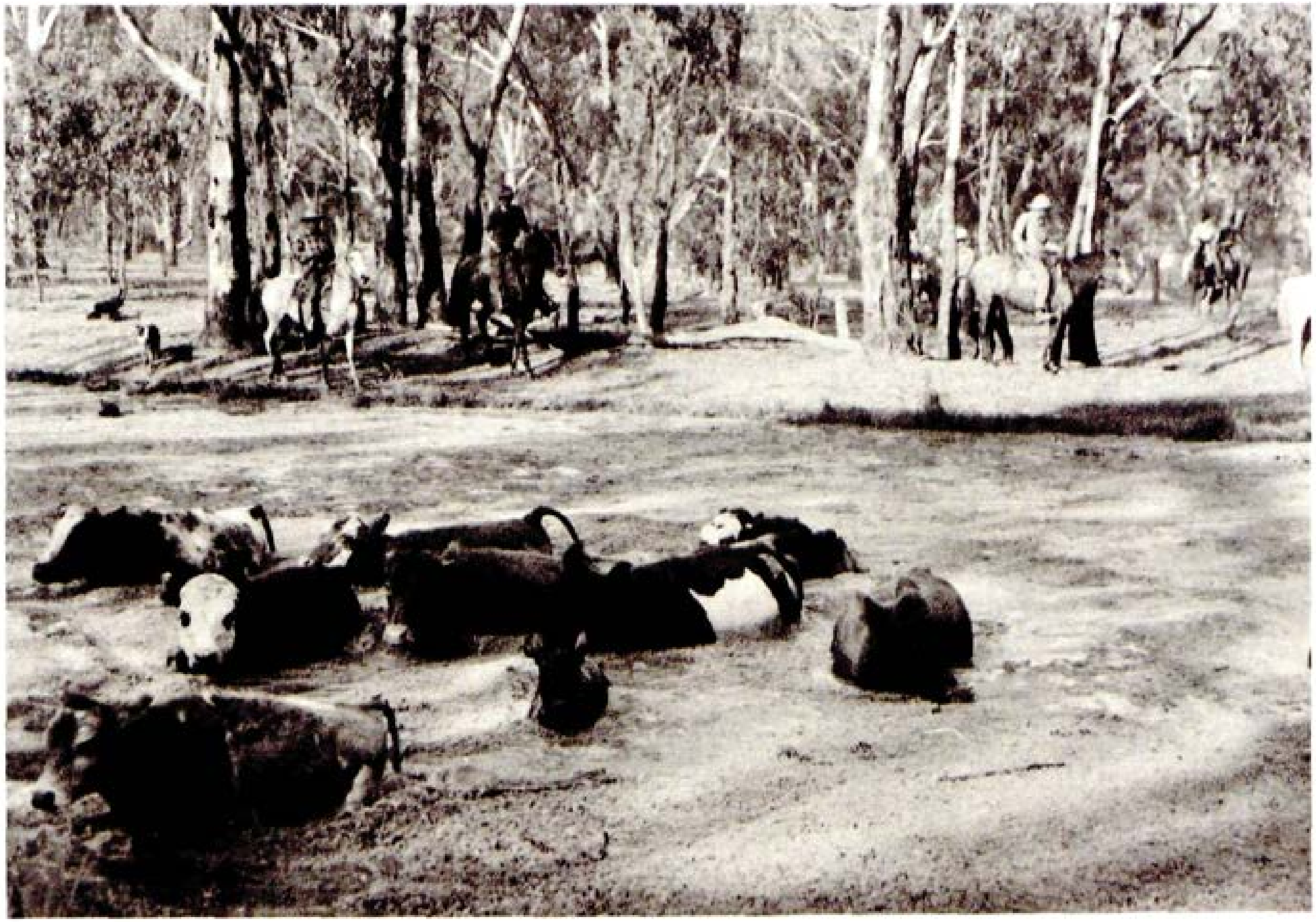
Salting caused by irrigation is not a currently significant land use hazard.

Both vermin and noxious weeds are present on public land, but neither of these constitutes a significant hazard at present.

All of the major rivers and streams, such as the Murray River and Broken Creek, are subject to flooding. Although winter--spring floods are necessary to maintain the adjacent river red gum forests, flooding of agricultural land is a major hazard. Flooding of a magnitude that causes some inconvenience to the landholders near streams occurs frequently. More serious flooding, resulting in considerable property damage and community disruption, is a less frequent but not uncommon phenomenon.

A major hazard to the heath and vitality of the riverine forests along the Murray - such as the Barmah Forest - is the alteration of the natural flood regime due to water impoundment and diversion for irrigation and water supply purposes. This alteration has resulted in floods being less frequent, shorter in duration, and reduced in extent. Unless the appropriate flood regimes necessary to maintain the health and vitality of the riverine forests are provided, it is expected that the operation of the Dartmouth Dam will agravate this situation.

Mustering cattle - Barmah Forest



Sections of the riverine forests are now frequently flooded in summer, when the rivers are kept high to provide water for irrigation. This summer flooding threatens river red gum regeneration and tree growth, access for protection, harvesting of forest products, recreation, and the maintenance of wildlife breeding areas and habitat. Efforts to overcome these effects of the altered flood pattern may conflict with the water supply and management commitments to water-users both along and downstream of the Murray River.

Conflict may arise over the use and management of the many wetlands in the block for nature conservation, wildlife habitat, water supply, flood mitigation, and drainage. Management of water forms a necessary part of land management for food and fibre products and flood mitigation, but can affect the value of wetlands for nature conservation and wildlife habitat.

Opinions differ about the effect of grazing on public land and the maintenance of the ground flora. It is often claimed that grazing causes a reduction in diversity of the ground flora species and domination of the site by one or more exotic or native species. Others claim that grazing is of economic importance and a necessary fire management tool for the type of forests in the block. In some areas grazing, with proper management and stocking, may not conflict with other values.

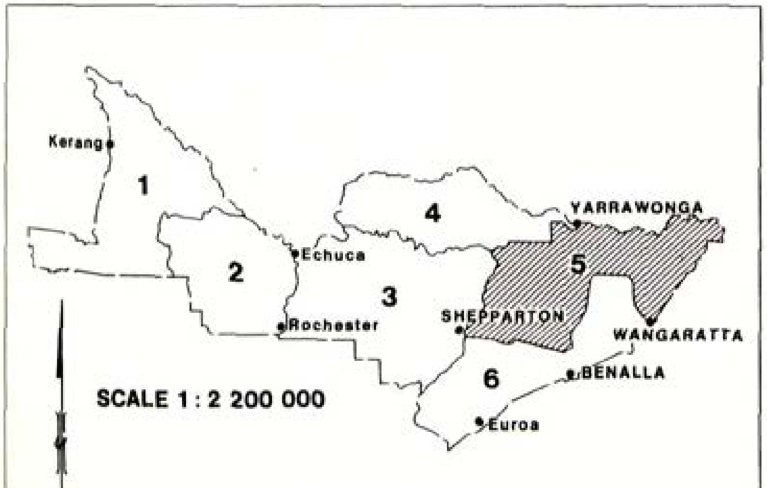
On areas of public land where recreation use is high, such as in the Barmah Forest, inevitably conflict with other uses will arise. Thus, some recreational activities may be inappropriate in prime water-bird habitats, camping and using recreational vehicles such as trail-bikes may be incompatible, and the heavy use of some river-bank areas may result in bank erosion.

5. YARRAWONGA

A. General

1. Land tenure and location

Yarrawonga block occupies some 293,000 ha in the east. Approximately 11,500 ha is public land, mainly comprising the reserved forest that straddles the Ovens River (4,000 ha), part of Lake Mulwala, and Dookie Agricultural College (2,500 ha). The remainder comprises Dowdle Swamp Wildlife Reserve (260 ha), various stream frontages, and reserved and unreserved Crown lands.



5. YARRAWONGA

2. New South Wales Crown land

Areas of New South Wales Crown land that abut this block are mostly State Forest, with a number of Crown land reserves, and have a total area of some 1,000 ha. The main ones are the Collendina, Corowa, Quat Quatta, and Quat Quatta East State Forests.

These lands serve many purposes, including timber production, grazing, flood mitigation, honey production, and recreation. They contain similar forest types - and would have similar conservation values - to those on the Victorian public land that abuts the Murray River.

B. Nature of the Land

1. Climate

Climate in this block can be described as temperate, hot summer and is generally uniform throughout.

Average annual rainfall - generally between 500 and 600 mm - ranges from 551 mm at Dookie to 596 mm at the Rutherglen Research Institute. It is sufficient to support dryland farming.

In general, temperatures are similar throughout. Summers are hot and winters mild, with a mean annual maximum temperature of some 22°C and a mean annual minimum of some 8°C.

2. Geology and geomorphology

The block consists predominantly of Quaternary alluvial plains with outcrops of Palaeozoic bedrock distributed in the south and east. The youngest alluvial deposits of clay, sand, and gravel occur within the flood plains of the present-day streams, principally the Murray and Ovens Rivers.

Older alluvial sediments make up the plains above the level of the modern stream terraces; these were deposited by an earlier drainage system, traces of which are still visible on the plains.

Small outcrops of Tertiary gravel and sand occur in the north-eastern corner and may be related to Tertiary sediments underlying the riverine plain to the west. An isolated exposure of Tertiary basalt occurs near Cosgrove.

Outcrops of Palaeozoic sediment, meta-sediment, granite, and greenstone occur as outliers and as low north-west-trending ridges protruding into the plains.

3. Soils

Sodic duplex soils with clayey subsoils ranging in colour from red to yellow (depending on the degree of profile drainage) comprise the major type on the plains. Uniform sodic clays predominate in poorly drained areas such as at Boorhaman East, and west of Mount Major.

On the hills of Palaeozoic sediments, shallow stony gradational soils occur on the crests with red sodic duplex soils common on the slopes. Yellow sodic duplex soils are confined to the drainage depressions.

Small hills of granitic origin also have red duplex soils on the slopes and yellow duplex soils in the depressions, but the presence of a hardpan at approximately one metre depth places severe limitations on land use.

Stony red gradational soils and red-brown uniform clay soils are common on the hills composed of Cambrian rocks around Dookie. Black uniform clays occur in the broad drainage depressions.

4. Vegetation

Along the Murray River, river red gum open forest II--III is the main vegetation, with patches of grassland and swamp. Public land along the Ovens River supports river red gum of similar structure. East of the Ovens the riverine forest is more fragmented. Some grey box and yellow box in open forest--woodland II formation occurs in the Ovens area. North-east of Peechelba East is a small patch of white box.

Broad-shelled river turtles are found in the rivers, streams, and billabongs in this block

River red gum open forest II, with grey box open forest--woodland II, grows along the Broken Creek systems with some swamps. Along some creeks draining into the Ovens, open forest--woodland III consists of river red gum, grey box, and yellow box. The swamp areas support river red gum, with grey box and yellow box in open forest--woodland II--III, and treeless swamp communities.

The Mount Major (Dookie Agricultural College) area has been disturbed and carries mainly improved pasture. Some yellow box grows on Mount Major, with some grey box and white box on the hills to the south.

Other small parcels often support volunteer pasture. Pockets of remaining vegetation include red gum open forest II and fragments of the grey box plains vegetation (in open forest--woodland II--III formation), with some yellow box (particularly in the hillier regions). Small pockets of red ironbark grow along the border between this block and Hume block, on the slopes above the Ovens River.

5. Fauna

A total of 21 native mammals have been recorded in this block, most of them found elsewhere in the study area. The long-nosed bandicoot and swamp wallaby have both been recorded here, apparently at the edge of their distribution.

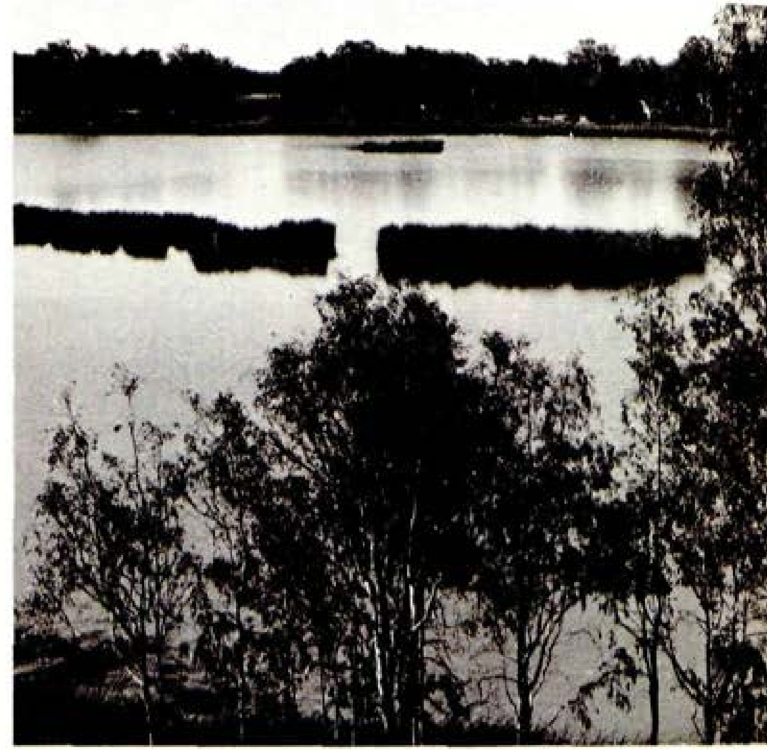
Only 92 species of native birds have been recorded in the block, the most notable being the white-bellied sea-eagle, little lorikeet, and yellow-tufted honeyeater.

The reptile fauna comprises 21 species, including Cunningham's skink, tree dragon, and Bougainville's skink. All 12 species of frogs known to occur in the study area have been recorded here, the most notable being the rare giant bullfrog.

C. Present Use and Conservation

1. Nature conservation

While all the forested land and other areas of public land have at least moderate capability for nature conservation, some areas are more important than others.



Lake Moodemere

Public land that abuts the Ovens River is significant as it carries good examples of river red gum with its associated flora and fauna.

Lake Moodemere near Rutherglen is ideal waterfowl habitat, and many species of waterfowl - such as musk duck and little grebe - are found there. Similarly, the Fisheries and Wildlife Division manages

Dowdle Swamp Wildlife Reserve south of Yarrawonga for conservation of water birds.

Many of the other small parcels of public land and stream frontages in this block carry examples of the native vegetation that occupied the area before European settlement. These have a high floristic and fauna significance and consequently high nature conservation value.

In general, most of the public land is accessible and has in many cases been altered in some way by man's activities. Despite this, much of it still retains important nature conservation values.

2. Recreation

River red gum forests that abut the Ovens River provide the main recreation resource of Yarrawonga block. At the junction of the Ovens and Murray, which attracts both campers and fishermen, campsites have been formally marked in the forest north of the Murray Valley Highway.

Lake Moodemere, near Rutherglen, is very popular for water-skiing, swimming, and bird-watching. Lake Mulwala too is very popular for water sports and fishing.

Mount Major, north of Dookie Agriculture College, provides panoramic views of the surrounding plains and also the Eastern Highlands.

Early mining sites in the vicinity of Rutherglen provide historical interest, with relics of the gold-rush days of the 1860s.

A number of small recreation reserves cater for organized sports such as football, cricket, and tennis.

3. Timber production

The main areas of public land with a high to medium capability for timber production are the river red gum forests that abut the Ovens River and those along the Murray. Two sawmills are licensed to draw sawlogs from these forests - one for salvage purposes only. Two rail-sleeper-cutters are licensed to cut sleepers from them. In addition, small quantities of firewood, fencing material, and short poles are cut.

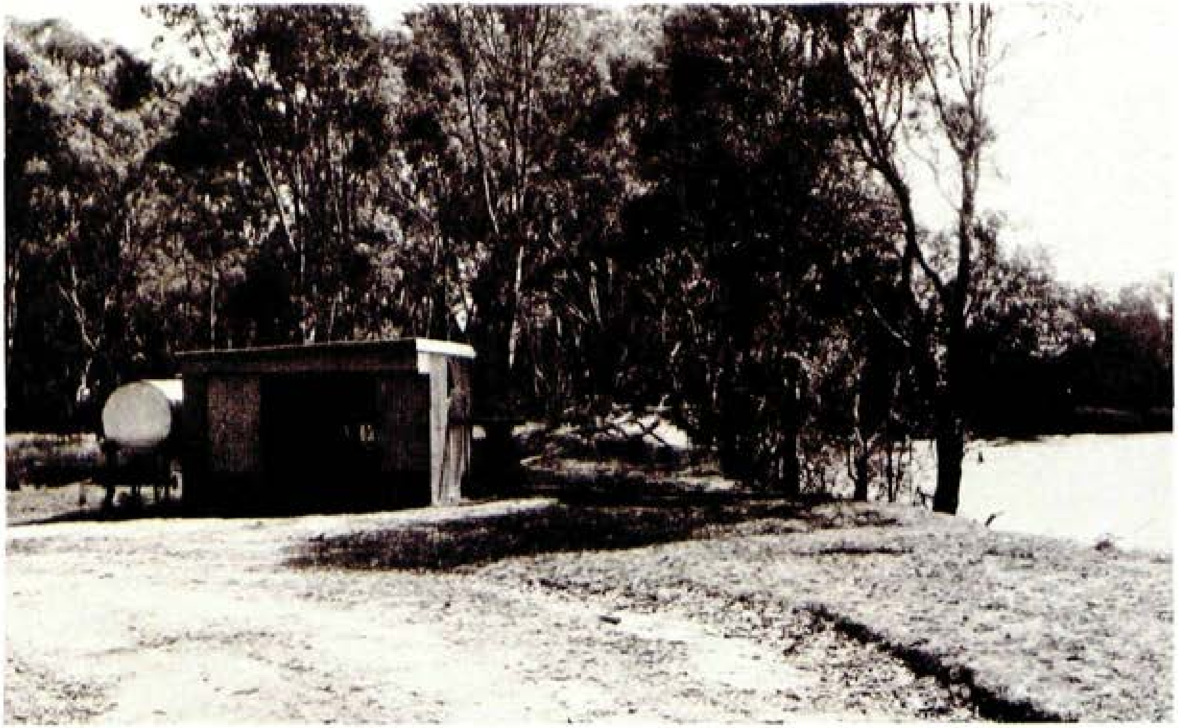
4. Agriculture and apiculture

Most of the public land, except for the agricultural research stations and colleges, has a low capability for agriculture, mainly due to its flood characteristics. Most is grazed under some form of licence.

The river red gum and box forests have a high capability for honey production.

5. Water

The western end of this block lies in the Broken River Drainage Basin while



A number of areas of public land abutting the Murray River are licensed as pump sites

the eastern end lies within the Ovens River Drainage Basin.

It does not contain any Irrigation Area, although substantial quantities of water are authorized for usage for irrigation, domestic, and stock purposes. This water comes from the Murray River or watercourses in the Ovens Drainage Basin.

Seven local water authorities are constituted under the *Water Act* 1959: the Shire of Rutherglen, Springhurst, Shire of Tungamah, Yarrawonga Urban, Goorambat, Katamatite, and Devenish Waterworks Trusts.

The block contains a substantial part of the Black Dog Creek Improvement District, the northern section of the Ovens and King River Improvement District, and part of the Broken River Improvement District.

6. Mineral and stone production

An important goldfield occupies the northern corner of the block, in a belt of country running north-west from Chiltern to Rutherglen. Large quantities of alluvial gold (and tin) were mined from a number of shallow leads, and smaller amounts of gold were also mined from quartz reefs in the bedrock. Exploration for further gold and tin deposits is currently taking place in the area. Diamonds have also been reported there, but in small quantities.

A small deposit of iron and manganese occurs at Mount Major near Dookie. This area of Cambrian rock is currently being explored for base metal mineralization.

A minor kaolinite deposit is located west of Nalinga, in the south-west.

The Shire of Rutherglen uses mine tailings for road construction purposes. Some of the material comes from alluvial mine dumps situated on public land near Rutherglen.

Most stone extraction in the block occurs on private land. Cambrian greenstones south of Dookie form a prospective hard rock resource on public land.

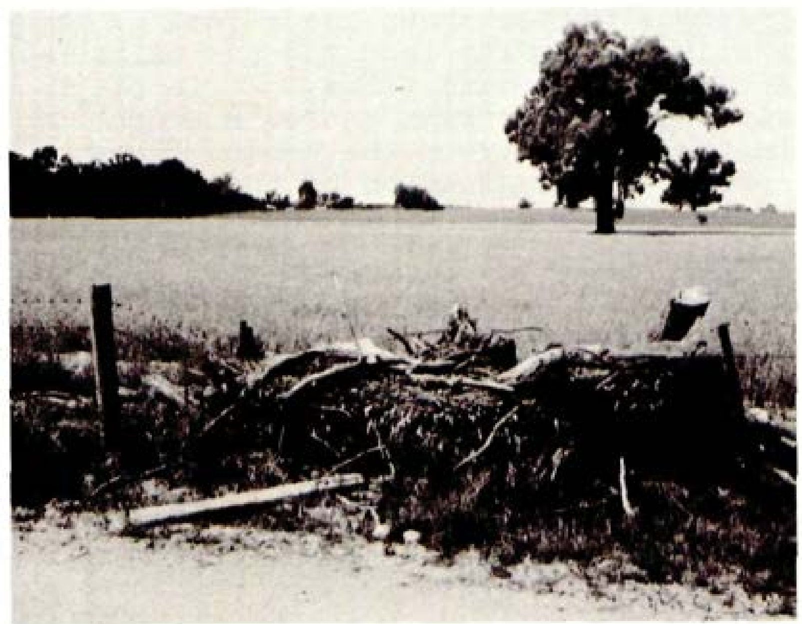
D. Hazards and Conflicts

Wildfires are always a major hazard. The forests on public land in this block, however, such as those abutting the Ovens River, do not have as high a fire risk as some others in the State, although wildfires remain a threat to life, property, and timber resources, and do, of course, affect wildlife and flora values.

While soil erosion is not a common feature on the public land, apart from some water erosion of tracks, there is a moderate to severe hazard of sheet and gully erosion, and a slight to moderate hazard of wind erosion of the sloping areas on Palaeozoic sediments and granitic rocks if the protective native vegetation is removed.

Both vermin and noxious weeds are present on public land, but neither constitutes a significant hazard at present.

All of the major rivers and streams, such as the Ovens and Murray Rivers, are subject to flooding. Although winter--spring floods are necessary to maintain the adjacent river red gum forests,



Flood debris can damage fences

flooding of agricultural land is a major hazard. Flooding of a magnitude that causes some inconvenience to the landholders near streams occurs frequently. More serious flooding, such as that of the Ovens River at Wangaratta, can result in considerable property damage and community disruption.

Altered flood regimes currently pose no hazard to the riverine forests along the Ovens River. This, with its tributaries, forms a relatively unimpounded river system. The riverine forests are therefore regularly flooded during winter--spring and no summer flooding occurs.

Opinions differ about the effect of grazing on public land and the maintenance of the ground flora. It is often claimed that grazing causes a reduction in the diversity of the ground flora species and domination of the site by one or more exotic or native species. Others claim that grazing is of economic importance and a necessary fire management tool for the type of forests in the block. In some areas grazing, with proper management and stocking, may not conflict with other values.

Conflict may arise over the use and management of the many wetlands for nature conservation and flood mitigation and drainage. Management of water is important for food and fibre production and flood mitigation, but can affect the value of wetlands involved for nature conservation.

On areas of public land where recreation use is high, inevitably conflict with other uses will arise. For example, on Lake Moodemere, speed-boating (a very popular activity) may interfere with the lake's value as a water-bird habitat and breeding area.

6. HUME

A. General

1. Land tenure and location

Hume block occupies some 225,000 ha in the south-east. Approximately 23,000 ha is public land, mainly comprising 6,400 ha of reserved forest at Killawarra and the Warby Range, the Warby Range State Park (3,270 ha), and Lake Mokoan (8,500 ha). The remainder is made up of various stream frontages and small areas of reserved and unreserved Crown lands.

B. Nature of the Land

1. Climate

Climate in this block can be described as temperate, hot summer.

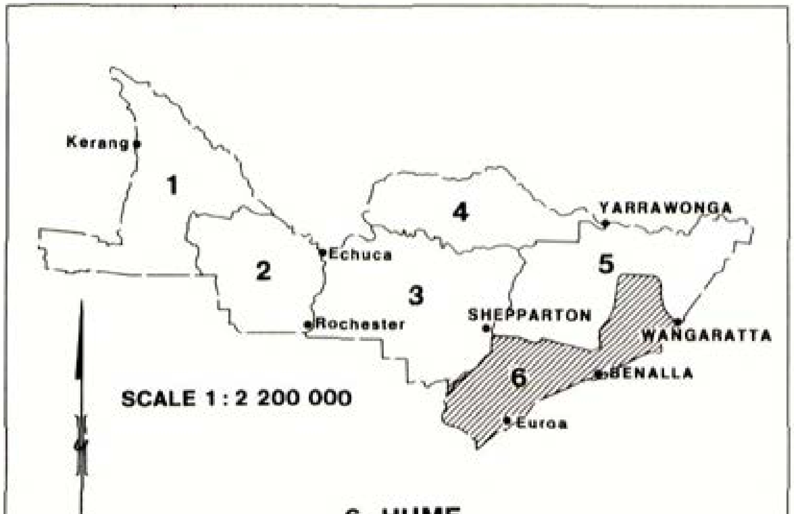
Average annual rainfall ranges from 550 mm in the north of the block to 672 mm in the vicinity of Benalla.

In general, temperatures are similar throughout. Summers are hot and winters mild, with a mean annual maximum temperature of some 21°C and a mean annual minimum of some 8°C. The range of maximum temperatures can be marked. Benalla has a mean summer maximum of 31°C, while its maximum extreme temperature on record is 46°C.

Severe frosts are likely to occur from mid June to September. Benalla on average experiences 44 frosts a year.

2. Geology and geomorphology

The block consists of large isolated outcrops of Palaeozoic bedrock interspersed with alluvial plains of Quaternary age. The youngest alluvial deposits of clay, sand, and gravel occur within



6. HUME

the flood plains of present-day streams, principally the Ovens River. Older alluvial sediments make up the plains above the level of the modern stream terraces: they were deposited by an earlier drainage system, traces of which are still visible on the plains.

Small isolated outcrops of Tertiary basalt and sediments occur east of Lake Mokoan.

Palaeozoic bedrock consists of prominent outcrops of granite making up the Warby Range, and lower undulating areas of sediments and granite to the south-west.

3. Soils

This block includes soils that have developed on a wide range of parent materials, resulting in a variety of soil types.

Yellow sodic duplex soils and grey calcareous sodic uniform clays predominate on the plains in the south and south-west. Red and yellow sodic duplex soils are the major types on the rest of the plains.

Throughout, gentle hills on Palaeozoic sediments have shallow stony gradational soils and red sodic duplex soils.

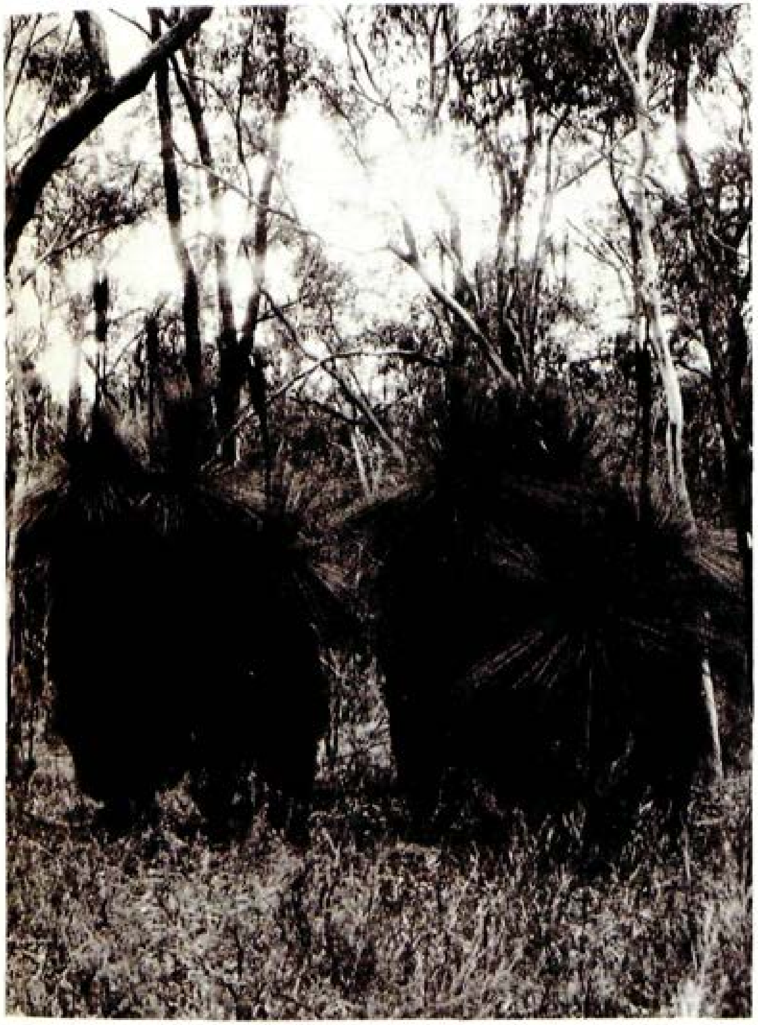
Red duplex soils with deep coarse sandy topsoils are a feature of the granitic hills including the Warby Range. Others that warrant a mention are the uniform coarse sandy soils that occur among the outcropping granite tors and the yellow duplex soils in drainage depressions.

4. Vegetation

The Warby Range mostly carries a mosaic of Blakely's red gum (*E. blakelyi*) woodland I and red stringybark open forest II, sometimes with red box and occasionally long-leaf box. Mixed open forest II--III of box species (including white box) occurs in gullies and at the bases of scarps. Some areas support white cypress pine woodland (dominant over Blakely's red gum, with which it associates). Also, areas of previously cleared land are regenerating.

Vegetation types on the sandstone hills - as at Killawarra - are more complex, being a mosaic of red ironbark, grey box, red stringybark, red box, and Blakely's red gum communities; mixed stands of these species are frequent. Some volunteer grassland is regenerating with wattles (in old clearings), and a strip of river red gum open forest II adjoins Irishtown Creek.

Along the creeks between Euroa and Benalla, open forest--woodland II of river red gum predominates. Yellow box may also be present. The pockets of public land may support fragments of a similar vegetation. Some open forest III of grey box, yellow box, and river red gum grows along streams that drain into the Ovens.



Impressive clumps of tall Austral grass-trees are found in the Warby Range

Rocky hills south of Thoona support similar vegetation types to the Warby Range - mainly Blakely's red gum woodland I, with some white cypress pine, and red stringybark--box mixtures in open forest formation.

In the hills near Earlston, pockets of grey box, white box, and red box remain, with very restricted occurrences of green mallee (*E. viridis*) in some drier situations.

5. Fauna

This block supports 34 species of mammals, including a wide range of arboreal species. Within the study area, the common wombat and grey-headed flying fox are known only in this section. The swamp wallaby, eastern grey kangaroo, and koala are most abundant here, the Warby Range being particularly important habitat for these and other species.

A total of 132 species of native birds have been recorded in this block, a number of them not recorded elsewhere in the Murray Valley area. The latter include the spotted harrier, little button-quail, turquoise parrot, black-eared cuckoo, white-throated nightjar, singing bushlark, painted honeyeater, satin flycatcher, speckled warbler, and brown thornbill. Others, such as the grey-crowned babbler, are more common here than in the other blocks.

The rocky areas of the Warby Range support several unique reptiles, such as Burton's snake lizard, rainbow skink, and black rock skink. Altogether, 25 species of reptile have been recorded in

Burton's snake-lizard is known to occur outside the Mallee areas only as one isolated population in the Warby Range

this block. Other interesting species include the carpet snake, Dwyer's snake, and sand goanna. Hume block also contains 11 species of frog, most of which are widespread in the study area.

C. Present Use and Capabilities

1. Nature conservation

This block's main area of public land with high nature conservation value is in the Warby Range, because of its diversity of flora and fauna and its location on the north-western foothills of the Eastern Highlands. Plant and animal species that are usually found further north in Australia have been recorded in the Range. These include the turquoise parrot, northern sandalwood, western silver wattle, and spur-wing wattle - all very rare in Victoria. The last two have their Victorian distribution confined to the Warby Range.

Morphetts Swamp Wildlife Reserve provides important habitat for various species of water birds. Also other wetlands occurring in this block - such as Jubilee Swamp - are thought to be breeding areas for duck species and therefore may have high conservation value.

2. Recreation

The Warby Range State Park, Killawarra State Forest, and Lake Mokoan are all used as recreation resources.

Warby Range State Park features a series of rocky prominences, steep escarpments, and eroded plateaus, and stands approximately 180 m above the surrounding plain. It provides excellent vantage points, pleasant picnic spots, and outstanding variety of bird life, and an interesting flora. Recreation facilities have been developed in a number of sections of the Park, mainly at Pine Gully, Jubilee Falls, Ryans Lookout, and Salisbury Falls.

The Killawarra Forest, consisting mainly of red ironbark and grey box, is popular for cross-country running and orienteering. The Forests Commission maintains a picnic area, which was once a forestry

The Killawarra Forest is popular for cross-country running and orienteering camp, where a fitness trail starts and ends.

Lake Mokoan provides water sports and fishing. Sailing is very popular here. Duck-hunters also shoot over the lake during duck season.

3. Timber production

Capability of the public land for timber production is low. Only small quantities of fencing material, poles, and firewood are cut from the red ironbark--box forests at Killawarra, and little timber is harvested from the Warby Range.

4. Agriculture and apiculture

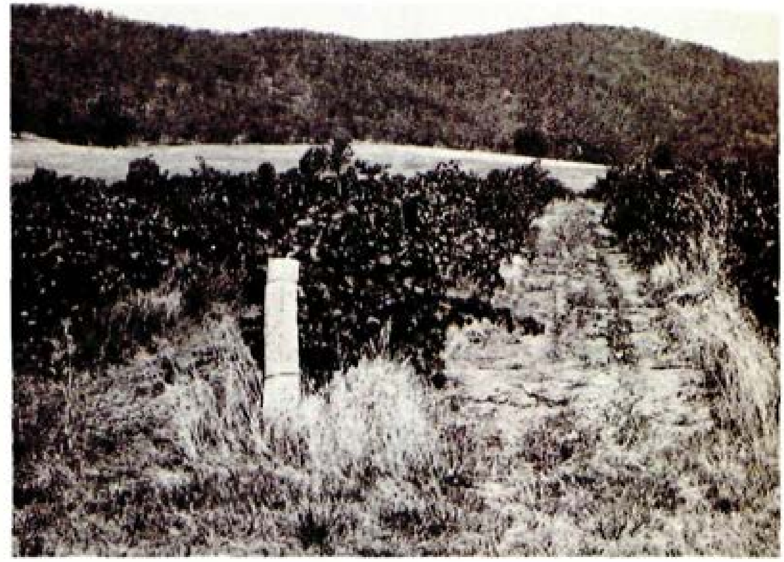
Most of the public land has low to medium capability for agricultural production.

Licensed grazing takes place on most areas, except the Warby State Park and the reserved forest in the Warby Range. Sheep are grazed in the Killawarra Forest.

Most of the public land has a high capability for honey production, and apiarists value the Warby Range highly as an over-wintering area.

5. Water

The western portion of this block lies within the Goulburn Drainage Basin, the



A number of wineries are located on the western side of the Warby Range

central portion within the Broken River Basin, and the eastern in the Ovens River Basin.

It does not contain any Irrigation Area, although substantial quantities of water are authorized for usage for irrigation, domestic, and stock purposes. This water comes from the Broken and Ovens Rivers.

Lake Mokoan, an off-river water storage, is located in the block and its water is transferred to the East Goulburn Channel via the Broken River.

Six local water authorities are constituted under the *Water Act* 1939: the Benalla, Euroa, Glenrowan, Longwood, Violet Town, and Wangaratta Waterworks Trusts.

The block contains parts of the Broken River Improvement District and Ovens and King River Improvement District.

6. Mineral and stone production

Minor alluvial goldfields occur at Tamleugh North, and astride the Hume Highway just south of Benalla.

Small deposits of fluorite are located in the Warby Range, and an occurrence of a phosphate mineral has been reported near Killawarra, in the north.

The Shire of Euroa extracts road and construction material from a pit next to the Hume Highway. The Shire of Wangaratta extracts a small amount of material from public land in the north-east of the block and there is further potential in this area.

A hard rock granite quarry is operated just outside the study area at Glenrowan and there is potential for further granite quarrying within public land in the Warby Range.

D. Hazards and Conflicts

Wildfires are always a major hazard. The forests on public land in the Warby Range have a moderate fire risk, while the remainder of the forested public lands have a lower fire risk than others in the State. Wildfires remain a threat to life, property, and timber resources, and do, of course, affect wildlife and flora values.

While soil erosion is not a common feature on the public land, apart from some water erosion of tracks, there is a moderate to severe hazard of sheet and gully erosion, and a slight to moderate hazard of wind erosion of the sloping areas on Paleozoic sediments and granitic rocks if the protective native vegetation is removed.

Dryland salting is becoming a serious hazard where the north-eastern slopes meet the riverine plain, the most notable being in the Caniambo area.

Both vermin and noxious weeds are present on public land, but neither constitutes a significant hazard at present.

All of the major rivers and streams are subject to flooding. Nuisance flooding occurs frequently, and more serious floods resulting in considerable property damage and community disruption occur less frequently.

Conflict may arise over the use and management of wetlands, such as Jubilee Swamp, for nature conservation, wildlife habitat, flood mitigation, and drainage.

Management of water forms a necessary part of land management for food and fibre production and flood mitigation, but this can affect the value of wetlands for nature conservation and wildlife habitat.

Opinions differ about the effect of grazing on public land and the maintenance of the understorey floristics. It is often claimed that grazing causes a reduction in the diversity of the ground storey species and consequent domination of the site by one or more exotic or native species.

Others claim that grazing is of economic importance to the grazier and a necessary fire management tool for the type of forests in the block. In some areas grazing, with proper management and stocking, may not conflict with other values.

APPENDICES

Appendix 1

SPECIES OF CONSERVATION SIGNIFICANCE

Distribution within the Murray Valley Area by descriptive blocks

Species

Category 1: very localized and/or very rare, to endangered or extinct. Species in this category have extremely restricted occurence in Victoria or else a very restricted distribution with a significant proportion of it in Victoria.

Category 2: localized and/or rare. Such species generally have restricted occurrence in Victoria.

Category 3: localized and uncommon to rare. The species may have a relatively wider range of distribution, but they are rare where they occur or have restricted habitat requirements and so they are localized to a small region of Victoria.

Category 4: uncommon and/or rare with restricted distribution (localization). This includes species that have conservation significance due to restricted distribution, but may not be currently rare or vulnerable because of restricted numbers.

Descriptive blocks

1	:	Gunbower
2	:	Patho
3	:	Goulburn
4-B	:	Barmah block excluding the Barmah Forest
B	:	Barmah Forest (in the Barmah block)
5	:	Yarrawonga
6	:	Hume
?	:	indicates doubt regarding exact location or identification
( )	:	old (>40 years) or non-verified record, often only general locality given
#	:	presumed extinct within descriptive block

OS : denotes recordings just outside Murray Valley area; number indicates nearest descriptive block

MVA : refers to the lists prepared by Beauglehole*

- not recorded by Beauglehole for the Murray Valley area

Ø species not listed by Beauglehole

+ listed for Murray Valley area, locality not given

* Beauglehole, A.C. (1980). 'Victorian Vascular Plant Checklists.' (Western Victorian Field Naturalists Club: Portland.)

Source: Frood, D. (1983). 'The Vegetation of the Murray Valley Area.' Report to the Land Conservation Council of Victoria (unpublished).

Species	Distribution								
	Descriptive block								
	1	2	3	4-B	B	5	6	OS	MVA
Category 1									
Acacia decora						5	6		
A. omalophylla				4		5			-
A. triptera							6		
Amphibromus gracilis					B				-
Brachycome gracilis						#	?6		
B. Muelleroides				4	B				
Brasenia schreberi						#		3	
Cassia artemisioides	#	#							-
Cheilanthes lasiophylla		2							
Chloris ventricosa						(?)		(5?)	-
Cyperus flaccidus					B				-
C. pygmaeus						?#			-
Diuris punctata							6		
Eleocharis minuta					B				-
Eragrostis japonica					B				-
Eryngium platagineum	(?)							1	-
Euphorbia planiticola	(?)								
Helipterum strictum					B				ø
Hydrilla verticillata						(5)			
Lepidium monoplocoides	1								-

Species	Distribution								
	Descriptive block								
	1	2	3	4-B	B	5	6	OS	MVA
Category 1 (cont.)									
Lepidium papillosum	1								
L. pseudohyssopifolium	1								ø
Leptorhynchos elongatus						?#			-
Lomandra dura				4					ø
Myriophyllum porcatum				(4)					
Psoralea parva		2			B		?#		
P. tenax	#								
Pterostylis hamata						?	6		
Rorippa sp. nov 's'					B				?ø
Santalum lanceolatum							6		
Senecio behrianus	#								
Sporobolus creber		(2)							
Stellaria sp. nov.					B				ø
Swainsona galegifolia						?#		(5)	ø
S. microcalyx					B				
S. murrayana									
(a) ssp. *eciliata*			3						
(b) ssp. *murrayana*	?#							#(5)	
S. plagiotropis	?#	2							
S. recta							#	#(3)	

Species	Distribution								
	Descriptive block								
	1	2	3	4-B	B	5	6	OS	MVA
Category 1 (cont.)									
Swainsona swainsonioides								(1)	-
Category 2									
Botrychium australe							(6)		
Brachycome readeri				4					
Bromus arenarius					B				-
Cyperus concinnus		(2)							
Digitaria ammophila					B				-
D. divaricatissima	1								
Eriochloa pseudo-acrotricha		2	3		B				
Goodenia subintegra				4	B				
Hypsela tridens					B				-
Indigofera signata							(6)		-
Leptorhynchos panaet-ioides		2?		4	B				
Lycium australe	1								
Myoporum montanum	1	?	3	4	B				
Najas tenuifolia	1		3	4		5?	6		
Panicum decompositum	1	2							
P. obseptum		2	?					3	

Species	Distribution								
	Descriptive block								
	1	2	3	4-B	B	5	6	OS	MVA
Category 2 (cont.)									
Philydrum lanuginosum	1?								
Plantago turrifera	1								-
Prasophyllum fuscum				(4)					
Prostanthera decussata							6		-
Rorippa eustylis									+
Santalum acuminatum	1	2		(4)					
Scirpus australiensis				4					
Sporobolus mitchellii	1?				B				
Trigonella suavissima	(1)								
Tripogon loliiformis					B				
Category 3									
Acacia stenophylla	1		3						
Amphibromus archeri		(2 - ?)					(6)		
Anogramma leptophylla						(5)			
Atriplex lindleyi	1								
Brachycome ciliaris		(2)		(4)	B	(5)			
Callitriche sonderi			3	(4-5)					
Cymbonotus lawsonianus				4	B				
Fimbristylis dichotoma							(6)		
Orthoceras strictum							6		

Species	Distribution								
	Descriptive block								
	1	2	3	4-B	B	5	6	OS	MVA
Category 3 (cont.)									
Paspalidium constrictum		2							
Pterostylis biseta	(1)	(2)	(?)	(4)			6		
P. vittata							?6		
Pultenaea cunninghamii							6		
P. platyphylla							6		
Spiranthes sinensis						?5	?6	5 & 6	-
Category 4									
Acacia difformis							6		
Brachychiton populneus							6		
Calocephalus sonderi	1								
Cheiranthera cyanea						?	6	3 & 5	
Chthonocephalus pseude-vax				4					-
Craspedia globosa		2		4	B				
Craspedia pleiocephala					B				-
Cyperus victoriensis					B				-
Danthonia richardsonii						?5			
Dichantheum sericeum			3						
Diplachne fusca	1								
Dodonaea boroniifolia									+

Species	Distribution								
	Descriptive block								
	1	2	3	4-B	B	5	6	OS	MVA
Category 4 (cont.)									
Eulalia fulva		2	3	4	B	?			
Goodenia hederacea									+
Haeckeria ozothamnoides							6		
Limosella curdieana				?	B				
Lipocarpha microcephala						?5			
Maireana excavata			3						-
Marsilea angustifolia		2	3	4	B	5			
M. hirsuta	1								
Melaleuca sp. aff. *ericifolia*						5			-
Muehlenbeckia horrida	1								
Panicum effusum					B				-
Pilularia novae-hollandiae			(3)				?(6)		
Prostanthera nivea		2							
Schoenus latelaminatus							(6)		
Sclerolaena divaricata					B				-
Senecio gregorii					B				-
Threlkeldia salsuginosa	1								

Appendix 2

FAUNA HABITAT BY VEGETATION COMMUNITY

Appendix 2a - Mammals
2b - Birds
2c - Reptiles
2d - Amphibians

These lists apply only to the study area, although similar habitat on New South Wales Crown land may well carry the same fauna species.

Abbreviations

+ Present, but abundance not assessed
V Vagrant
R Rare
U Uncommon
C Common
A Abundant
Records derived from museum specimens (no relevant habitat given)
* Introduced species

Note that Appendices 2a, 2c, and 2d contain all available records, while Appendix 2b contains only observations from Robertson *et al.* (1983).

Appendix 2a - Mammals

Scientific name	Common name		River red gum	Mixed box	Black box	Red ironbark	Blakely's red gum	Mallee	White cypress pine	Granite outcrop	Grassland	Lignum	Saltbush	Water bodies	Urban
Tachyglossus aculeatus	Short-beaked echidna					+	+				+				+
Ornithorphynchus anatinus	Platypus													+	
Antechinus flavipes	Yellow-footed antechinus		+	+		+	+								
Antechinus stuartii	Brown antechinus														
Dasyurus maculatus	Tiger quoll										+				
Phascogale tapoatafa	Brush-tailed phascogale		+	+		+									
Sminthopsis crassicaudata	Fat-tailed dunnart				+						+		+		
Perameles nasuta	Long-nosed Bandicoot														
Trichosurus vulpecula	Common brushtail possum		+	+	+	+	+	+	+		+				+
Acrobates pygmaeus	Feathertail glider		+				+								
Petaurus breviceps	Sugar glider		+				+								
Petaurus norfolcensis	Squirrel glider		+	+		+									
Pseudocheirus peregrinus	Common ringtail possum		+	+		+	+		+						
Macropus giganteus	Eastern grey kangaroo		+	+	+	+	+		+		+				
Wallabia bicolor	Swamp Wallaby					+	+		+						
Phascolarctos cinereus	Koala		+	+		+	+								
Vombatus ursinus	Common wombat														
Pteropus poliocephalus	Grey-headed flying-fox														
Pteropus scapulatus	Little red flying-fox		+												
Mormopterus sp.	Little Mastiff-bat		+			+	+				+				
Tadarida australis	White-striped mastiff-bat		+	+	+		+								+
Chalinolobus gouldii	Gould's wattled bat		+		+	+	+				+				
Chalinolobus morio	Chocolate wattled bat		+	+		+			+						
Eptesicus regulus	King River eptesicus		+	+											
Eptesicus sagittula	Large forest eptesicus		+	+											
Eptesicus vulturnus	Little forest eptesicus		+	+	+	+	+		+		+				
Myotis adversus	Large-footed myotis		+											+	
Nycticeius sp.	Broad-nosed bat		+			+	+				+				
Nyctophilus geoffroyi	Lesser long-eared bat		+	+	+	+	+		+						
Nyctophilus gouldi	Gould's long-eared bat		+	+		+									
Hydromys chrysogaster	Water-rat													+	
Mus musculus*	House mouse		+	+	+				+	+	+	+			+
Rattus norvegicus*	Brown rat#														
Rattus rattus*	Black rat		+												+
Canis familiaris*	Dog				+										
Vulpes vulpes*	Fox		+	+	+	+	+		+	+	+				
Felis catus*	Cat		+		+						+				+
Equus caballus*	Horse		+												
Sus scrofa*	Pig		+											+	
Lepus capensis*	Brown hare		+	+	+			+			+	+			
Oryctolagus cuniculus*	European rabbit		+	+	+	+	+	+	+	+	+	+			
Total number of native species		31	21	14	7	15	16	1	7	0	9	0	1	3	3
Total number of species		41	29	18	13	17	19	3	10	3	14	3	1	4	6

Appendix 2b - Birds

Scientific name	Common name	River red gum	Mixed box	Black box	Red ironbark	Blakely's red gum	Mallee	White cypress pine	Granite outcrop	Grassland	Lignum	Saltbush	Water bodies	Urban
Non-passerines														
Dromaius novaehollandiae	Emu	R												
Podiceps cristatus	Great crested grebe												R	
Poliocephalus poliocephalus	Hoary-headed grebe												C	
Tachybaptus novaehollandiae	Australasian grebe												C	
Pelecanus conspicillatus	Australian pelican												C	
Anhinga melanogaster	Darter												U	
Phalacrocorax carbo	Great cormorant												U	
Phalacrocorax varius	Pied cormorant												R	
Phalacrocorax sulcirostris	Little black cormorant												U	
Phalacrocorax melanoleucos	Little pied cormorant	U											C	
Ardea pacifica	Pacific heron									C			C	
Ardea novaehollandiae	White-faced heron	U								C			C	U
Ardeola ibis	Cattle egret									+				
Egretta alba	Great egret												R	
Egretta intermedia	Intermediate egret												U	
Nycticorax caledonicus	Rufous night heron	R	R										U	
Ixobrychus minutus	Little bittern												R	
Plegadis falcinellus	Glossy ibis									U			U	
Threskiornis aethiopica	Sacred ibis	U								A			C	U
Threskiornis spinicollis	Straw-necked ibis	U								A			C	U
Platalea regia	Royal spoonbill												U	
Platalea flavipes	Yellow-billed spoonbill									U			C	
Dendrocygna eytoni	Plumed whistling-duck												R	
Cygnus atratus	Black swan									U			C	
Stictonetta naevosa	Freckled duck												R	
Tadorna tadornoides	Australian shelduck									C			C	
Anas superciliosa	Pacific black duck	U								U			C	
Anas gibberifrons	Grey teal	U											C	
Anas castanea	Chestnut teal												U	
Anas rhynchotis	Australasian shoveller												U	
Malacorhynchus membranaceus	Pink-eared Duck												U	
Aythya australis	Hardhead												U	
Chenonetta jubata	Maned duck												U	
Oxyura australis	Blue-billed duck												R	
Biziura lobata	Musk duck												R	
Elanus notatus	Black-shouldered kite									U				R
Milvus migrans	Black kite													R
Haliastur sphenurus	Whistling kite	U		R					R	U			U	
Accipiter fasciatus	Brown goshawk	U	R										R	
Accipiter cirrhocephalus	Collared sparrowhawk	R	R			R								
Haliaeetus leucogaster	White-bellied sea-eagle	R											R	
Aquila audax	Wedge-tailed eagle	U	R		R	U								
Hieraaetus morphnoides	Little eagle		R			R		R	R	R			R	
Circus assimilis	Spotted harrier									R				

Appendix 2b - Birds (cont.)

Scientific name	Common name	River red gum	Mixed box	Black box	Red ironbark	Blakely's red gum	Mallee	White cypress pine	Granite outcrop	Grassland	Lignum	Saltbush	Water bodies	Urban
Non-passerines (cont.)														
Circus aeruginosus	Marsh harrier												U	
Falco subniger	Black falcon									R				
Falco peregrinus	Peregrine falcon		R			R							R	
Falco longipennis	Australian hobby	R							R	U			R	R
Falco berigora	Brown falcon	U	U	R	R	R		R	U	C	R		U	U
Falco cenchroides	Australian kestrel								R	C			U	U
Coturnix novaezelandiae	Stubble quail									+				
Coturnix australis	Brown quail	+												
Turnix varia	Painted button-quail	U	R											
Turnix velox	Little button-quail					R								
Rallus philippensis	Buff-banded rail	+											+	
Porzana pusilla	Baillon's crake												+	
Porzana fluminea	Australian crake												+	
Porzana tabuensis	Spotless crake												+	
Gallinula ventralis	Black-tailed native-hen										U		U	
Gallinula tenebrosa	Dusky moorhen												U	
Porphyrio porphyrio	Purple swamphen										U		U	
Fulica atra	Eurasian coot												U	
Burhinus magnirostris	Bush thick knee	R		R						R				
Rostratula benghalensis	Painted snipe												+	
Vanellus miles	Masked lapwing									C	U		C	
Vanellus tricolor	Banded lapwing									U				
Erythrogonys cinctus	Red-kneed dotterel									R			U	
Charadrius ruficapillus	Red-capped plover												R	
Charadrius melanops	Black-fronted plover									U			U	
Himantopus himantopus	Black-winged stilt									R			U	
Recurvirostra novaehollandiae	Red-necked avocet												U	
Triga hypoleucos	Common sandpiper												R	
Tringa nebularia	Greenshank									R			R	
Tringa stagnatilis	Marsh sandpiper												R	
Gallinago hardwickii	Latham's snipe									R			R	
Calidris acuminata	Sharp-tailed sandpiper									R			R	
Calidris ruficollis	Red-necked stint												R	
Calidris ferruginea	Curlew sandpiper												R	
Stiltia isabella	Australian pratincole									R				
Larus novaehollandiae	Silver gull									U			U	U
Chlidonias hybrida	Whiskered tern									U			U	
Gelochelidon nilotica	Gull-billed tern									R			R	
Hydroprogne caspia	Caspian tern												R	
*Columba livia**	Feral pigeon													U
Geopelia placida	Peaceful dove	C	U	U	U	U		C						
Phaps chalcoptera	Common bronzewing	U	U	U	U	R	R	U						
Ocyphaps lophotes	Crested pigeon	U	U	U	R		U	U	U	C	U			U
Cacatua roseicapilla	Galah	U	U	U	R	R		C		C			C	C

Appendix 2b - Birds (cont.)

Scientific name	Common name	River red gum	Mixed box	Black box	Red ironbark	Blakely's red gum	Mallee	White cypress pine	Granite outcrop	Grassland	Lignum	Saltbush	Water bodies	Urban
Non-passerines (cont.)														
Cacatua tenuirostris	Long-billed corella	U								U				
Cacatua sanguinea	Little corella	R								R			R	
Cacatua galerita	Sulphur-crested cockatoo	C	U	U		R				C			C	C
Glossopsitta concinna	Musk lorikeet	R	R											
Glossopsitta porphyrocephala	Purple-crowned lorikeet	R												
Glossopsitta pusilla	Little lorikeet	R	R		U	R								
Polytelis swainsonii	Superb parrot	R												
Nymphicus hollandicus	Cockatiel	U	R			R				U			U	R
Melopsittacus undulatus	Budgerigar									R				
Platycercus elegans flaveolus	Yellow rosella	A	C	C									U	
Platycercus eximius	Eastern rosella	U	U	U	R	R		U	R	C	U		U	U
Barnardius barnardi	Mallee ringneck		R					R						
Psephotus haematonotus	Red-rumped parrot	U	U	U	U	R		A					U	U
Neophema chrysostoma	Blue-winged parrot									R				
Neophema pulchella	Turquoise parrot		R		R	U								
Cuculus pallidus	Pallid cuckoo	U	U	R						U			R	
Cuculus pyrrhophanus	Fan-tailed cuckoo	U	R	R										
Chrysococcyx osculans	Black-eared cuckoo					R								
Chrysococcyx basalis	Horsfield's bronze-cuckoo	U	U			R				U			U	
Chrysococcyx lucidus	Shining bronze-cuckoo		R		R	R								
Ninox novaeseelandiae	Southern boobook	U	U	U		R		R	U	U			U	
Ninox connivens	Barking owl	R				R								
Tyto alba	Barn owl									U				
Podargus strigoides	Tawny frogmouth	U	U	U		U				U			U	
Aegotheles cristatus	Australian owlet-nightjar	U	U	U		U		R						
Caprimulgus mystacalis	White-throated nightjar				R									
Ceyx azureus	Azure kingfisher	R											R	
Dacelo novaeguineae	Laughing kookaburra	C	U	U	U	U		U	U	C			U	U
Halcyon pyrrhopygia	Red-backed kingfisher	R												
Halcyon sancta	Sacred kingfisher	C	U	U	U	R	R						U	
Merops ornatus	Rainbow bee-eater	U	U	U		R				U			U	
Eurystomus orientalis	Dollarbird	U	U										U	
Passerines														
Mirafra javanica	Singing bushlark									+				
*Alauda arvensis**	Skylark									+				
Cheramoeca leucosternum	White-backed swallow									R				R
Hirundo neoxena	Welcome swallow	C	U	U		U		U		C			C	U
Cecropis nigricans	Tree martin	U	U	U	R	R		R	R	R			U	
Cecropis ariel	Fairy martin	R		R						C			U	
Anthus novaeseelandiae	Richard's pipit								U	C	R	+		
Coracina novaehollandiae	Black-faced cuckoo-shrike	C	C	U	U	R		U		C			U	U
Coracina papuensis	White-bellied cuckoo-shrike		R			R								

Appendix 2b - Birds (cont.)

Scientific name	Common name	River red gum	Mixed box	Black box	Red ironbark	Blakely's red gum	Mallee	White cypress pine	Granite outcrop	Grassland	Lignum	Saltbush	Water bodies	Urban
Passerines (cont.)														
Lalage sueurii	White-winged triller	U	U	U		U		U		U				
*Tardus merula**	Blackbird	R												U
Petroica phoenicia	Flame Robin									R				
Petroica multicolor	Scarlet Robin	R	R			R								
Petroica goodenovil	Red-capped Robin	R	U	U	U	U		U			R			
Melanodryas cucullata	Hooded robin		R	R		R		U						
Eopsaltria australis	Eastern yellow robin		R		R	R								
Microeca Leucophaea	Jacky winter	U	U	U	R	U		U		U			U	U
Falcunculus frontatus	Crested shrike-tit	U	U	U	R	R								
Pachycephala inornata	Gilbert's whistler		R											
Pachycephala pectoralis	Golden whistler	R												
Pachycephala rufiventris	Rufous whistler	R	U	U	U	U		U						
Colluricincla harmonica	Grey Shrike-thrush	C	C	C	U	U		U	R					U
Myiangra ruvecula	Leaden flycatcher		R											
Myiagra cyanoleuca	Satin flycatcher	R												
Myiagra inquieta	Restless flycatcher	U	U	U	R	R		U		U			U	U
Rhipidura fuliginosa	Grey fantail	U	U	U		U	U							
Rhipidura leucophrys	Willie wagtail	C	C	C	R	R	U	U	U	A			C	C
Pomatostomus temporalis	Grey-crowned babbler	R	U											
Pomatostomus superciliosus	White-browed babbler		U	R	U	R		U						
Acrocephalus stentoreus	Clamorous reed-warbler	U											U	
Megal urus gramineus	Little grassbird													U
Cisticola exilis	Golden-headed cisticola													U
Cinclorhamphus mathewsi	Rufous songlark	U	U	U	U	R				R	R		U	
Cinclorhamphus cruralis	Brown songlark									U				
Malurus cyaneus	Superb fairy-wren	U	U	U	U	U		U		U	U		U	U
Malurus lamberti	Variegated fairy-wren			R							R			
Malurus leucopterus	White-winged fairy-wren									R		U		
Sericornis frontalis	White-browed scrubwren	U												
Sericornis sagittatus	Speckled warbler		R			U								
Sericornis brevirostris	Weebill	R	U	U	U	U								
Gerygone fusca	Western gerygone	R	U	U	U	U								
Acanthiza pusilla	Brown thornbill		R	U										
Acanthiza apicalis	Inland thornbill			R										
Acanthiza uropygialis	Chestnut-rumped thornbill		U	U										
Acanthiza reguloides	Buff-rumped thornbill	R	U	U		U								
Acanthiza chrysorrhoa	Yellow-rumped thornbill	R	U	U		+				C			U	U
Acanthiza nana	Yellow thornbill	R	U	U		R								
Acanthiza lineata	Striated thornbill	R	U			U								
Aphelocephala leucopsis	Southern whiteface	R	U					C		U	U			
Daphoenositta chrysoptera	Varied sitella	R	R		U	U								
Climacteris leucophaea	White-throated treecreeper	U	R	R	U	U							R	
Climacteris picumnus	Brown treecreeper	C	C	C	U	U	R	U						
Anthochaera carunculata	Red wattlebird		R				R							

Appendix 2b - Birds (cont.)

Scientific name	Common name		River red gum	Mixed box	Black box	Red ironbark	Blakely's red gum	Mallee	White cypress pine	Granite outcrop	Grassland	Lignum	Saltbush	Water bodies	Urban
Acanthagenys rufogularis	Spiny-cheeked honeyeater				R										
Plectorhyncha lanceolata	Striped honeyeater		R												
Philemon corniculatus	Noisy friarbird		U	U		R									
Phileomon citreogularis	Little friarbird		A	C	C		U								
Entomyzon cyanotis	Blue-faced honeyeater		R	R											R
Manorina melanocephala	Noisy miner		C	C	C	R	R	U							
Manorina flavigula	Yellow-throated miner		R												
Lichenostomus chrysops	Yellow-faced honeyeater		R	R											
Lichenostomus virescens	Singing honeyeater									U					R
Lichenostomus melanops	Yellow-tufted honeyeater			R		U	R								
Lichenostomus fuscus	Fuscous honeyeater			R		C	U								
Lichenostomus penicillatus	White-plumed honeyeater		A	A	A	U	U	U	U						U
Melithreptus gularis	Black-chinned honeyeater			R		U	R	R							
Melithreptus brevirostris	Brown-headed honeyeater		U	U	U	U	U								
Grantiella picta	Painted honeyeater					R									
Ephthianura aurifrons	Orange chat												R		
Ephthianura albifrons	White-fronted chat										U	U	U	U	
Dicaeum hirundinaceum	Mistletoebird		U	U		U	U								
Pardalotus punctatus	Spotted pardalote		U	U	U		U								
Pardalotus striatus	Striated pardalote		A	A	C	C	U		U						
Zosterops lateralis	Silvereye			U			U								
*Carduelis carduelis**	European goldfinch			R					R		U				U
*Passer domesticus**	House sparrow		R	U	U				U'		C	U			C
*Passer montanus**	Tree sparrow														+
Emblema temporalis	Red-browed firetail		R								R				
Emblema guttata	Diamond firetail		R	U	U		R		U						
Poephila guttata	Zebra finch				R						U	U			
*Sturnus vulgaris**	Common starling		U	U	U	R			U		A			C	C
Oriolus sagittatus	Olive-backed oriole		U	U		U	U								
Corcorax melanorhamphos	White-winged chough		U	U	U	U	U		U						
Grallina cyanoleuca	Australian magpie-lark		U	R	R	R	R	R	U		A			C	C
Artamus leucorhynchus	White-breasted woodswallow		U	R										U	
Artamus personatus	Masked woodswallow		U	R		R									
Artamus superciliosus	White-browed woodswallow		U	U		U	R	C			U			R	
Artamus cinereus	Black-faced woodswallow										R				
Artamus cyanopterus	Dusky woodswallow		C	C	C	U	U	U	U						
Cracticus torquatus	Grey butcherbird		R	R											
Cracticus nigrogularis	Pied butcherbird		R		R						U				
Gymnorhina tibicen	Australian magpie		U	U	U	U	U	R	U		A			C	C
Strepera graculina	Pied currawong														U
Corvus coronoides	Australian raven		U	U	U	U	U		U		U				
Corvus mellori	Little raven		R	R	R				R		C				C
Total (passerines)		95	60	65	46	37	47	11	27	5	32	9	4	20	21
Total (non-passerines)		120	47	32	19	14	25	3	12	9	48	6	0	84	17
Total (native species)		208	104	94	63	50	72	14	36	14	76	14	4	103	32

Appendix 2c - Reptiles

Scientific name	Common name	River red gum	Mixed box	Black box	Red ironbark	Blakely's red gum	Mallee	White cypress pine	Granite outcrop	Grassland	Lignum	Saltbush	Water bodies	Urban
Chelodina expansa	Broad-shelled river turtle	+											+	
Chelodina longicollis	Eastern long-necked tortoise	+	+	+							+		+	
Emydura macquarii	Murray turtle	+											+	
Amphibolurus barbatus	Bearded dragon	+	+	+		+	+		+	+	+			
Amphibolurus muricatus	Tree dragon		+			+								
Diplodactylus intermedius	Eastern spiny-tailed gecko								+					
Diplodactylus vittatus	Wood gecko		+			+		+						
Phyllodactylus marmoratus	Marbled gecko	+	+	+		+	+	+	+					
Delma inornata	Legless lizard		+							+				
Lialis burtonis	Burton's snake-lizard					+								
Pygopus nigriceps	Hooded scaly-foot			+										
Carlia tetradactyla	Rainbow skink		+		+	+								
Cryptoblepharus carnabyi	Snake-eyed skink	+	+	+				+						
Ctenotus robustus	Large striped skink					+			+					
Egernia cunninghami	Cunningham's skink								+					
Egernia saxatilis	Black rock skink					+		+						
Egernia striolata	Tree skink	+	+	+					+					
Egernia whitii	White's skink#													
Lampropholis guichenoti	Garden skink	+												
Lerista bougainvillii	Bougainville's skink					+			+					
Menetia greyi	Skink													
Morethia adelaidensis	Skink									+		+		
Morethia boulengeri	Boulenger's skink	+	+	+	+	+	+	+	+	+	+	+		+
Sphenomorphus tympanum W.T.F.	Water skink	+											+	
Tiliqua rugosa	Stump-tailed lizard		+	+			+			+				
Tiliqua scincoides	Eastern blue-tongued lizard					+				+				
Varanus gouldii	Sand goanna				+	+			+					
Varanus varius	Tree goanna	+	+	+	+	+	+	+						
Phython spilotes variegata	Carpet snake	+		+		+			+				+	
Notechis scutatus	Mainland tiger snake	+		+						+			+	
Pseudechis porphyriacus	Red-bellied black snake	+	+	+	+	+				+			+	
Pseudonaja textilis	Eastern brown snake		+				+	+	+	+				
Suta suta	Curl snake			+								+		
Unechis dwyeri	Dwyer's snake					+								
Unechis nigriceps	Short-tailed snake								+					
Vermicella annulata	Bandy bandy#													
Typhlina bituberculata	Blind snake#													
Typhlina nigrescens	Blind snake#													
Typhlina proxima	Blind snake#													
Total number of species	39	14	14	13	5	16	6	7	12	9	3	3	7	1

Appendix 2d - Amphibians

Scientific name	Common name		River red gum	Mixed box	Black box	Red ironbark	Blakely's red gum	Mallee	White cypress pine	Granite outcrop	Grassland	Lignum	Saltbush	Water bodies	Urban
Litoria paraewingi	Brown tree frog#														
Litoria peroni	Peron's tree frog		+	+	+		+				+			+	
Litoria raniformis	Green and golden bell frog		+	+							+			+	
Limnodynastes dumerili	Southern bullfrog		+	+							+			+	
Limnodynastes fletcheri	Barking frog		+											+	
Limnodynastes interioris	Giant bullfrog#														
Limnodynastes tasmaniensis	Spotted grass frog		+								+			+	
Neobatrachus sudelli	Burrowing frog#														
Pseudophryne bibroni	Brown toadlet						+								
Ranidella parinsignifera	Froglet		+	+	+	+	+	+	+		+	+		+	
Ranidella signifera	Eastern froglet		+	+	+	+	+	+	+		+	+		+	
Ranidella sloanei	Sloan's froglet		+											+	
Total number of species		12	8	5	3	2	4	2	2	0	6	2	0	8	0

Appendix 3

DISTRIBUTION OF FAUNA BY DESCRIPTIVE BLOCKS

Appendix 3a - Mammals
3b - Birds
3c - Reptiles
3d - Amphibians

Abbreviations

+ Present, but abundance not assessed
V Vagrant
R Rare
U Uncommon
C Common
A Abundant
Records derived from museum specimens (no relevant habitat given)
* Introduced species

Note that Appendices 3a, 3c, and 3d contain all available records while Appendix 3b contains only observations from Robertson *et al.* (1983).

Appendix 3a. Distribution of mammals by descriptive blocks

Scientific name	Common name	Gunbower	Patho	Goulburn	Barmah	Yarrawonga	Hume
Tachyglossus aculeatus	Short-beaked echidna		R	R	R	R	C
Ornithorhynchus anatinus	Platypus	R	R	C	C	C	U
Antechinus flavipes	Yellow-footed antechinus	C		C	C	U	C
Antechinus stuartii	Brown antechinus			+			
Dasyurus maculatus	Tiger quoll					+	+
Phascogale tapoatafa	Brush-tailed phascogale		R	U	U		U
Sminthopsis crassicaudata	Fat-tailed dunnart	U	U	U		R	U
Perameles nasuta	Long-nosed bandicoot					R	
Trichosurus vulpecula	Common brushtail possum	A	C	A	A	A	A
Acrobates pygmaeus	Feathertail glider	R		U		R	R
Petaurus breviceps	Sugar glider	U		R	R		U
Petaurus norfolcensis	Squirrel glider		R	C	U	R	U
Pseudocheirus peregrinus	Common ringtail possum	U	U	C	C	U	C
Macropus giganteus	Eastern grey kangaroo	A	U	C	A	U	A
Wallabia bicolor	Swamp wallaby					R	C
Phascolarctos cinereus	Koala	R		R	U		C
Vombatus ursinus	Common wombat						+
Pteropus poliocephalus	Grey-headed flying-fox						+
Pteropus scapulatus	Little red flying-fox	R		R	R		R
Mormopterus sp.	Little mastiff-bat			U	U		C
Tadarida australis	White-striped mastiff-bat	C		U	U		C
Chalinolobus gouldii	Gould's wattled bat	U		U	U	U	A
Chalinolobus morio	Chocolate wattled bat	U	U	U	U	U	C
Eptesicus regulus	King River eptesicus	U		U	U	U	
Eptesicus sagittula	Large forest eptesicus			U	U	U	R
Eptesicus vulturnus	Little forest eptesicus	C	U	C	U	U	C
Myotis adversus	Large-footed myotis			R	R	R	
Nycticeius sp.	Broad-nosed bat			U	U		U
Nyctophilus geoffroyi	Lesser long-eared bat	C	U	U	U	U	C
Nyctophilus gouldi	Gould's long-eared bat			R	R	R	U
Hydromys chrysogaster	Water-rat	C	C	C	C	U	U

Appendix 3a. Distribution of mammals by descriptive blocks (cont.)

Scientific name	Common name		Gun-bower	Patho	Goul-burn	Bar-mah	Yarra-wonga	Hume
*Mus musculus**	House mouse		A	U	C	C	C	U
*Rattus norvegicus**	Brown rat		R					
*Rattus rattus**	Black rat		U		U		U	U
*Canis familiaris**	Dog		U					
*Vulpes vulpes**	Fox		C	U	U	C	U	U
*Felis catus**	Cat		U		C	U	U	C
*Equus caballus**	Horse					U		
*Sus scrofa**	Pig		U		U	U		U
*Lepus capensis**	Brown hare		A		A	U	U	C
*Oryctolagus cuniculus**	European rabbit		A	C	C	C	C	C
Total number of native species		31	17	12	26	23	21	27
Total number of species		41	26	15	33	30	27	34

Appendix 3b. Distribution of birds by descriptive blocks

Scientific name	Common name	Gun-bower	Patho	Goul-burn	Bar-mah	Yarra-wonga	Hume
Non-passerines							
Dromaius novaehollandiae	Emu	U			U		
Podiceps cristatus	Great crested greba	+					+
Poliocephalus poliocephalus	Hoary-headed grebe	+		+	+		+
Tachybaptus novaehollandiae	Australasian grebe	+		+	+		+
Pelecanus conspicillatus	Australian pelican	+	+	+	+	+	+
Anhinga melanogaster	Darter	+	+	+	+		+
Phalacrocorax carbo	Great cormorant	+	+	+	+	+	
Phalacrocorax varius	Pied cormorant	+		+		+	
Phalacrocorax sulcirostris	Little black cormorant	+	+	+	+	+	
Phalacrocorax melanoleucos	Little pied cormorant	+	+	+	+	+	+
Ardea pacifica	Pacific heron	+	+	+	+	+	+
Ardea novaehollandiae	White-faced heron	+	+	+	+	+	+
Ardeola ibis	Cattle egret	+					
Egretta alba	Great egret	+	+	+	+	+	+
Egretta intermedia	Intermediate egret	+		+			
Nycticorax caledonicus	Rufous night heron	+		+	+	+	+
Ixobrychus minutus	Little bittern	+					
Plegadis falcinellus	Glossy ibis	R		R	R		
Threskiornis aethiopica	Sacred ibis	+	+	+	+	+	+
Threskiornis spinicollis	Straw-necked ibis	+	+	+	+	+	+
Platalea regia	Royal spoonbill	+		+	+		
Platalea flavipes	Yellow-billed spoonbill	+	+	+	+	+	+
Dendrocygna eytoni	Plumed whistling-duck		R	R			
Cygnus atratus	Black swan	+	+	+	+	+	+
Stictonetta naevosa	Freckled duck	R					
Tadorna tadornoides	Australian shelduck	+	+	+	+	+	+
Anas superciliosa	Pacific black duck	+	+	+	+	+	+
Anas gibberifrons	Grey teal	+	+	+	+	+	+
Anas castanea	Chestnut teal	+					

Appendix 3b. Distribution of birds by descriptive blocks (cont.)

Scientific name	Common name	Gun-bower	Patho	Goul-burn	Bar-mah	Yarra-wonga	Hume
Anas rhynchotis	Australasian shoveller	+					+
Malacorhynchus membranaceus	Pink-eared Duck	+	+	+			
Aythya australis	Hardhead	+	+	+	+		+
Chenonetta jubata	Maned duck	+		+	+	+	+
Oxyura australis	Blue-billed duck	+					
Biziura lobata	Musk duck	+					+
Elanus notatus	Black-shouldered kite	+	+	+	+		+
Milvus migrans	Black kite	R					
Haliastur sphenurus	Whistling kite	+	+	+	+	+	+
Accipiter fasciatus	Brown goshawk	+		+	+		
Accipiter cirrhocephalus	Collared sparrowhawk	+		+			+
Haliaeetus leucogaster	White-bellied sea-eagle			R	R	R	
Aquila audax	Wedge-tailed eagle	+	+	+	+	+	+
Hieraaetus morphnoides	Little eagle	+	+		+		+
Circus assimilis	Spotted harrier						R
Circus aeruginosus	Marsh harrier	+	+	+	+		+
Falco subniger	Black falcon		R				
Falco peregrinus	Peregrine falcon	R		R			R
Falco longipennis	Australian hobby	+	+	+	+	+	+
Falco berigora	Brown falcon	+	+	+	+	+	+
Falco cenchroides	Australian kestrel	+	+	+	+	+	+
Coturnix novaezelandiae	Stubble quail	+					
Coturnix australis	Brown quail			U	U		
Turnix varia	Painted button-quail	U			U		
Turnix velox	Little button-quail						R
Rallus philippensis	Buff-banded rail	+			+		
Porzana pusilla	Baillon's crake	+					
Porzana fluminea	Australian crake	+			+		
Porzana tabuensis	Spotless crake	+					
Gallinula ventralis	Black-tailed native-hen	+	+	+	+	+	
Gallinula tenebrosa	Dusky moorhen	+	+	+	+	+	

Appendix 3b. Distribution of birds by descriptive blocks (cont.)

Scientific name	Common name	Gun-bower	Patho	Goul-burn	Bar-mah	Yarra-wonga	Hume
Porphyrio porphyrio	Purple swamphen	+	+	+	+	+	
Fulica atra	Eurasian coot	+	+	+	+	+	+
Burhinus magnirostris	Bush thick-knee	U		R			R
Rostratula benghalensis	Painted snipe	+					
Vanellus miles	Masked lapwing	+	+	+	+	+	+
Vanellus tricolor	Banded lapwing	+	+		+	+	
Erythrogonys cinctus	Red-kneed dotterel	+		+	+	+	
Charadrius ruficapillus	Red-capped plover	+	+				
Charadrius melanops	Black-fronted plover	+		+	+	+	+
Himantopus himantopus	Black-winged stilt	+	+	+	+		
Recurvirostra novae-hollandiae	Red-necked avocet	+					
Tringa hypoleucos	Common sandpiper			+			
Tringa nebularia	Greenshank	+					
Tringa stagnatilis	Marsh sandpiper	+					
Gallinago hardwickii	Latham's snipe	+		+	+		
Calidris acuminata	Sharp-tailed sandpiper	+		+			
Calidris ruficollis	Red-necked stint	+					
Calidris ferruginea	Curlew sandpiper	+					
Stiltia isabella	Australian pratincole	+					
Larus novaehollandiae	Silver gull	+		+		+	+
Chlidonias hybrida	Whiskered tern	+	+	+	+		
Gelochelidon nilotica	Gull-billed tern	+					
Hydroprogne caspia	Caspian tern	+		+			
*Columba livia**	Feral pigeon	+		+	+		
Geopelia placida	Peaceful dove	+	+	+	+	+	+
Phaps chalcoptera	Common bronzewing	+	+	+	+		+
Ocyphaps lophotes	Crested pigeon	+	+	+	+	+	+
Cacatua roseicapilla	Galah	+	+	+	+	+	+
Cacatua tenuirostris	Long-billed corella	+		+	+		
Cacatua sanguinea	Little corella						+

Appendix 3b. Distribution of birds by descriptive blocks (cont.)

Scientific name	Common name	Gun-bower	Patho	Goul-burn	Bar-mah	Yarra-wonga	Hume
Cacatua galerita	Sulphur-crested cockatoo	+	+	+	+	+	+
Glossopsitta concinna	Musk lorikeet	+					+
Glossopsitta porphyrocephala	Purple-crowned lorikeet	+					
Glossopsitta pusilla	Little lorikeet					+	+
Polytelis swainsonii	Superb parrot				R		
Nymphicus hollandicus	Cockatiel	+	+	+	+	+	+
Melopsittacus undulatus	Budgerigar						+
Platycercus elegans flaveolus	Yellow rosella	C	C	C	C	C	
Platycercus eximius	Eastern rosella	+	+	+	+	+	+
Barnardius barnardi	Mallee ringneck		+				
Psephotus haematonotus	Red-rumped parrot	+	+	+	+	+	+
Neophema chrysostoma	Blue-winged parrot	R					
Neophema pulchella	Turquoise parrot						U
Cuculus pallidus	Pallid cuckoo	+	+	+	+	+	+
Cuculus pyrrhophanus	Fan-tailed cuckoo	+	+	+	+		
Chrysococcyx osculans	Black-eared cuckoo						+
Chrysococcyx basalis	Horsfield's bronze-cuckoo	+	+	+	+	+	+
Chrysococcyx lucidus	Shining bronze-cuckoo		+		+		+
Ninox novaeseelandiae	Southern boobook	+	+	+	+	+	+
Ninox connivens	Barking owl	R		R			R
Tyto alba	Barn owl	+	+	+			+
Podargus strigoides	Tawny frogmouth	+		+	+	+	+
Aegotheles cristatus	Australian owlet-nightjar	+	+	+	+		+
Caprimulgus mystacalis	White-throated nightjar						R
Ceyx azureus	Azure kingfisher	+			+		
Dacelo novaeguineae	Laughing kookaburra	+	+	+	+	+	+
Halcyon pyrrhopygia	Red-backed kingfisher	R					
Halcyon sancta	Sacred kingfisher	+	+	+	+	+	+
Merops ornatus	Rainbow bee-eater	+	+	+	+	+	+

Appendix 3b. Distribution of birds by descriptive blocks (cont.)

Scientific name	Common name	Gun-bower	Patho	Goul-burn	Bar-mah	Yarra-wonga	Hume
Eurystomus orientalis	Dollarbird			+	+	+	
Passerines							
Mirafra javanica	Singing bushlark						+
*Alauda arvensis**	Skylark	+					
Cheramoeca leucosternum	White-backed swallow	+	+	+			
Hirundo neoxena	Welcome swallow	+	+	+	+	+	+
Cecropis nigricans	Tree martin	+	+	+	+	+	+
Cecropis ariel	Fairy martin	+	+	+	+	+	+
Anthus novaeseeiandiae	Richard's pipit	+	+	+	+	+	+
Coracina novaehollandiae	Black-faced cuckoo-shrike	+	+	+	+	+	+
Coracina papuensis	White-bellied cuckoo-shrike			+			+
Lalage suerii	White-winged triller	+	+	+	+	+	+
*Tardus merula**	Blackbird	+		+	+	+	+
Petroica phoenicia	Flame robin	+					
Petroica multicolor	Scarlet robin	+			+		+
Petroica goodenovii	Red-capped robin	+	+	+	+		+
Melanodryas cucullata	Hooded robin	+	+		+		+
Eopsaltria australis	Eastern yellow robin						+
Microeca leucophaea	Jacky winter	+	+	+	+	+	+
Falcunculus frontatus	Crested shrike-tit	+	+	+	+	+	+
Pachycephala inornata	Gilbert's whistler	R	R				
Pachycephala pectoralis	Golden whistler	+		+			
Pachycephala rufiventris	Rufous whistler	+	+	+	+	+	+
Colluricincia harmonica	Grey shrike-thrush	+	+	+	+	+	+
Myiangra rubecula	Leaden flycatcher				+		+
Myiagra cyanoleuca	Satin flycatcher						+
Myiagra inquieta	Restless flycatcher	+	+	+	+	+	+

Appendix 3b. Distribution of birds by descriptive blocks (cont.)

Scientific name	Common name	Gunbower	Patho	Goulburn	Barmah	Yarrawonga	Hume
Rhipidura fuliginosa	Grey fantail	+	+	+	+	+	+
Rhipidura leucophrys	Willie wagtail	+	+	+	+	+	+
Pomatostomus temporalis	Grey-crowned babbler	R	R	R	R		U
Pomatostomus superciliosus	White-browed babbler		+				+
Acrocephalus stentoreus	Clamorous reed-warbler	+	+	+	+	+	+
Megalurus gramineus	Little grassbird	+	+	+	+	+	
Cisticola exilis	Golden-headed cisticola	+		+			
Cinclorhamphus mathewsi	Rufous songlark	+	+	+	+	+	+
Cinclorhamphus cruralis	Brown songlark	+		+	+	+	+
Malurus cyaneus	Superb fairy-wren	+	+	+	+	+	+
Malurus lamberti	Variegated fairy-wren	R					
Malurus leucopterus	White-winged fairy-wren	U					
Sericornis frontalis	White-browed scrubwren	U			U		
Sericornis sagittatus	Speckled warbler						U
Sericornis brevirostris	Weebill	+	+	+	+	+	+
Gerygone fusca	Western gerygone	U	U	U	U	U	U
Acanthiza pusilla	Brown thornbill						+
Acanthiza apicalis	Inland thornbill	R					
Acanthiza uropygialis	Chestnut-rumped thornbill	U					R
Acanthiza reguloides	Buff-rumped thornbill	+	+	+	+		+
Acanthiza chrysorrhoa	Yellow-rumped thornbill	+	+	+	+	+	+
Acanthiza nana	Yellow thornbill	+	+	+	+		+
Acanthiza lineata	Striated thornbill	+		+	+		+
Aphelocephala leucopsis	Southern whiteface	+	+				
Daphoenositta chrysoptera	Varied sitella	+		+	+		+
Climacteris leucophaea	White-throated tree-creeper	+	+	+	+	+	+
Climacteris picumnus	Brown treecreeper	+	+	+	+	+	+
Anthochaera carunculata	Red wattledbird	R					R
Acanthagenys rufogularis	Spiny-cheeked honeyeater	R					

Appendix 3b. Distribution of birds by descriptive blocks (cont.)

Scientific name	Common name	Gunbower	Patho	Goulburn	Barmah	Yarrawonga	Hume
Plectorhyncha lanceolata	Striped honeyeater	R					
Philemon corniculatus	Noisy friarbird	+		+	+		+
Philemon citreogularis	Little friarbird	+	+	+	+	+	+
Entomyzon cyanotis	Blue-faced honeyeater	R					R
Manorina melanocephala	Noisy miner	+	+	+	+	+	+
Manorina flavigula	Yellow-throated miner	R					
Lichenostomus chrysops	Yellow-faced honeyeater			R			
Lichenostomus virescens	Singing honeyeater	R	R				
Lichenostomus melanops	Yellow-tufted honeyeater					R	R
Lichenostomus fuscus	Fuscous honeyeater						U
Lichenostomus penicillatus	White-plumed honeyeater	+	+	+	+	+	+
Melithreptus gularis	Black-chinned honeyeater	U		R	R		U
Melithreptus brevirostris	Brown-headed honeyeater	+	+	+	+	+	+
Grantiella picta	Painted honeyeater						R
Ephthianura aurifrons	Orange chat	R					
Ephthianura albifrons	White-fronted chat	+	+	+	+	+	+
Dicaeum hirundinaceum	Mistletoebird	+	+	+	+	+	+
Pardalotus punctatus	Spotted pardalote	+	+	+	+		+
Pardalotus striatus	Striated pardalote	+	+	+	+	+	+
Zosterops lateralis	Silvereye	+			+	+	+
*Carduelis carduelis**	European goldfinch	+	+	+	+		+
*Passer domesticus**	House sparrow	+	+	+	+	+	+
*Passer montanus**	Tree sparrow				+		
Emblema temporalis	Red-browed firetail			R	U	U	R
Emblema guttata	Diamond firetail	+	+		+		+
Poephila guttata	Zebra finch	+	+	+	+		
*Sturnus vulgaris**	Common starling	+	+	+	+	+	+
Oriolus sagittatus	Olive-backed oriole	+		+	+	+	+
Corcorax melanorhamphos	White-winged chough	+	+	+	+	+	+
Grallina cyanoleuca	Australian magpie-lark	+	+	+	+	+	+

Appendix 3b. Distribution of birds by descriptive blocks (cont.)

Scientific name	Common name		Gun-bower	Patho	Goul-burn	Bar-mah	Yarra-wonga	Hume
Artamus leucorhynchus	White-breasted wood-swallow		U		U	U	R	R
Artamus personatus	Masked woodswallow						U	U
Artamus superciliosus	White-browed wood-swallow		U	R	U	U	C	C
Artamus cinereus	Black-faced wood-swallow		U	R		R		
Artamus cyanopterus	Dusky woodswallow		C	U	C	C	U	C
Cracticus torquatus	Grey butcherbird		R					R
Cracticus nigrogularis	Pied butcherbird		U	R	R	R		
Gymnorhina tibicen	Australian magpie		+	+	+	+	+	+
Strepera graculina	Pied currawong		R			R		
Corvus coronoides	Australian raven		+	+	+	+	+	+
Corvus mellori	Little raven		+	+	+	+	+	+
Total (passerines)		95	80	54	60	64	46	72
Total (non-passerines)		120	103	56	76	71	49	64
Total (native species)		208	177	107	131	129	92	132

Appendix 3c. Distribution of reptiles by descriptive blocks

Scientific name	Common name	Gunbower	Patho	Goulburn	Barmah	Yarrawonga	Hume
Chelodina expansa	Broad-shelled river turtle		U		U	U	
Chelodina longicollis	Eastern long-necked tortoise	C		C	C	C	+
Emydura macquarii	Murray turtle			C	U	C	
Amphibolurus barbatus	Bearded dragon	C	C	U	U	U	U
Amphibolurus muricatus	Tree dragon					R	U
Diplodactylus intermedius	Eastern spiny-tailed gecko		R				
Diplodactylus vittatus	Wood gecko					U	U
Phyllodactylus marmoratus	Marbled gecko	C	C	C	C	C	C
Delma inornata	Legless lizard	U	U	R	R	U	U
Lialis burtonis	Burton's snake-lizard						R
Pygopus nigriceps	Hooded scaly-foot	R					
Carlia tetradactyla	Rainbow skink						C
Cryptoblepharus carnabyi	Snake-eyed skink	C	U				
Ctenotus robustus	Large striped skink	U	C	U		U	U
Egernia cunninghami	Cunningham's skink		R			R	
Egernia saxatilis	Black rock skink						R
Egernia striolata	Tree skink	C	C				
Egernia whitii	White's skink			+			+
Lampropholis guichenoti	Garden skink	U			U		U
Lerista bougainvillii	Bougainville's skink		C				C
Menetia greyi	Skink	+					
Morethia adelaidensis	Skink	R					
Morethia boulengeri	Boulenger's skink	A	A	A	A	A	A
Sphenomorphus tympanum W.T.F.	Water skink			U	C	U	U
Tiliqua rugosa	Stump-tailed lizard	C	U				

Appendix 3c. Distribution of reptiles by descriptive blocks (cont.)

Scientific name	Common name		Gun-bower	Patho	Goul-burn	Bar-mah	Yarra-wonga	Hume
Tiliqua scincoides	Eastern blue-tongued lizard		U	U			U	U
Varanus gouldii	Sand goanna			R				U
Varanus varius	Tree goanna		U	U	C	C	C	C
Phython spilotes variegata	Carpet snake		R	R	R			R
Notechis scutatus	Mainland tiger snake		U	U	U	U		U
Pseudechis porphyriacus	Red-bellied black snake		C			C	U	C
Pseudonaja textilis	Eastern brown snake		C	C	C	C	C	U
Suta suta	Curl snake		R					
Unechis dwyeri	Dwyer's snake						R	U
Unechis nigriceps	Short-tailed snake		R	R				
Vermicella annulata	Bandy bandy		+	+	+		+	+
Typhlina bituberculata	Blind snake		+	+	+			
Typhlina nigrescens	Blind snake				+		+	+
Typhlina proxima	Blind snake		+	+	+		+	+
Total number of species		39	24	22	17	13	20	26

Appendix 3d. Distribution of amphibians by descriptive blocks

Scientific name	Common name		Gun-bower	Patho	Goul-burn	Bar-mah	Yarra-wonga	Hume
Litoria paraewingi	Brown tree frog				+		+	+
Litoria peroni	Peron's tree frog		+	+	+	+	+	+
Litoria raniformis	Green and golden bell frog		+	+	+	+	+	+
Limnodynastes dumerili	Southern bullfrog		+	+	+	+	+	+
Limnodynastes fletcheri	Barking frog		+	+	+	+	+	+
Limnodynastes interioris	Giant bullfrog				+		+	
Limnodynastes tasmaniensis	Spotted grass frog		+	+	+	+	+	+
Neobatrachus sudelli	Burrowing frog		+	+	+		+	+
Pseudophryne bibroni	Brown toadlet		+	+	+		+	+
Ranidella parinsignifera	Froglet		+	+	+	+	+	+
Ranidella signifera	Eastern froglet		+	+	+	+	+	+
Ranidella sloanei	Sloan's froglet			+	+	+	+	+
Total number of species		12	9	10	12	8	12	11

Appendix 4

SUPPLEMENTARY LIST OF BIRDS
recorded in the Murray Valley area

(from R.A.O.U. Field Atlas Printout 8.9.80, National Museum of Victoria records literature survey, and R. Loyn, Forests Commission of Victoria, pers. comm.)

Abbreviations

V - Vagrant
D - Species that have declined in abundance
E - Species that are now extinct

Scientific name	Common name	Status
Non-passerines		
Leucocarbo fuscescens	Black-faced shag	V
Ardea picata	Pied heron	V
Egretta garzetta	Little egret	
Botaurus poiciloptilus	Australasian bittern	
Anseranas semipalmata	Magpie goose	D
Dendrocygna arcuata	Wandering whistling-duck	V
Cereopsis novaehollandiae	Cape Barren goose	V
Anas platyrhynchus	Mallard	
Nettapus coromandelianus	Cotton pygmy-goose	V
Pandion haliaetus	Osprey	V
Elanus scriptus	Letter-winged kite	V
Lophaictinia isura	Square-tailed kite	V
Hamirostra melanosternon	Black-breasted buzzard	V
Accipiter novaehollandiae	Grey goshawk	

Appendix 4 (*continued*)

Scientific name	Common name	Status
Falco hypoleucos	Grey falcon	V
Leipoa ocellata	Malleefowl	D
Coturnix chinensis	King quail	V
Turnix pyrrhothorax	Red-chested button-quail	V
Pedionomus torquatus	Plains-wanderer	D
Rallus pectoralis	Lewin's rail	
Grus rubicundus	Brolga	D
Ardeotis australis	Australian bustard	E
Pluvialis dominica	Lesser golden plover	V
Charadrius bicinctus	Double-banded plover	V
Peltohyas australis	Inland dotterel	
Cladorhynchus leucocephalus	Banded stilt	V
Arenaria interpres	Ruddy turnstone	V
Numenius madagascariensis	Eastern curlew	V
Numenius minutus	Little curlew	V
Tringa glareola	Wood sandpiper	V
Limosa limosa	Black-tailed godwit	V
Calidris canutus	Red knot	V
Calidris tenuirostris	Great knot	V
Calidris melanotos	Pectoral sandpiper	V
Calidris bairdii	Baird's sandpiper	V
Calidris subminuta	Long-toed stint	V
Calidris alba	Sanderling	V

Appendix 4 (*continued*)

Scientific name	Common name	Status
Tryngites subruficollis	Buff-breasted sandpiper	V
Limicola falcinelius	Broad-billed sandpiper	V
Philomachus pugnax	Ruff	V
Chlidonias leucoptera	White-winged tern	V
Sterna hirundo	Common tern	V
Sterna nereis	Fairy tern	V
Streptopelia chinensis	Spotted turtle-dove	V
Geopelia cuneata	Diamond dove	
Phaps elegans	Brush bronzewing	V
Calyptorhynchus lathami	Glossy black-cockatoo	V
Calyptorhynchus funereus	Yellow-tailed black-cockatoo	V
Callocephalon fimbriatum	Gang-gang cockatoo	
Cacatua leadberteri	Pink cockatoo	V
Trichoglossus haematodus	Rainbow lorikeet	V
Trichoglossus chlorolepidotus	Scaly-breasted lorikeet	V
Alisterus scapularis	Australian king-parrot	V
Polytelis anthopepius	Regent parrot	D
Pezoporus wallicus	Ground parrot	V
Lathamus discolor	Swift parrot	V
Barnardius zonarius	Port Lincoln ringneck	V
Psephotus varius	Mulga parrot	V
Northiella haematogaster	Blue bonnet	
Neophema elegans	Elegant parrot	V

Appendix 4 (*continued*)

Scientific name	Common name	Status
Cuculus variolosus	Brush cuckoo	V
Scythrops novaehollandiae	Channel-billed cuckoo	V
Ninox strenua	Powerful owl	V
Caprimulgus guttatus	Spotted nightjar	V
Hirundapus caudacutus	White-throated needletail	
Apus pacificus	Fork-tailed swift	
Passerines		
Coracina tenuirostris	Cicadabird	V
Coracina maxima	Ground cuckoo-shrike	V
Zoothera dauma	White's thrush	V
Drymodes brunneopygia	Southern scrub-robin	V
Petrioca rosea	Rose robin	V
Petroica rodinogaster	Pink Robin	V
Pachycephala olivacea	Olive whistler	V
Oreoica gutteralis	Crested bellbird	
Rhipidura rufifrons	Rufous fantail	V
Cinclosoma punctatum	Spotted quail-thrush	V
Cinclosoma castanotum	Chestnut quail-thrush	V
Pomatostomus ruficeps	Chestnut-crowned babbler	V
Malurus splendens	Splendid fairy-wren	V
Stipiturus ruficeps	Rufous-crowned emu-wren	V
Sericornis pyrrhopygius	Chestnut-rumped hylacola	V

Appendix 4 (*continued*)

Scientific name	Common name	Status
Sericornis cautus	Shy hylacola	V
Sericornis fuliginosus	Calamanthus	V
Gerygone mouki	Brown gerygone	V
Gerygone olivacea	White-throated gerygone	V
Climacteris erythrops	Red-browed treecreeper	V
Climacteris affinis	White-browed treecreeper	V
Xanthomyza phrygia	Regent honeyeater	D
Manorina melanophrys	Bell miner	V
Meliphaga lewinii	Lewin's honeyeater	V
Lichenostomus leucotis	White-eared honeyeater	V
Lichenostomus ornatus	Yellow-plumed honeyeater	V
Melithreptus lunatus	White-naped honeyeater	V
Phylidonyris pyrrhoptera	Crescent honeyeater	V
Phylidonyris novaehollandiae	New Holland honeyeater	V
Phylidonyris albifrons	White-fronted honeyeater	V
Phylidonyris melanops	Tawny-crowned honeyeater	V
Acanthohynchus tenuirostris	Eastern spinebill	V
Certhionyx niger	Black honeyeater	V
Myzomela sanguinolenta	Scarlet honeyeater	V
Ephthianura tricolor	Crimson chat	V
Pardalotus xanthopygus	Yellow-rumped pardalote	V
Carduelis chloris	European greenfinch	V
Emblema bella	Beautiful firetail	V

Appendix 4 (*continued*)

Scientific name	Common name	Status
Poephila bichenovii	Double-barred finch	V
Aidemosyne modesta	Plum-headed finch	V
Acridotheres tristis	Common myna	V
Sphecotheres viridis	Figbird	V
Ptilonorhynchus violaceus	Satin bowerbird	V
Chlamydura maculata	Spotted bowerbird	V
Struthidea cinerea	Apostlebird	V
Strepera versicolor	Grey currawong	
Corvus bennetti	Little crow	V

Appendix 5

RECORDED NOXIOUS WEEDS OF THE MURRAY VALLEY AREA

Common name	Botanical name	Common name	Botanical name
Artichoke thistle	*Cynara cardunculus*	Hawthorn	*Crataegus laevigata* and hybrids
Bathurst burr	*Xanthium spinosum*	Hemlock	*Conium maculatum*
Bindweed	*Convolvulus arvensis*	Hoary cress	*Cardaria draba*
Blackberry	*Rubus fruticosus* agg.	Horehound	*Marrubium vulgare*
Boneseed	*Chrysanthemoides monilifera*	Ivy-leaf sida	*Sida leprosa*
Boxthorn	*Lycium ferocissimum*	Khaki weed	*Alternanthera pungens*
Buffalo burr	*Solanum cornutum*	Noogoora burr	*Xanthium pungens*
Caltrop	*Tribulus terrestris*	Nut grass	*Cyperus rotundus*
Camel thorn	*Alhagi pseudalhagi*	Onion weed	*Asphodelus fistulosus*
Cape broom	*Genista monspessulana*	Pampas lily of the valley	*Salpichroa origanifolia*
Chilean cestrum	*Cestrum parqui*	Patersons curse	*Echium plantagineum*
Chinese scrub	*Cassinia arcuata*	Prairie ground cherry	*Physalis viscosa*
Dodder	*Cuscuta* spp.	Purple-flowered devil's claw	*Proboscidea louisianica*
Erect prickly pear	*Opuntia stricta*	Russian knapweed	*Centaurea repens*
Fennel	*Foeniculum vulgare*	Saffron thistle	*Carthamus lanatus*
Five-spined saltbush	*Bassia quinquecuspis*	Sand rocket	*Diplotaxis tenuifolia*
Furze	*Ulex europaeus*	Scotch thistle	*Onopordum acanthium*
Golden thistle	*Scolymus hispanicus*		
Great mullein	*Verbascum thapsus*		

Appendix 5 (*continued*)

Common name	Botanical name
Silver-leaf night-shade	*Solanium elaeagni-folium*
Skeleton weed	*Chondrilla juncea*
Slender thistle	*Carduus tenuiflorus*
Soursob	*Oxalis pes-caprae*
Spear thistle	*Cirsium vulgare*
Spiny burr-grass	*Cenchrus longispinus*
Spiny emex	*Emex australis*
Spiny rush	*Juncus acutus*
St Barnaby's thistle	*Centaurea sol-stitialis*
St John's wort	*Hypericum perforatum*
Star thistle	*Centaurea calcitrapa*
Stemless thistle	*Onopordum acaulon*
Stinkwort	*Inula graveolens*
Sweet briar	*Rosa rubiginosa*
Thorn apple	*Datura ferox*
Tree of heaven	*Ailanthus altissima*
Variegated thistle	*Silybum marianum*
Water hyacinth	*Eichhornia crassipes*
Wild mignonette	*Reseda luteola*
Yellow burr weed	*Amsinckia* spp.
Yellow-flowered devil's claw	*Ibicella lutea*

As proclaimed on 15th January, 1974

Appendix 6 LOCAL WATER AUTHORITIES

Controlling body	Towns supplied	Total population served	Source of water
Benalla Waterworks Trust	Benalla	8,700	McCall Say Reservoir and Loombah Weir on Ryans Creek - catchment pastoral and forested
Boort Waterworks Trust	Boort	850	Water Commission North Boort Irrigation Channel
Cobram Waterworks Trust	Cobram	4,250	Murray River by pumping
Cohuna Waterworks Trust	Cohuna	2,200	Gunbower Creek by pumping
Shire of Deakin Waterworks Trust	Girgarre) Tongala)	1,350	Water Commission irrigation channel
Devenish Waterworks Trust	Devenish	130	Back Creek pumping
Echuca Waterworks Trust	Echuca	8,000	Murray River by pumping

(CONSTITUTED UNDER THE *WATER ACT*)

Headworks capacity (ML)	Local storage Type	Capacity (ML)	Annual consumption (ML)	Water treatment
1,780	Three excavated basins	13.64 9.16 4.50	1,877	Chlorination
	Standpipe	0.45		
-	Two excavated basins	77 0.90	295	Chemical clarification; Chlorination; fluoridation
-	Standpipe Elevated tank	1.22 0.36	790	Filtration plant under construction; chlorination
-	Elevated tank	0.68	650	Chemical clarification; chlorinator
-	Two excavated basins	27 22.5	735	Girgarre - chlorination
	Two elevated storages	0.6		Tongala - filtration; chlorination; fluoridation
-	Excavated basin Standpipe	25 0.13		
-	Underground tank Two elevated storages Ground-level tank	4.5 0.93 0.75	2,700	Filtration; chlorination

Appendix 6 (*continued*)

Controlling body	Towns supplied	Total population served	Source of water
Euroa Waterworks	Euroa	3,100	Polly McQuinns Reservoir on Seven Creeks G.A. Waterjoise Reservoir and Mountain Hut No. 1 Reservoir on Mountain Hut Creek
Glenrowan Waterworks Trust	Glenrowan	300	Reservoir filled by channel from un-named stream draining Mt Glenrowan; water also obtained Fifteen Mile Creek by pumping
Goorambat Waterworks Trust	Goorambat	100	Broken Creek by pumping
Katamatite Waterworks Trust	Katamatite	320	Water Commission irrigation channel by pumping
Kerang Waterworks Trust	Kerang	4,000	Loddon River by pumping
Kyabram Water Authority	Kyabram	5,200	Water Commission irrigation channel
Longwood Water works Trust	Longwood	350	Reservoir on Nine Mile Creek
Merrigum Waterworks Trust	Merrigum	800	Water Commission irrigation channel

Headworks capacity (ML)	Local storage		Annual consumption (ML)	Water treatment
	Type	Capacity (ML)		
136	Excavated basin	2.3	654	Chlorination
264				
43	Excavated basin	20	30	
-	Elevated tank	0.11	21	
-	Excavated basin Standpipe	9 0.23	100	Chlorination
-	Clear water storage Elevated tank	2.27 0.68	1,500	Chemical clarification; chlorination
-	Two excavated basins Two settling basins	112.7 41.5	1,600	Storage detention; chlorination
16	Excavated basins	0.45		
16	Excavated basins Elevated tank	18 0.14	700	

Appendix 6 (*continued*)

Controlling body	Towns supplied	Total population served	Source of water
Mooroopna Waterworks Trust	Mooroopna	5,400	Goulburn River by pumping
Shire of Nathalia Waterworks Trust	Barmah) Picola) Nathalia)	1,800	Murray River by pumping Water Commission irrigation by pumping Broken Creek by pumping
Shire of Numurkah Waterworks Trust	Katunga) Numurkah) Strathmerton) Wunghnu)	3,500	Bore by pumping Broken Creek by pumping Bore by pumping Treated water by pipeline from Numurkah
Rochester Waterworks Trust	Rochester	3,000	Water Commission irrigation channel Campaspe River by pumping (winter)
Shire of Rutherglen Waterworks Trust	Rutherglen) Wahgungah)	2,400	Murray River by pumping (separate pumping stations and supply mains to be replaced by single pumping station now under construction)
Shepparton Urban Waterworks Trust	Shepparton) Shepparton) Kialla	24,250	Goulburn River by pumping

Headworks capacity (ML)	Local storage Type	Capacity (ML)	Annual consumption (ML)	Water treatment
-	Clear water storage Elevated tank	0.68 0.45	1,300	Filtration; Chlorination
-	Elevated tank	0.08)		Filtration; Chlorination
-	Elevated tank	0.11)	600	
-	Clear water storage Elevated tank	2.00) 0.27)		
-	Elevated tank	0.02)		Chlorination
-	Elevated tank	0.68)		Filtration
-	Elevated tank	0.14))		Chlorination Chlorination as for
-	Elevated tank	0.18)		Numurkah
-	Excavation basin	1.2	1,000	Filtration; chlorination
-	Elevated tank	0.54		
-	Excavation basin Standpipe	5.9 0.64	710	
-	Four ground-level tanks Two elevated tanks	12.5) 0.75)	8,920	Filtration; chlorination

Appendix (*continued*)

Controlling body	Towns supplied	Total population served	Source of water
Springhurst Waterworks Trust	Springhurst	200	Dam on Diddah Diddah Creek
Tatura Waterworks Trust	Tatura	3,350	Water Commission irrigation channel
Shire of Tungamah Waterworks Trust	Katandra West) St. James) Tungamah) Tungamah Rural)	1,970	Water Commission irrigation Casey's Weir on Broken River Bossey Creek Casey's Weir on Broken River
Violet Town Waterworks Trust	Violet Town	650	Reservoir on Honeysuckle Creek - catchment pastoral and forested
Wangaratta Waterworks Trust	Wangaratta	17,000	Ovens River by pumping
Yarrawonga Urban Waterworks Trust	Yarrawonga	4,200	Murray River (Lake Mulwala by pumping

Notes:

1. The schedule includes authorities under the *Water Act*. Other supplies may exist under such Acts as the *Local Government Act*.

2. The Toolamba township water supply is at present managed by the Victorian Rail-

Headworks capacity (ML)	Local storage		Annual consumption (ML)	Water treatment
	Type	Capacity (ML)		
55			25	
-	Excavated basin	150	1,450	Storage detention; chlorination
	Detention basin	4.5		
	Elevated storage	0.27		
-)	Three excavated	11.4)		
-)	storages	)	9,560	
-)	Two elevated tanks	0.24)		
-)	One standpipe	0.16)		
122	Excavated basin	0.23	175	Chlorination
-	Clear water storage	15.1	6,300	Filtration; chlorination
	Elevated storage	0.77		
-	Elevated tank	0.18	2,200	Filtration; chlorination

ways. A new scheme is at present being constructed which will be managed by the Mooroopna Waterworks Trust. It is expected that this new scheme will be in operation sometime in 1983.

3. Only existing works have been included in the schedule. Works proposed or under construction have been excluded.

Appendix 7

LOCAL SEWERAGE AUTHORITIES CONSTITUTED UNDER THE *SEWERAGE DISTRICTS ACT*

Controlling body (Sewerage Authority)	Town served	Total population served	Treatment type	Effluent disposal	Average annual discharge (ML)	Re-use of effluent
Benalla	Benalla	8,485	Activated sludge process, lagoons	Irrigation, and to Broken River	1,300	Pasture irrigation
Cobram	Cobram	4,250	Lagoons	Irrigation	790	" "
Cohuna	Cohuna	2,200	Lagoons	Evaporative lagoon	220	" "
Echuca	Echuca	8,000	Lagoons	Irrigation, and to Campaspe River	1,650	" "
Euroa	Euroa	2,900	Sedimentation, trickling filter, lagoons	Irrigation, and to Seven Creeks	260	" "
Kerang	Kerang	4,000	Lagoons	Evaporation in Fosters Swamp	240	" "
Kyabram	Kyabram	5,100	Imhoff tank, trickling filter, lagoons	Irrigation	460	" "
Mooroopna	Mooroopna	5,400	Lagoons	Goulburn River	1,660	" "
Nathalia	Nathalia	1,300	Lagoons	Irrigation	115	" "
Numurkah	Numurkah	3,000	Lagoons	Irrigation	200	" "
Rochester	Rochester	2,270	Imhoff tank and lagoons	Irrigation	170	" "

Appendix 7 (*continued*)

Controlling body (Sewerage Authority)	Town served	Total population served	Treatment type	Effluent disposal	Average annual discharge (ML)	Re-use of effluent
Shepparton	Shepparton	23,850	Lagoons	Goulburn River	5,600	Pasture irrigation
Tatura	Tatura	3,350	Lagoons	Evaporative lagoon and irrigation	480	" "
Tongala	Tongala	1,000	Lagoons	Irrigation	-	" "
Wangaratta	Wangaratta - residential	15,800	Lagoons	Irrigation and Reedy Creek	1,406	Poplar tree and pasture irrigation
	- industrial	-	Extended aeration plant	3 Mile Creek	74	
Yarrawonga	Yarrawonga	3,500	Sedimentation, trickling filters, lagoons	Irrigation, and to Murray River	500	Pasture irrigation

Notes:

1. Only existing works have been included in the schedule. Works proposed have been excluded.

2. There are no schemes under construction in the area at the present time.