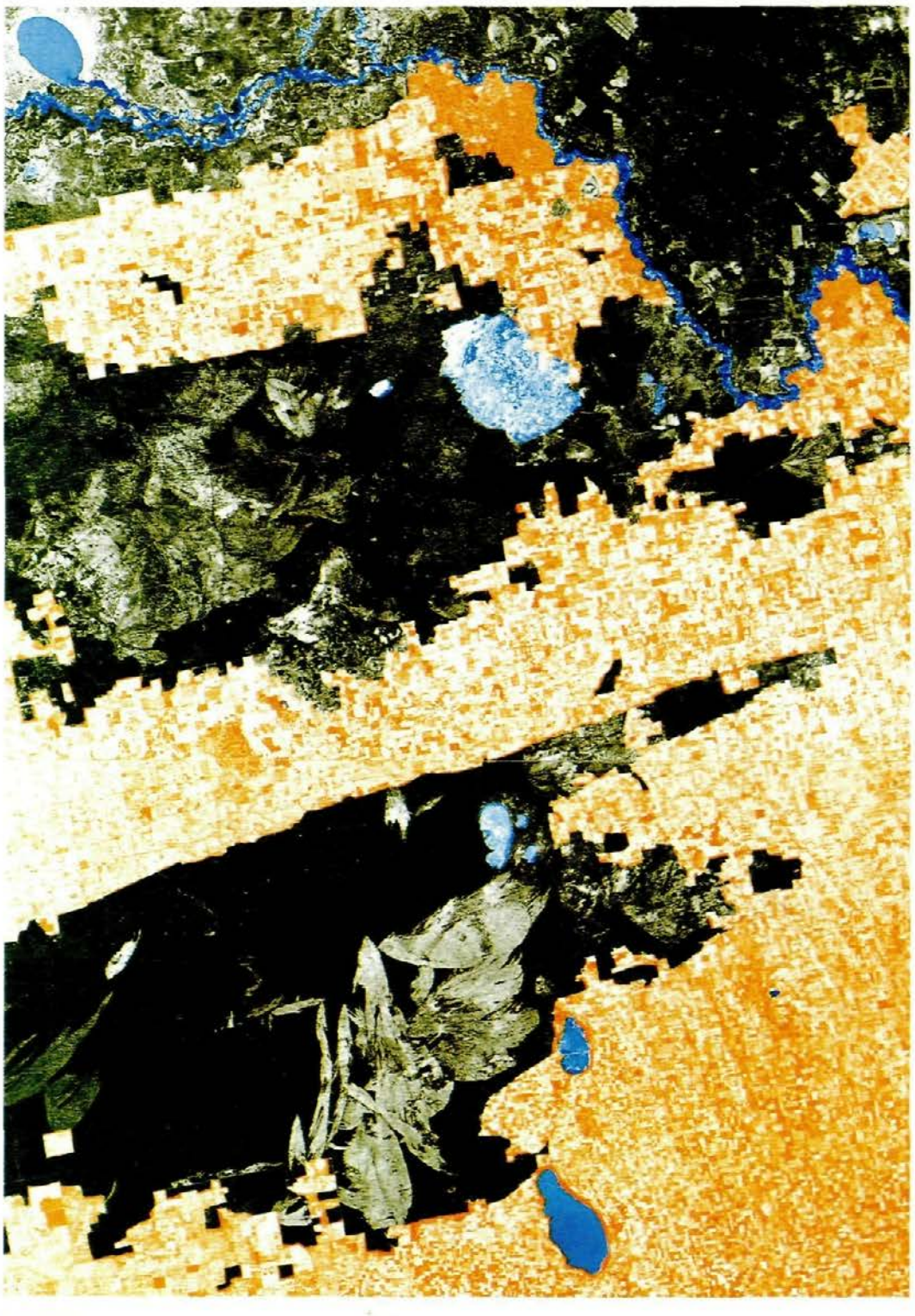
MALLEE AREA

REVIEW



LCC LAND CONSERVATION COUNCIL

LAND CONSERVATION COUNCIL
Government of Victoria
Fourth Floor, 464 St. Kilda Rd. Melbourne, Victoria 3004
Phone: (03) 267 1311

Reference:

REPORT

MALLEE AREA REVIEW

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

In view of the Christmas-New Year public holidays, the normal 60-day period for receiving submissions has been extended to 5 February 1988. They should be forwarded to the Secretary, Land Conservation Council, at the above address.

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

The Chairman of the Land Conservation Council will also be available in the Mallee region to discuss the report with interested people. Details of these meetings will be published in local newspapers circulating in the area.

S. M. Whitty

SANDRA M. WHITTY
Secretary

REPORT ON THE

MALLEE AREA

REVIEW

NOVEMBER 1987

LAND CONSERVATION COUNCIL
Fourth Floor, 464 St. Kilda Rd. Melbourne, Victoria 3004
Phone: (03) 267 1311
Government of Victoria

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Front cover: *Landsat image of the western portion of the Mallee*

The two largest blocks of public land in the Mallee - the Big Desert (bottom) and Sunset Country (upper centre) can be clearly identified. The unusual patterns within these two blocks are the result of recent fires. The course of the Murray and adjoining forested public land (top) are also clearly visible, as are Lake Victoria in New South Wales (top left), the Outlet Creek system featuring Lake Hindmarsh (bottom centre), and Lake Albacutya further north.

Saline discharge areas comprising sand-plains, gypsum flats, gypsite (copi) hills, and salinas (the largest of which occurs in the north-eastern portion of the Sunset Country) show up as a lighter blue colour in the image.

The pattern of agricultural development is also clearly visible. The greater intensity of colour and smaller field size in the south and within the irrigation districts along the Murray reflect a generally higher productivity than the remaining agricultural land.

Landsat imagery provided by the Australian Centre for Remote Sensing, Division of National Mapping, Department of Administrative Services.

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FOREWORD

The Land Conservation Council was established under the *Land Conservation Act* 1970. The function of the Council 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 public land in Victoria.

This report provides a factual basis for the preparation of submissions to the Council, by describing and assessing the natural, economic, and cultural resources and characteristics of public land in the Mallee area. Its purpose is to ensure that all those persons and bodies who have an interest in the future use of this public land can obtain and study the basic information that the Council itself will study, and so make informed and constructive suggestions to the Council for its consideration.

Demands for land for various purposes are many and varied. Some are compatible and some conflicting or competitive. It is therefore important that the decisions made are based on the best information available.

Submissions are now invited and should be forwarded to the Secretary of the Land Conservation Council by the closing date for submissions, as notified in the *Victoria Government Gazette*, and State and regional newspapers. The Council will make its recommendations on the use of public land in the Mallee area only after due consideration of all these submissions.

DAVID SCOTT
Chairman

Land Conservation Council
4th Floor,
464 St Kilda Road
MELBOURNE 3004

EXTRACT

LAND CONSERVATION ACT **1970**

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 and 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 that 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 of which any part of the area or 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 be-

tween the Minister and the Minister administering that department or responsible for that authority.

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

(3) Where the Council has made a recommendation to the Minister under paragraph (a) of sub-section (1) of section 5 the Minister may, after he has given not less than fourteen days notice of his intention so to do to the Minister administering a government department or responsible for a public authority recommend to the Governor in Council that notice of the recommendation or that part of the recommendation that affects the government department or public authority 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 foureen days after the meeting of Parliament.

A copy of the *Land Conservation Act* 1970 can be obtained from the Information Victoria Centre, 318 Little Bourke Street, Melbourne, 3000.

ACKNOWLEDGEMENTS

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

Information for chapters and maps was supplied by: the Departments of Agriculture and Rural Affairs; Conservation, Forests and Lands; and Industry, Technology and Resources; Museum of Victoria; the Rural Water Commission; and Victoria Archaeological Survey.

The following staff from these organizations were involved in the preparation and revision of chapters and other data for the report: I. Ada, R. Adair, A. Bennett, D. Cheal, J. Cooke, A. Cooney, C. Faye, W. Gilmour, J. Lane, G. Lucas, L. Lumsden, P. Macumber, K. Menkhorst, R. Nathanielsz, A. Northey, D. Parkes, I. Roberts, P. Robertson, J. Rowan, C. Silveira, T. Varcoe, G. Vercoe, and A. Yen.

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Other individuals and organizations also generously assisted by checking drafts and contributing valuable discussion and advice. Included here are various government agencies of South Australia, New South Wales, and Victoria, industry representatives, and individuals with expert knowledge of specific disciplines or localities. Their assistance is gratefully acknowledged.

The Council is indebted to the following individuals and organizations that made photographs available for use in the report: the Victorian Departments of Agriculture and Rural Affairs, of Conservation, Forests and Lands, and of Industry, Technology and Resources; Division of National Mapping, Department of Administrative Services, Canberra; the Rural Water Commission; Victoria Archaeological Survey; Latrobe Library; Museum of Victoria; New South Wales Forestry Commission; and A. Bennett, W. Borthwick, D. Cheal, R. Costello, L. Lumsden, P. Macumber, R. Roberts, P. Robertson, J. Rowan, A. Shugg, C. Silveira, and A. Yen.

Part I

INTRODUCTION

1. INTRODUCTION

The Land Conservation Council commenced the first investigation of the Mallee area in 1972, and published a descriptive report in 1974. Final recommendations on the use of public land in the area were published in 1977.

Those recommendations provided for the enlargement of the pre-existing Wyperfeld and Hattah Lakes National Parks and the establishment of a State park based on the Pink Lakes. The Big Desert Wilderness Area, the first land in the State to be set aside exclusively for wilderness-based recreation, was also recommended. Two regional parks, a large number of wildlife and flora and fauna reserves, and bushland reserves (covering many of the small areas still carrying native vegetation within the farming districts) were also included. A total of 107 000 ha of public land was set aside for agricultural use while more than 60% of the public land (almost 1.2 million ha), including large areas of mallee scrub in the Big Desert and Sunset Country, remained uncommitted to any primary use.

The total area of public land within each major category of land use is indicated in Table 1. Their locations are shown on Map 8. In all, public land - as defined under the *Land Conservation Act* 1970 - occupies some 1 674 000 ha or 39% of the study area.

All of the recommendations have been accepted by the government; however the degree of implementation of each varies.

The Council is aware that many changes in demand for the use of public land cannot be foreseen, and that the value of resources will change as exploration, research, and technology progress. For these reasons, the Council believes that periodic reviews of public land use in the State are desirable and that its recommendations should be reassessed in the light of the new information. It must be expected that resources will be re-allocated or adapted to meet changed demands. In accord with this policy, the Council planned to commence the Mallee review during 1986.

Concern expressed early in 1985 over the clearing of Mallee land for agriculture and the deficiency in detailed ecological information for much of the public land of the region prompted the government to ask the Council to bring forward its review of the Mallee area. The Council was able to do so, and advertisements stating that the Council intended to review the Mallee area appeared in the *Victoria Government Gazette* and in local and Victorian newspapers on or about 19 June 1985.

The government also decided not to proceed with the allocation of land recommended by the Council in 1977 for culti-

Table 1

PUBLIC LAND USE

Major land use category	Area (ha)
National parks	139 900
State park	49 600
Regional parks	12 200
Wilderness area	113 500
Reference areas	19 300
Flora, flora and fauna reserves	16 300
Wildlife reserves	35 600
Water supply and drainage reserves	11 800
Bushland and scenic reserves	10 400
Education areas	2 100
Recreation reserves	1 900
Hardwood production	35 100
Uncommitted land	1 174 200
Agriculture	36 500
Mineral production	2 200

Notes:

1. Figures are rounded; the balance that makes up the total public land resource comprises stream frontages, rail and road reserves, and small parcels such as those occupied by utilities and other services.

2. The table reflects the 1977 land use recommendations of the Council, corrected by more accurate area calculations and other adjustments, and includes those reserves that have been set aside subsequent to and independent of the Land Conservation Council process.

3. The 'uncommitted' land use category encompasses land for which, in 1977, no one use was considered to have priority. This category, however, also includes areas (such as near Robinvale and Nowingi) that, at the time, were used for dryland cropping but were not allocated to a specific use by the Council.

4. In 1977, some 73 200 ha of public land were recommended for alienation. Much of this land has now been taken up for agriculture and is no longer considered as public land. Some 1940 ha of it remain and are included in the table; they are indicated on the map as 'F1'.

vation leases until comprehensive flora or fauna surveys had been undertaken in the Mallee, and also not to release certain areas that the Council had recommended for alienation.

To overcome the deficiency in information, the Department of Conservation, Forests and Lands, the Museum of Victoria, and the Council undertook a series of studies of the ecology and agricultural use of the region. These studies were completed by August 1987.

The major purpose of the review is thus to assess the Council's previous land use decisions in the light of changed demands and the availability of new information. All public land in the study area will be reviewed.

Aims and Methods

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

It draws extensively on information contained in the original 'Report on the Mallee Study Area', published in 1974. Where necessary, information has been updated and additional material that was not then available has been incorporated.

For a more comprehensive description of some aspects of the study area, however, readers are referred to the original report and recommendations, copies of which are held in many local libraries, by shire offices in the region, and by regional offices of government departments, such as the Department of Conservation, Forests and Lands at Mildura and the Department of Agriculture and Rural Affairs at Swan Hill. Copies are also available for inspection at the offices of the Land Conservation Council.

The present report is the first stage in the decision-making process for the future use of public land in the study area. It does not contain recommendations, but aims at providing a factual basis on which land use recommendations can be formulated.

It is divided into three main parts: Part I is an introduction, Part II describes the physical and biological nature of the land, and Part III deals with the major forms of land use. Explanatory tables, maps, and a number of appendices complete the report. Map 1 pinpoints a number of localities frequently referred to throughout the text and Appendix I is a glossary of the technical terms.

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

The Study Area

The Mallee area, in north-western Victoria, comprises almost one-fifth of the area of the State (Figure 1). It is bounded to the north and west by the State borders of New South Wales (the top of the southern bank of the Murray River) and South Australia, in the south by a line approximating the 36th parallel, and to the east by the Loddon River. It includes all of the Shires of Karkarook, Mildura, Swan Hill, and Walpeup, as well as large parts of the Shires of Birchip, Kerang, and Wycheproof and small portions of Dimboola, Gordon, Kaniva, and Lowan Shires. Municipal, county, and parish boundaries are shown on Map 2.

Adjacent to the study area are the Cities of Mildura and Swan Hill and the Borough of Kerang. 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. This Crown land, however, does abut public land in places.

The Murray River is technically outside the Mallee study area, but it has a major influence here through the effects of its waters on irrigation, stock, and domestic water supply, plant and animal distribution, and recreation, and through floods.

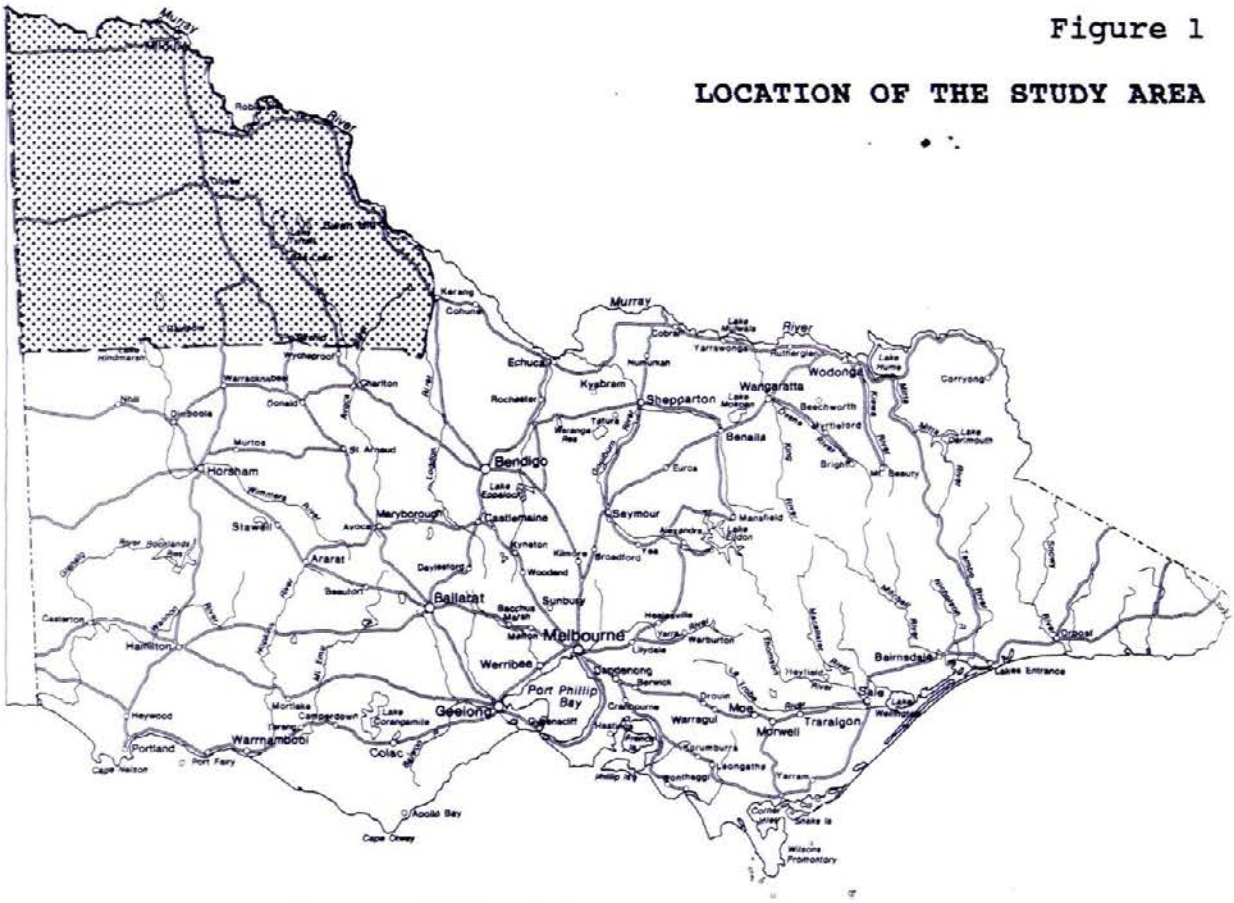
The Mallee area is a vast plain that slopes gradually from an altitude of about 100 m in the south to less than 50 m in the north; relief is low throughout. There is little local variation in the climate, which is semi-arid with characteristically hot summers and mild winters. Rainfall diminishes gradually from south to north, but has little seasonal variation; its effectiveness, however, varies greatly with seasonal temperatures.

Soils have developed on aeolian materials that are often calcareous and vary from sands to clays; they are sometimes saline.

The region derives its name from the characteristic and widespread native scrub of low, multi-stemmed eucalypts called mallees. (Other plant communities include river red gum and black box woodlands, heath, grassland, and the saltbush--blue-bush plains.) It comprises the south-eastern

Figure 1

LOCATION OF THE STUDY AREA



The characteristic and widespread native scrub of low multi-stemmed eucalypts gives the Mallee its name.

extent of Australia's semi-arid inland and many of the plant and animal communities here are unique in the State and of high conservation significance.

Of the total area of more than 4.3 million hectares, public land occupies approximately 1 670 000 ha or 37%, the bulk of which comprises the Big Desert and Sunset Country - the two extensive tracts of mallee scrub in the west that appear in the Landsat image on the cover of this review. The balance is located along the Murray River and scattered throughout the agricultural region.

Public land in the study area is extensively used for grazing and apiculture, while timber products are extracted from the riverine forests and woodlands. A number of sites are used intensively for salt or gypsum production.

Almost 80% of the major blocks of public land here offer remote or semi-remote types of recreational experiences. The more intensive recreational activities tend to be concentrated into the major parks and along the Murray River. Recreation along the river ranges from that provided by highly developed tourist facilities such as at Swan Hill to quiet camp-sites on remote river bends. The area's attractions are enhanced by the mild winter climate and magnificent spring wildflower displays.

The large proportion of freehold land is used for dryland cropping, principally cereals and, to a lesser extent, legumes, as well as for stock grazing on the fallows and pasture.

Irrigated areas along the Murray River produce vine crops (mainly grapes and grape products), vegetables, citrus and stone fruits, and almonds. Pastures and crops are irrigated

near Swan Hill and Kerang. Away from the Murray and Loddon Rivers, the land has no significant natural supplies of surface water, and supplies to the dryland farms come from the vast Wimmera--Mallee Domestic and Stock Water Supply System, and, west of Underbool, from groundwater resources.

Population

The total population of the region as a whole, including the Cities of Mildura and Swan Hill, increased from 64 532 to

Table 2

POPULATION GROWTH

Local government area	Population 1971	1981	1986	Annual average (%) 1971--81
Shires				
Totally within study area				
Karkarook	3 725	3 119	2 822	-1.6
Mildura	16 720	18 868	19 373	+1.3
Swan Hill	12 338	12 395	12 062	+ small
Walpeup	3 954	3 594	3 496	-0.9
Partly within study area				
Birchip	698	571	NA	-1.8
Dimboola	1 091	1 029	NA	-0.6
Kerang	2 061	1 768	NA	-1.4
Wycheproof	3 062	2 538	NA	-1.7
Total in study area	43 649	43 882	-	+ small
Cities				
Mildura	13 190	15 763	18 382	+2.0
Swan Hill	7 693	8 398	8 831	+0.9
Total for region	64 532	68 043	-	+0.5
Total for Victoria	3 496 000	3 832 000	4 019 478	+1.0

Notes:

1. Where part of a shire falls within the study area, the population figure is derived from Collector District data. However, these data from the 1986 Census were not available at the time of preparation of this report.

2. A small number of people live in those portions of the shires of Gordon, Kaniva, and Lowan that overlap the study area.

Source: Australian Bureau of Statistics.

68 043 between 1971 and 1981 (see Table 2) - an average increase of 0.5% per annum, against a background of 1.0% per annum for the State as a whole.

The table also indicates that only two shires experienced an increase in the numbers of people living there over the decade: the Shire of Mildura had an increase of 2148 people, almost certainly associated with the expansion of the City of Mildura, and the Shire of Swan Hill rose by 57 people. All other shires suffered a decrease such that the net total for all the shires (and parts of shires) included in the Mallee area increased by only 233 people over that period.

Information presently available from the 1986 Census indicates that the population trends (an increase for the Cities of Mildura and Swan Hill and a decrease elsewhere) have been sustained.

Public Land Management

Department of Conservation, Forests and Lands

The bulk of public land in the study area is managed by the Department of Conservation, Forests and Lands. The Department's role is to:

- manage public lands, including inland and marine waters, and their resources to achieve a balance between conservation, production, and recreational aims, while achieving optimum return to the State

- conserve and protect native flora and fauna and their environments (including marine and fresh-water environments), to maintain essential ecological processes and life-support systems, to preserve genetic diversity, and to maintain in reserves representation of all species, habitats, and ecosystems

- manage elements of the use of private and public land to conserve soil, control salinity, reverse tree decline, enhance water supplies, and protect land from hazards caused by erosion and pest plant and animal species

- protect the State's public land and its resources from wildfire by undertaking measures to minimize the risk of fire on public land

- further develop the Department's work related to recreation and tourism resources (based on native flora, fauna, and natural landscape)

- foster efficient and stable sawmilling, panel products, and pulp and paper industries based on sustainable yields of hardwoods from native forests and increasing outputs of softwood from plantations; and to promote industries using minor forest produce

- manage marine ecosystems and control the Victorian marine fishing industry so that it is economically viable while, at the same time, conserving the resource

Management of the Department revolves around a highly regionalized organization structure. The State is divided into 16 regions, with each one having a large degree of delegated responsibility and accountability for the management of public land and the achievement of Departmental goals and policies.

Each region manages all Crown land controlled by the Department of Conservation, Forests and Lands in that region, irrespective of its land use classification or legal land status. This includes national parks, State parks, State forest, and an extensive variety of other conservation and community-use reserves. The day-to-day management of some public land is delegated to Committees of Management. However, the Department, through its regional offices, is responsible for overseeing delegated managers.

The Department has its head office located in Melbourne, and is structured around six divisions. Two of these control regional management standards and co-ordination and provide the Department's corporate services. The remaining four - the Fisheries, Land Protection, National Parks and Wildlife, and Public Lands and Forests Divisions - cover the specialist responsibilities of the Department.

These four divisions are responsible for policy development, research, the preparation of State-wide plans and programs, technical standards, and guidelines and prescriptions, and for monitoring implementation of policy and programs by the regions.

The Mallee study area encompasses the Department's Mildura Region and includes portions of its Bendigo Region (in the east) and Horsham Region (in the south).

Local advisory committees in the Mildura Region assist in management of certain issues and areas. These include the Regional Land Protection, the Hattah National Park, and the Wyperfeld National Park Advisory Committees.

The Department is responsible for a broad range of land use and management legislation, including:

- *Conservation, Forests and Lands Act* 1987
- *Crown Land (Reserves) Act* 1978
- *Fisheries Act* 1968
- *Forests Act* 1958
- *National Parks Act* 1975
- *Reference Areas Act* 1978
- *Soil Conservation and Land Utilization Act* 1958
- *Vermin and Noxious Weeds Act* 1958
- *Wildlife Act* 1975

A package of new material is being developed, to consolidate and update much of the existing legislation. Key elements of this package will be a *Lands Act* (to consolidate the

present laws on Crown land and forests), a *Land Protection Act* (to consolidate the existing *Soil Conservation and Vermin and Noxious Weeds Act*) and a *Flora and Fauna Guarantee Act* (which will provide more effective protection for native and other flora and fauna). The last two will cover both public and freehold land.

Some existing Acts will be maintained, but will be reviewed and updated as appropriate. These include the *Fisheries*, *National Parks*, and *Wildlife Acts*.

Rural Water Commission

The Rural Water Commission of Victoria is a body corporate established by the *Water (Central Management Restructuring) Act* 1984. It provides water and water-related services for irrigation, domestic, and stock purposes as well as for commercial, industrial, recreation, environmental, and other uses. It designs, constructs, operates, and maintains the necessary infrastructure to enable the delivery of services, allocates and sells water, and implements pricing and demand management policies.

Responsibilities of the Rural Water Commission include:

- development of rural water policy
- strategic planning for the Commission's resources
- planning and investigation of rural water resources
- evaluation of water-resource data
- irrigation extension and research services
- management of public irrigation systems
- supervision of river and groundwater diversions
- management of domestic, stock, and minor urban systems, and of flood-protection districts
- operation and maintenance of water-management structures and related recreation facilities
- building, survey, and hydrogeology services
- safety and surveillance of Rural Water Commission structures

In the Mallee area, the Commission has numerous facilities located on land reserved for water supply purposes, road easements, natural watercourses, and other public land. These include lakes and storages, modified watercourses, channels, drains, pipelines, elevated tanks, pumps, depots, and residences. Land immediately surrounding these facilities is maintained by the Commission. Several declared recreation areas (such as Middle and Reedy Lakes) are managed on behalf of the Commission by local Committees of Management set up under the *Water Act* 1958.

Channel and drainage reserves are leased, where appropriate, to adjacent landholders, with suitable controls to reduce interference with the facilities. The lessee is responsible for control of vermin and noxious weeds on the land.

The Commission also manages land on the Murray River floodplain in the extreme north-west of the Mallee area, on behalf of the River Murray Commission. This land was bought for a proposed storage that is now not likely to be implemented.

Department of Agriculture and Rural Affairs

The government wishes for the Department of Agriculture and Rural Affairs to:

- maximize long-term economic, employment, and income growth for Victoria derived through rural industries, including agriculture and horticulture

- facilitate the development, co-ordination, and promotion of initiatives that equitably meet the priority needs of Victorians in rural areas, particularly those whose needs are greatest

- promote the delivery of agricultural and horticultural produce of reasonable price, quality, nutritional value, and variety

- promote sound animal welfare policies

In order to better achieve those goals, the Department has become regionalized to fully integrate extension, research, regulatory, and industry development services. Each of its six regional offices in the State is responsible for management of all local research institutes, veterinary laboratories, and district offices.

The North-west Region of the Department, which includes the Mallee study area, is managed from Horsham and contains units at Horsham, Mildura, Swan Hill, and Walpeup. These units aim at creating and maintaining the competitive advantage of farmers and industries, and assisting in developing new market opportunities and products to meet consumer needs. In an important ancillary program, in co-operation with the Office of Rural Affairs, the regional units work with local communities to provide information and services and to generate policies that would enable people and communities to survive rapid change in agricultural conditions. This also involves preparing reports to the government on issues and problems affecting rural communities.

In the Mallee area, the Department manages the 81-ha Sunraysia Horticultural Centre at Irymple and the 1032-ha Mallee Research Station at Walpeup.

Several other authorities also manage public land in the Mallee area.

- The State Transport Authority - V/Line - has responsibility for the extensive system of railway easements, indicated in Figure 6 (see page 44), and its associated sidings and facilities. The majority of the bulk-grain storage and loading facilities controlled by the Grain Elevators Board also occupy land managed by V/Line.

- The Road Construction Authority constructs and maintains all roads in the declared network and the easements in which they lie, while local Shire Councils are responsible for the vast network of other used roads in the area.

- Although not 'public land' under the *Land Conservation* Act 1970, other government-owned land here includes that managed by local government authorities for sewage-treatment works and that managed by Commonwealth departments for such services as communications. In some cases the Commonwealth government leases land from the State.

2. ABORIGINAL HISTORY AND ASSOCIATION WITH THE LAND

For a broad appreciation of the Aborigines' association with the land, the reader should refer to the relevant sections in two of the Council's other reports. The report on the Murray Valley area (1983) deals in detail with the use of the riverain environment and the one on the Wimmera area (1985) provides information on how the land immediately to the south of the Mallee was used. These reports also place the Aboriginal use of the Mallee area in perspective.

In the Council's resources report of 1974, the history chapter included a brief summary of Aboriginal history, which reflected the extent of knowledge at that time. As new data became available, much of that history section required updating; this chapter includes information from the most recent studies. Details concerning archaeological research have been provided by the Victoria Archaeological Survey.

Archaeological Research

In the last decade, the Victoria Archaeological Survey has carried out a number of large-scale investigations in the Mallee area. Projects have also been undertaken here by university researchers and some archaeological sites have been recorded by private individuals.

The outcome of this research is the recording of almost 3000 prehistoric Aboriginal sites, showing a diversity of types. About 600 of the recorded sites are scarred trees on Bumbang Island, and close to one-third of the total are within the Hattah--Kulkyne area. Several burial sites have also been identified.

Archaeological investigations in the resource-rich environments of the Murray River valley suggest that the Aboriginal occupation of the area has considerable antiquity. Near Merbein, a midden of fresh-water mussel shells has been dated to about 16 000 BP (before present). This site seems to have been used intermittently for about 3000 years. Another site of similar type at Red Cliffs was excavated some years ago to reveal two separate occupation phases. The earliest of these was radiocarbon-dated to about 11 000 BP, and the more recent to about 1000 years ago.

A number of the large earthen mounds recorded in the Nyah Forest have also been excavated. The largest of these are up to 40 metres in diameter and a metre high. They were built up, sometimes over a smaller mound, over a period of time and contain shell and bone as well as burnt clay. Since they are not found outside the Murray River floodplain, it is probable that they were used as refuges in time of flooding. Radiocarbon dates from the large mounds suggest they

were in use between about 1300 and 600 BP. Some smaller mounds were used at the same time and, in one case, within the past 300 years.

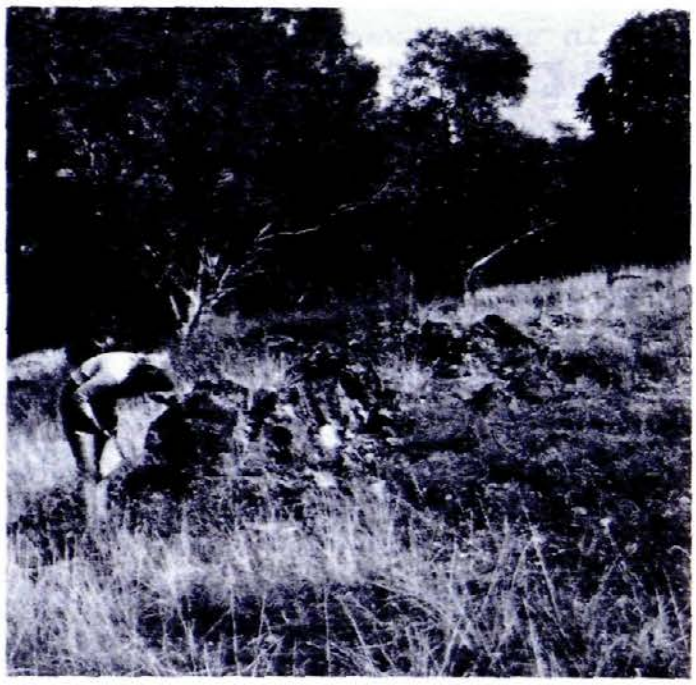
Away from the Murray River, research has centred on lacustrine systems, such as at Raak Plains, Lake Tyrrell, Hattah Lakes, Lake Hindmarsh, and Lake Albacutya. The many sites recorded include fresh-water shell middens, scarred trees, ochre pits, and surface scatters of stone tools. On the basis of the stone tool type they contain, most of these sites are no older than about 5000 years, containing a range of small, finely worked points and blades that do not appear anywhere in Australia before that period. There are, however, some earlier sites in the Mallee. A fresh-water shell midden associated with artefacts and hearths at Raak Plains, for instance, has been dated to about 7600 years ago.

Lunettes on the eastern side of many lakes in the Mallee consist of wind-blown clay and sand that accumulated during the Pleistocene, more than 10 000 years ago. The lunette at Lake Tyrrell, on the surface of which a variety of artefacts have been found, was built up between about 32 000 and 25 000 BP. It is yet to be clarified whether these artefacts were deposited during the development of the lunette, and are therefore also of Pleistocene age.

Archaeological sites throughout the Mallee are subject to a variety of natural and human threats, such as wind and water erosion and increased recreational activities. Many Aboriginal burial sites in dunes and lunettes in the Mallee have been exposed - due to grazing by rabbits and stock - and are continuing to deteriorate through trampling and erosion.

The following account summarizes a report prepared in 1986 for the Land Conservation Council by Ms A. Ross, then of

Excavation of an Aboriginal mound site, Nyah Forest. Mounds were built up artificially, by repeated occupation of the site.



These rock outcrops on the Wirrengren Plain are associated with the Bram-bram-bult brothers, who, during the Dream-time, formed many aspects of the Mallee landscape through their adventures.

the Department of Pre-history and Archaeology, University of New England. The report is based principally on a thesis by Ms Ross, in which she interprets the settlement patterns in the western Mallee in terms of the prehistoric environments and archaeological information. A copy of the report, 'Aboriginal Land Use in the Mallee District of North Western Victoria', is available on request from the Council's office.

Report Summary

According to Dreamtime stories from north-western Victoria, the people of the Mallee are linked geographically and demographically with the Aboriginal tribes of the Western District. The Mallee was also widely occupied, both along the major water corridors through the dune country and throughout the more marginal parts of this semi-arid area.

The latter point, in particular, contradicts the traditional idea that the poorly watered parts of the Mallee were irregularly occupied, and that Aborigines depended on resource abundance for survival in marginal areas.

The preconceptions about 'simple' societies like hunters and gatherers had their beginnings in the Romantic Movement of the mid eighteenth century, which considered these people as 'Noble Savages' or 'Children of Nature' - innocent creatures very closely attuned to the surrounding environment.

This was the intellectual background against which the early observations of Australian Aborigines were made. It was believed that Aborigines were locked into their nomadic way of life, responding to the changes in seasons or to longer-term environmental changes in much the same way that animal behaviour is determined by the availability of food resources. According to such attitudes, hunter--gatherer behaviour was totally determined by the dictates of climate and resource abundance (an environmental determinist model), and marginal

areas like the Victorian Mallee should only have been occupied during periods of plentiful food and water. Many of the traditional ideas about hunter--gatherers, however, are not supported by the archaeological evidence.

Ethnographic record

A number of the writers of the earliest historical accounts of the Mallee and its occupants put forward the idea that the dune country was wild and inhospitable, with few natural food resources, and was therefore uninhabitable. It was simply 'back country' into which the surrounding tribes ventured only occasionally, principally for trade or to obtain certain food items found only among the dunes.

The first white man to observe the Mallee - Sturt, in 1830 - looked over it from a high vantage point close to the Murray River, but the dense vegetation and inhospitable nature of the country prevented him from venturing far from the Murray floodplain. Mitchell (1836), too, was repelled by the scrub, calling the area 'one of the most barren regions in the world'.

Edward John Eyre made an attempt to cross the Mallee in 1838, but was forced to retreat from 'this barren and waterless waste' for want of feed for himself and his horses. It was not until 1849 that the Mallee itself was explored in detail. E.R. White, a surveyor, and John Beilby, an explorer, each made separate long trips through the area in that year. However, neither of them sighted any evidence for Aboriginal occupation, apart from 'smokes' from what they presumed to be Aboriginal fires. A few years later two other explorers travelled through the Mallee. In 1861 William Lockhart Morton made five trips into the dune country from Pine Plains and made detailed recordings of his observations. From 1860 to 1862 George Neumayer made several trips into the Mallee as part of his magnetic survey of Victoria. Once again, neither man was able to make any direct observations of the Aborigines of the area.

One of the earliest accounts of the Aborigines of northern Victoria generally comes from the reports of Edward Stone Parker, Aboriginal Protector for the north-western district of the State from 1839 to about 1852. He first attempted to contact the Aborigines of the Mallee in 1841, when he sent out scouts from the community around his Aboriginal Station at Franklinford on the upper reaches of the Loddon River.

As a result of the searches, November 1841 marked the first visit to the Loddon Station of the 'Mallegoondeet'. Parker was away at the time, but he describes the visit second-hand:

> During my absence nearly 200 natives had been at the station - a few of them obviously strangers to white people. The character of the country [called Mallee (*sic*)] which they inhabit may be judged by a peculiar circumstance - they each carried a rude sort of bottle, made from the skins of kangaroos, or large opossum, for the purpose of carrying a supply of water in their wan-

> derings. Their country is described to me as nearly destitute of water courses.

Parker himself never visited the Mallee, and provided no first-hand account of the occupants of the far north-west of the State. In fact, in his 1848 annual report, Parker had to admit that, after nearly 10 years as Aboriginal Protector for the north-western area:

> The natives to the extreme west and north west are the least known to me. They have no connection with this part of the country.

It would seem that no first-hand accounts of the traditional life of the Mallee Aborigines have survived to the present day. Many of the attitudes towards the Mallee and its habitability are not in fact based on direct observation, but come from a projection of Eurocentric ideas onto the Aboriginal people of the area. Because they regarded the district as inhospitable, Europeans assumed that the Aborigines must also have found it inhospitable and therefore uninhabitable.

Later writers, such as Brough Smyth (1878), put great store on the evidence of Murray River settlers such as Beveridge. Beveridge had land at Swan Hill and he noted that the only exploitation of the Mallee was in the eastern parts closest to the River, by Aborigines based on the Murray, who went on short-term forays to collect certain resources only available in dune country. These writers believed that the sandhill country was virtually devoid of people and resources.

Nonetheless it is certain that the Mallee dune country was occupied at European contact, even if not on quite the same scale as occupation in the better-watered areas.

George Everard was a shepherd and itinerant stock-worker on the small sheep runs of Outlet Creek from 1857 to 1883. He often travelled several kilometres into the Mallee scrub, away from the homesteads along the creek, and occasionally made contact with the Aborigines of this 'wild' country. He describes one Aboriginal family he met who had been living in the dry Pink Lakes district 'for some years'.

> I often came across their camps, and the heaps of hakea roots was something astonishing. You could see them piled up like small hay stacks at all their camps; in the summertime they had little else to depend upon (for water).

W. L. Morton recorded piles of flowers at recently abandoned camps throughout the Mallee as late as 1861:

> From the flowers of this shrubby tree the blacks are in the habit of making a sweet drink, of which they are very fond. In those localities where it grows within reach of water, heaps of the flowers of it may be seen at their old camps.

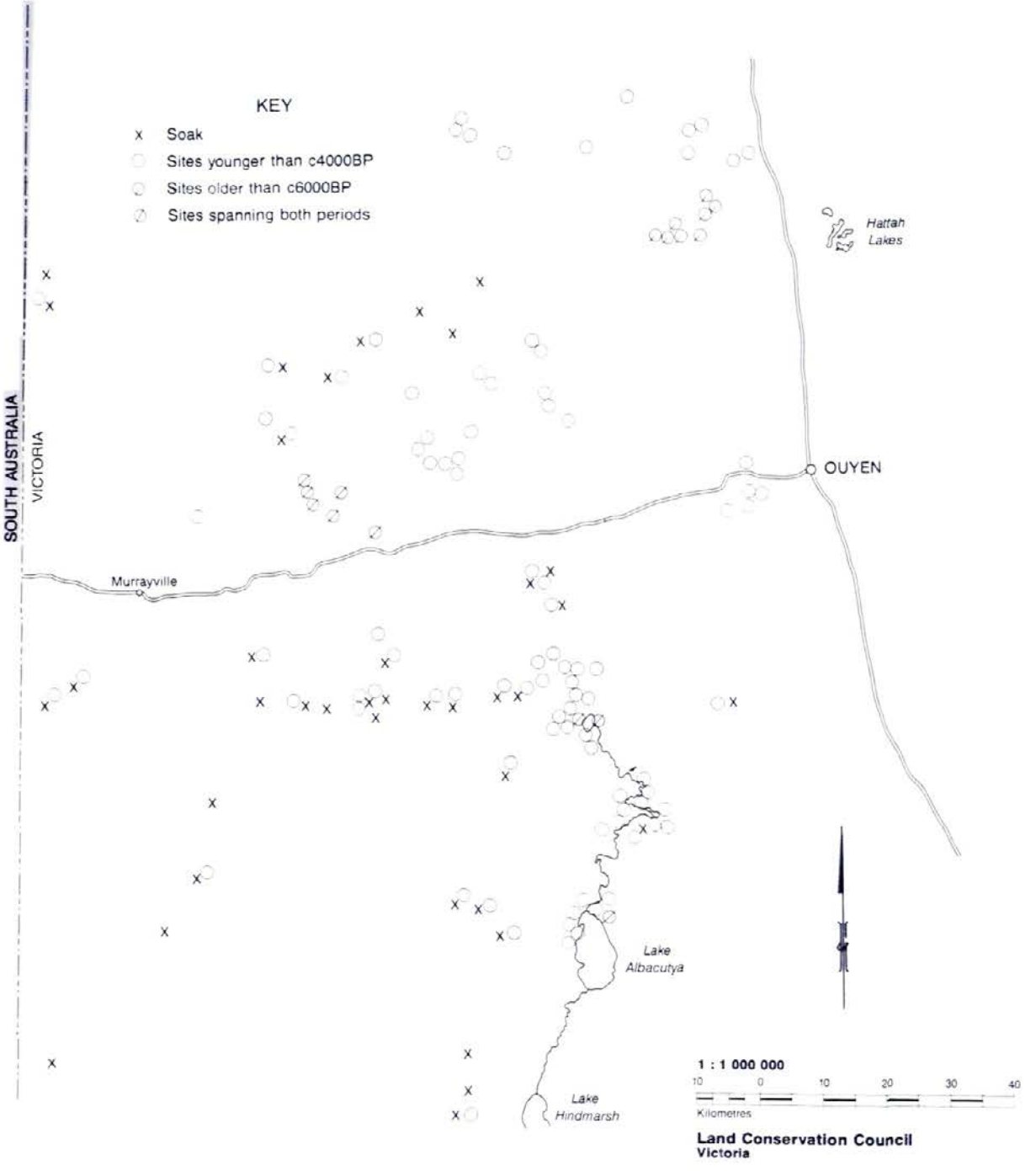
Therefore - more than a decade after European pastoral settlement of the Mallee - there were some Aboriginal groups

still resident in the area for quite long periods, including summer months when water is hard to find. This does not accord with Brough Smyth's suggestion that the Mallee was simply 'back country' for the surrounding tribes.

The distribution of archaeological sites in the Mallee (as indicated in Figure 2) also tends to contradict the ideas that the dune country was never or rarely occupied and that the marginal sites were used only during periods of resource abundance. As well as hundreds of sites along the Murray River and its adjacent floodplain, where ethnographic data

Figure 2

DISTRIBUTION OF ARCHAEOLOGICAL SITES IN THE WESTERN MALLEE



agree that Aboriginal occupation was focused, sites are found throughout the more arid parts of the Mallee.

Prehistoric environments

It is predictable, from the concept that settlement patterns among hunter--gatherers are influenced by the availability of food and water resources, that most of the archaeological sites in semi-arid areas such as the Mallee would be found near water. This is the case in north-western Victoria, where all recorded sites occur within 500 m of a water source.

White Springs, near the northern fringe of the Big Desert. Archaeological sites commonly occur near such water sources.

However, very few of the water-resource areas in the sand-hill country of the Mallee are permanent today. In fact a large number of the lakes and water-holes are quite dry, or even saline, and have been so for at least the period within living memory. This means that the archaeological sites occurring throughout the Mallee might have been occupied in a different climatic and environmental regime from that in existence today - a time when the lakes and water-holes were filled with fresh water. When the lakes dried or became saline, most of the sites would have been abandoned.

The Mallee today lies in Australia's semi-arid zone. It is the driest region of Victoria, receiving an average rainfall of only about 400 mm in the south and less than 250 mm in the north. Its most common surface features are the dunes - which were last active about 16 000 years ago - and the ancient lake systems.

The Lake Hindmarsh--Outlet Creek--Pine Plains system is the major surface water system in the Mallee dune country. Most of the other lakes - such as Lake Tyrrell, Raak Plains, the Pink Lakes, and Rocket Lake - were formed primarily by saline groundwater discharge.

Fresh-water soaks - like this one in Wyperfeld National Park - were important for the survival of Aboriginal groups in the Mallee dune country.

Soaks, the only other sources of fresh water in the Mallee dune country, are found mainly to the west of Pine Plains in the sub-parabolic dune-field. When properly maintained they will retain fresh water for long periods, even during drought. In the past these soaks would have been important for the survival of Aboriginal groups, when Outlet Creek and its associated lakes dried.

Food sources

Vegetation in the Mallee varies depending on water availability and soils. In most places the dense mallee scrub, which gave the area its name, dominates. Many of the plant species that grow here would have been important to the Aborigines. Dr Beth Gott of Monash University has documented 137 'useful plants' from north-western Victoria. Although mostly food plants, many had other uses such as in artefact manufacture and for medicinal purposes and clothing.

As their roots store considerable quantities of fresh water, certain species of mallee were dug up and drained whenever camps were made away from places of plentiful water supply. Many other native plant species such as the quandong, native poplar, pittosporum, black box, red gum, and eumong also provided edible roots and/or seeds. Almost all (86%) of the useful plants listed by Gott are adapted to a non-saline environment.

The water corridors of the Mallee provided the major habitat zones for many of the Mallee fauna that comprised the primary food source for the Aborigines. The larger macropods are found mainly in areas containing grassy plains, such as alongside lakes and rivers or on dry lake-beds. These animals almost certainly formed a major component of the

Aboriginal meat diet, although emus and water-birds are likely to have played a significant role. From the quantities of shellfish remains on some sites, it is certain that aquatic fauna were also taken when the lakes contained water.

Reptiles too would have been important food sources for the Aborigines in the Mallee. Snakes and lizards are plentiful, both around the lakes and in the dune country.

When fresh water was more abundant it would be reasonable to expect that food resources would also have been more plentiful. For such periods the environmental determinist model would predict that Aboriginal settlement areas would have expanded to take advantage of the greater abundance, and contracted again as water and resources declined. As we shall see, however, the evidence does not support this.

Period of occupancy

Aborigines have lived in south-eastern Australia for at least the last 40 000 years. During this time the environment has altered dramatically. The Mallee and south-eastern Australia as a whole would have experienced moist conditions between about 50 000 BP and 25 000 BP, when lake levels were generally high and vegetation quite mesic. After this time the lakes began to dry and vegetation became more xeric. By 18 000 BP the Mallee (and the whole of south-eastern Australia) was very dry. Sand dunes were devegetated and actively blowing right across present-day arid and semi-arid Australia, and even into currently temperate areas. The Mallee would have been without trees or water. Any evidence of Aboriginal occupation during the preceding wet period would almost certainly have been obliterated by dune activity.

Climatic conditions improved after about 15 000 BP, and by about 10 000 BP lakes and other water-resource areas in the Mallee contained considerable quantities of fresh water. According to the environmental determinist model, this would be the major period of occupation of the Mallee. With a fall in lake levels at the return of drier conditions in the Mallee some 5000 to 4000 years ago, the number of occupied sites would be expected to decline.

Archaeological sites are distributed widely throughout the Mallee, including in the poorly watered areas away from the main rivers and lakes. Almost all the sites are found close to a water source (see Figure 2), so to an extent the theory that the presence of water influences hunter--gatherer site location is supported by the evidence from the Mallee. However, the theory must also be analysed through time. If Aboriginal site location were indeed determined by the presence and availability of water resources, then it would be expected that the sites would be distributed widely only during wet periods, such as occurred during the early part of the Holocene, some 10 000 to 6000 years ago.

The most common type of archaeological site in the Mallee is the surface camp-site. Others include quarries, fireplaces, scarred trees (from which bark has been removed for

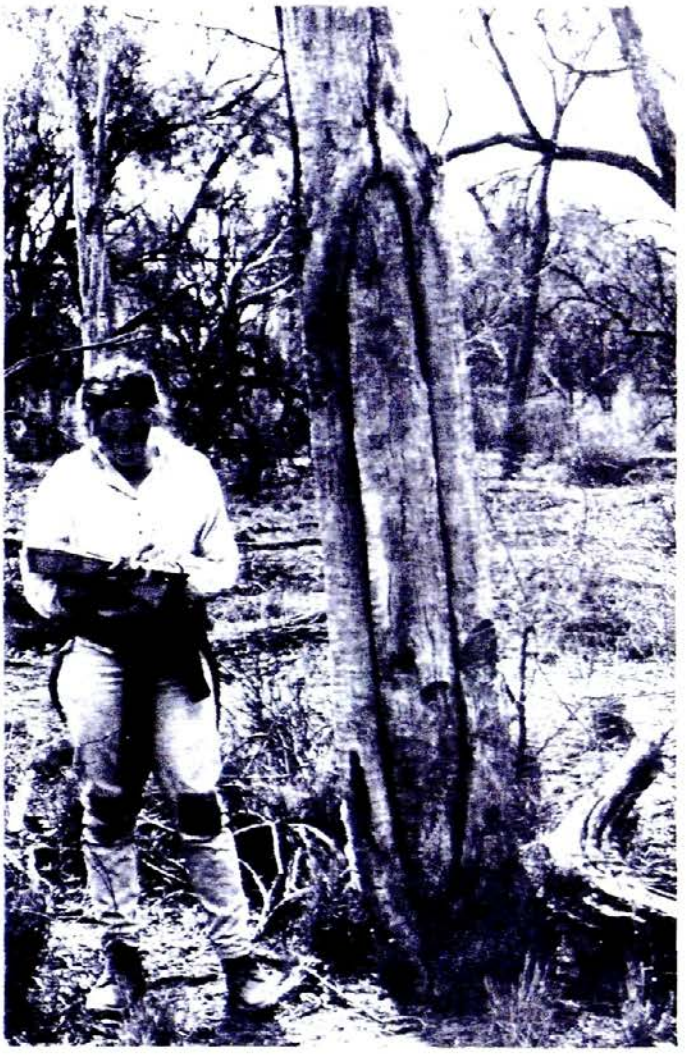
the manufacture of wooden implements), shell middens along the Murray River, cooking mounds, and burials.

Antiquity of sites

Sites can be dated in two ways. The first is by conventional physico-chemical means - radiocarbon dating and thermo-luminescence. The radiocarbon technique records the amount of radioactive carbon-14 atoms present in a sample of a once-living substance, such as shells from shellfish or tree charcoal, and carbon-14 levels have a well-established correlation with age. Thermo-luminescence measures the length of time that has elapsed since a substance containing quartz has been heated. Burnt clay or rocks from fireplaces can be dated in this way.

The second method is to study the stone tool typology. Australia has no good 'fossil indicators' among the stone tool assemblages accumulated over time. Nevertheless, the artefacts in one group, known as 'geometric microliths', are almost never found in deposits older than about 4500 BP, and they are usually less than 3500 years old. The presence of such very small tools and heavily retouched flakes is a general indicator of the age of a site.

Using both of these methods of dating, archaeologists have determined the ages of the occupation sites in the Mallee.



A scarred tree in the Hattah--Kulkyne National Park. The bark removed might have been used to provide a slab for a hut or for a canoe.

Along the Murray River and the country immediately adjoining the River, sites are found to date from the Pleistocene period (from about 20 000 BP) and through the Holocene period. Shell middens along the Murray River, for example, date to 16 120 (+/-200) BP, 13 340 (+/-170) BP, and 11 250 BP. Similar sites around Lake Victoria date to 14 950 (+/-200) BP and 14 650 (+/-230) BP. Dates such as these, which are from the period of extreme glacial aridity in Australia, indicate that areas like the Murray Valley were a major focus for human occupation during these difficult times.

Other sites in the Murray River area are of more recent age. The oven mounds are less than 4000 years old, with most dating to the last 2000 years. Other camp-sites in this area date to the Holocene period. It is therefore likely that occupation in the vicinity of the Murray River has been almost continuous from the late Pleistocene to the present.

The dating of the sites in the sand-hills is of great importance in discovering when the Mallee was occupied, but has proved more difficult than that in the Murray Valley. Most of the dating has had to rely on examination of the artefact assemblage at each site. On almost every camp-site the main tool types are typical of the geometric microlith tradition, both in the types of artefacts found and in the fact that the tools are very small and very heavily retouched, indicating an age of less than 4500 years. Conventional dating has been possible on some of these sites, and the dates generally support the interpretation of their more recent age.

Not all of them, however, are recent. Around the Raak Plains, for instance, many of the sites date to a time when these now-saline lakes contained fresh water and supported big populations of fresh-water mussel species. The artefact assemblages at these sites indicate the pre-microlithic tradition, and that conclusion is supported by conventional dating methods, as Figure 2 shows.

From this evidence it can be inferred that the widespread distribution of archaeological sites does not date only to the period of greatest water abundance in the Mallee - about 10 000 to 6000 years ago. In fact, it would seem that most of the Mallee, apart from areas close to the Murray River, was virtually unoccupied then. This not only means that the Aborigines were able to live in environments the Europeans had perceived as hostile, but would also indicate that there was probably some other trigger, not related to resources abundance or environmental change, that both caused and allowed people to come into the Mallee at a time when food resources were low.

Social relations in the Mallee

The discussion above indicates that Aborigines could occupy a marginal environmental area such as the Mallee even when it was more arid (and 'inhospitable') than when Europeans first arrived.

The use of the area around Raak Plains some 8000 to 6000 years ago seems to have been related to the fact that these

now-saline lakes contained fresh water at that time. Probably the Aborigines living along the Murray River moved into the area to make use of the abundant resources on the fringe of the dune country during the period of higher rainfall. But the use of the more southerly part of the Mallee cannot be explained in this way.

Environment did play a role in determining prehistoric settlement patterns, and people were not able to occupy arid Australia during the glacial period when water was completely absent. But the environment was not the only control, and Aborigines did not have to respond to every comparatively small change in resource abundance by retreating to large 'refuge' areas during a decline. On the contrary, at about 4000 BP, the onset of arid conditions seems to have been accompanied by an expansion into a marginal area. There must, then, have been other factors involved in explaining this behaviour.

The expansion into the Mallee at about 4000 BP does not seem to be the result of a simple shift in population out of one area and into another. Evidence from throughout south-eastern Australia indicates a similar pattern of increasing numbers of sites occupied during the last 4000 years (although this may only reflect the fact that the more recent sites would be more intact).

This widespread evidence indicates a population increase during a period of desiccation and resource decline. There is now growing archaeological evidence (not yet proved, however) to suggest the development at about 4000 BP of complex social relations among Aboriginal groups in south-eastern Australia, and it is probable that these social networks supported population growth and expansion.

One example of this development comes from an analysis of trade. Much of Aboriginal trade is visible in the archaeological record, as it involved the exchange of raw materials for stone tool manufacture. Stone from the quarry on Mount William in Victoria, for instance, was traded for hundreds of kilometres in a complex pattern of distribution that took into account important social interrelations.

The extensive trading networks in existence at the time of European contact involved the establishment of alliance networks between trading partners. Such trade relations were cemented by marriage and kinship ties, and it is likely that these complex social relations developed together with the trade networks. Edge-ground axes, for instance, are not found in the archaeological deposits of south-eastern Australia until after 5000 BP. It is possible that this complex trade network, and the associated development in complex social relations, arose at the same time as the postulated population increase - about 4000 years ago.

As well as trade and its associated alliance networks, tentative evidence comes from other developments in social complexity in Aboriginal society in south-eastern Australia at about this time. The construction of villages of stone huts at Lake Condah in south-western Victoria, for example,

dates to the recent archaeological past. According to the records of early European settlers these stone huts had several 'rooms' and 'thatched' roofs. Excavations of some of these huts and their associated mound features indicate that the villages could be as much as 2500 years old.

Along the Murray River, where the more conventional bark huts were constructed and the main economic activities were based around the water bodies, the first European explorers made numerous references to Aborigines living in 'settled villages'. There is as yet no archaeological evidence to indicate the antiquity of these villages, but studies of disease patterns in the population of the Murray River from about 1000 BP indicate that Aborigines at this time were suffering from diseases typical of those suffered by the inhabitants of sedentary agricultural settlements elsewhere in the world.

The relative abundance of food along the river would have allowed the Aborigines to avoid much of the usual pattern of movement, adopted by hunter--gatherers, of dispersing during times of food scarcity and congregating during times of plenty. The quite diverse living zones here comprised: rivers, particularly their margins with tall river red gums; the wetlands, including swamps, billabongs, streams, and anabranches; and the grassy plains interspersed with patches of scrub. These zones would have established over the last 10 000 years - since stabilization of the present river system.

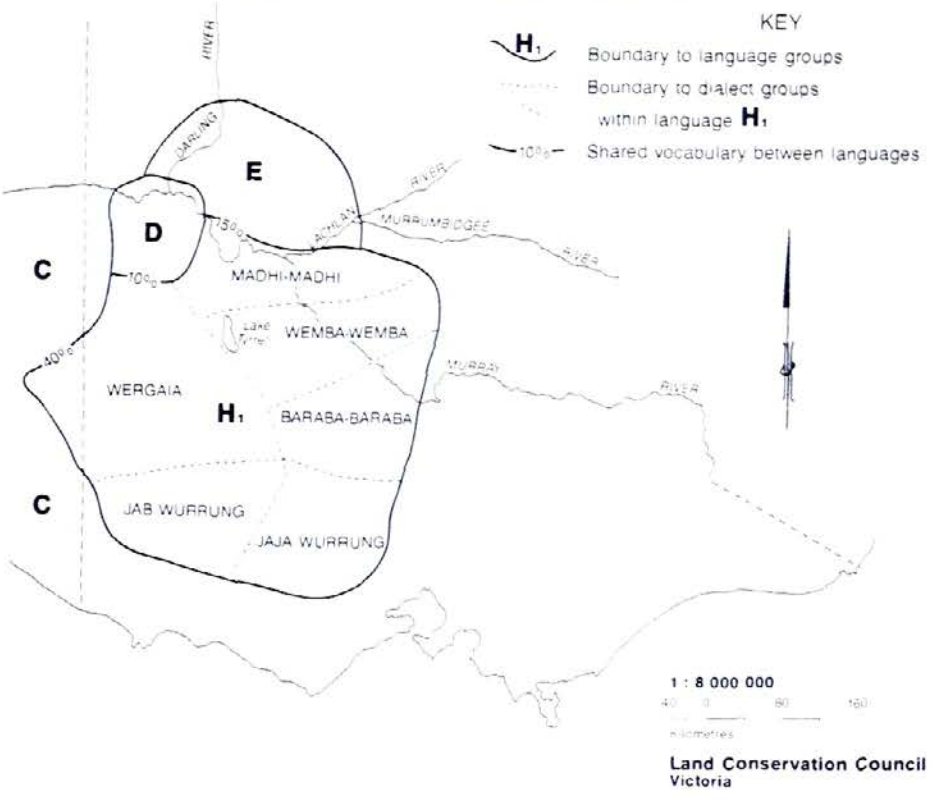
Some ethnographic evidence also suggests deliberate horticultural activities in many parts of Australia. Aboriginal use of fire to ensure the continuation of grasslands is a well-known phenomenon, and has been termed 'fire-stick farming'. Not so well known, however, are: the deliberate practices of plant regeneration by seed- and root-planting, which were widespread in both tropical and arid Australia at the time of earliest European colonization; the construction of water-channelling systems, such as those at Toolondo and Mount William in south-western Victoria; and the construction of dams and fish weirs such as those of Lake Condah and Brewarrina in New South Wales.

The complex social relations that were required to maintain these systems could also have supported increased numbers of people living in marginal areas such as the Mallee. Population increase requires a structured social system so that in time of stress people may rely on the hospitality of their neighbours for their survival.

The archaeological record in the Mallee would suggest that the Raak Plains and the areas bordering the Murray River were most probably occupied by an expansion of people from the Murray River in times of resource abundance. The more recent visits to Raak Plains were probably related to short-term forays from the river into the dune country in search of certain resources, such as lerp, much as was described by Beveridge. The social ties of the people from this part of the Mallee were therefore likely to have been with Murray River groups.

Figure 3

LANGUAGES OF THE MALLEE



On the other hand, the sites from the dune country are more closely related to areas further to the south. Exotic raw material for stone tool manufacture, such as quartz and flint, came from the southern coast and the Grampians. Such raw material is rarely found on the Raak Plains or along the Murray River. Ethnographic evidence and the myths of the formation and peopling of the Mallee also suggest that the movement of people into the area was down the Wimmera River and northwards into the dune country.

Languages of the Mallee

North-western Victoria contained three main language groups, which have been termed 'D', 'E', and 'H1'. Language H1 was made up of the following six 'dialects', which their speakers also recognized as different 'languages'.

Madhi-Madhi	Wergaia
Wemba-Wemba	Jab Wurrung
Baraba-Baraba	Jaja Wurrung

These, and the language groups, are shown in Figure 3.

The languages spoken in groups D and E had very little similarity to H1. Correlation between H1 and the language group to the west, group C, was also low. This suggests that the boundaries between H1 and D, E, and C were likely to be major tribal or social boundaries.

Within language group H1, all the dialects had closely related vocabularies, which indicates that a social network

operated within H1 at a broad level. However, the three dialects in the north-eastern part of H1 differed from those in the south-west. This difference was grammatical, and it clearly distinguished between speakers from the north and those from the south. That is, Madhi-Madhi, Wemba-Wemba, and Baraba-Baraba formed one group, while Wergaia, Jab Wurrung, and Jaja Wurrung formed another.

It would therefore appear that the pattern predicted by the archaeological evidence is supported by the linguistic evidence. In the Mallee, the Murray River people and their alliance partners on the Mallee fringe were divided from those in the southern Mallee and their alliance partners to the south. This evidence has important implications for understanding the Aboriginal tribal groups in the study area. Traditionally most people have used the tribal map prepared by Tindale (1974) to determine tribal group names, and these names were mentioned in the Council's previous report. However, an examination of Tindale's data shows that his boundaries conform to neither the archaeological nor the linguistic evidence from the Mallee. Tindale has drawn his boundaries in such a way that Pine Plains is a major tribal meeting point. There is no evidence for this supposition.

The names of the dialects within the large H1 language group are derived from information provided by Aborigines in the 1950s and 1960s, who still spoke these languages. Thus it is most probable that the Aborigines of the Wimmera--Mallee dune country were the Wergaia and their northern and eastern neighbours were the Madhi-Madhi (or Madhi-Dadhi), Wemba-Wemba, and Baraba-Baraba. These are the names by which the Aboriginal people of the area call themselves today.

Aboriginal society after the arrival of Europeans

Destruction of Aboriginal society commenced before European pastoralists arrived in the Mallee. Recent demographic research has suggested that Victoria's Aboriginal population was decimated by outbreaks of smallpox in 1789 and 1831--32. Professor N.G. Butlin has simulated the impact such epidemics would have had on Aboriginal populations, which had little immunity to European diseases. His radical conclusion is that by the 1830s European diseases might have reduced the Victorian Aboriginal population to about one-quarter of its pre-1788 size. Professor Butlin's calculations are still the subject of scholarly debate, but most experts now agree that Aboriginal populations were greatly reduced prior to the squatting era.

When squatters did venture into the Mallee, in the late 1840s, their use of the area for grazing of sheep and cattle was fundamentally opposed to the Aboriginal hunter--gatherer life style. Aboriginal society, already in disarray from the ravages of European disease, was simply dispossessed of its hunting grounds. It was not until the 1860s that any attempt was made to ameliorate the damage done by white settlement in the Mallee. In 1862, the second report of the Central Board appointed to watch over the interests of the Aborigines in the Colony of Victoria noted that Kulkyne was a station for the distribution of stores and clothing to

Aborigines. Honorary correspondents had also been appointed to watch over the interests of the Aborigines. By 1869 relief was distributed only to the old and infirm. Most of the Aborigines supported themselves by working as station musterers, shepherds, and general labourers.

In 1869, Mr J. Green recommended that an official Aboriginal station be established at Kulkyne; and 4 years later the Board for the Protection of the Aborigines asked the Surveyor-General whether a reserve for an Aboriginal station could be set aside there.

After a further year, in March 1874, a reserve of 2000 acres was gazetted as a site for an Aboriginal station. It was on a triangular block bounded by the Murray River and Chalka Creek at its southern junction with the River. The station seems to have fallen into disuse after the resignation of the local guardian, Mr John Miller, early in 1880. (The Kulkyne (or Gayfield) reserve was revoked on 9 February 1910 after an application for a grazing licence was received for the reserve. Today the site of this station forms part of the Hattah--Kulkyne National Park.)

Other mission stations in the area included the two Moravian Missions, at Ebenezer near Dimboola (1859--1904) and at Lake Boga (1851--57), the Anglican Mission at Yelta (1855--66), and the Lutheran Mission at Lake Hindmarsh. Resistance by the Aborigines to confinement to a permanent settlement, however, brought about the collapse of many of the missions after only a few years' operation and the reserves were taken up by selectors.

Following a review in 1886 of the *Aborigines Protection Act*, the concept of 'protection' was replaced with one of 'assimilation'. In essence, this meant that those whose blood had not been diluted by white contact were officially 'State' wards. Others were considered 'citizens'.

Under this new Act the managers of reserves in effect had the power to break up Aboriginal families there and send the children into unpaid domestic service or other employment, or to other reserves. Conditions within the reserves were highly restrictive and demoralizing. Although only two reserves persisted (one at Framlingham, the other at Lake Tyers), the legislation remained in force until 1957, when an inquiry found that the regulations and practices established under the Act were illegal and had flagrantly exceeded the powers provided by the Act.

The loss of tribal lands, enforced dispersion, and intermarriages have meant that the racial composition and tribal affiliations of the Aborigines in Victoria have undergone considerable change.

Census data and other estimates of population from before settlement to the 1960s show a progressive drop in the number of people of full Aboriginal descent in the State and an increase in the number of people of mixed descent, such that by 1962, of a total population of 2898 people of Aboriginal descent in the State, only 10 were classed as 'full-bloods'.

Bark canoes enhanced the food-gathering opportunities of Aborigines living beside the River Murray.

Today, about 650 Aboriginal people live in the Mallee area, principally in the Cities and Shires of Swan Hill (66%) and Mildura (27%). Since they now live mainly in towns, the people no longer have a direct economic relation with the land. They do, however, recognize certain areas as important parts of their cultural heritage, and they are actively trying to maintain their cultural identity and pass it on to their children.

Four Aboriginal community groups are active in and adjacent to the study area: the Sunraysia and District Aboriginal Corporation in Mildura; the Murray Valley Aboriginal Co-operative at Robinvale; the Swan Hill and District Aboriginal Co-operative; and the Goolum-Goolum Aboriginal Co-operative at Horsham.

The Robinvale Co-operative has had considerable involvement with the Victoria Archaeological Survey in relation to sites at Bumbang Island and areas along the Murray River and in the Hattah--Kulkyne National Park.

All of the archaeological sites are regarded as important by the Aboriginal people now living in the region. Members of the Goolum-Goolum Aboriginal Co-operative at Horsham regard the sites of the southern parts of the Mallee as a tangible part of their history, and they are concerned that the sites are properly managed.

Dunes along the watercourses of the Mallee area and lunettes beside the lakes were used as burial sites by the Aborigines. Many of these have been exposed by wind erosion and are now susceptible to human interference. Because of the presence of human remains, these sites pose problems for conventional methods of rabbit control and site reclamation.

Whether of Aboriginal origin, or from a period of more recent occupation, the artefacts and associations of people with the land enrich the cultural history of the community as a whole.

References

Beilby, J.W. (1849). Wanderings in the western wilds, being rough notes of a journey in search of a run. *The Port Phillip Gazette*, 29.11.1849--1.12.1849.

Beveridge, P. (1878). Notes to Brough Smyth. In Brough Smyth (1878), p.38.

Beveridge, P. (1889). 'The Aborigines of Victoria and Riverina.' (Hutchinson: Melbourne.)

Brough Smyth, R. (1878). 'The Aborigines of Victoria.' (John Ferres, Government Printer: London.)

Butlin, N.G. (1983). 'Our Original Aggression.' (Allan and Unwin: Sydney.)

Everard, G. (nd). 'Pioneering Days.' Reprinted 1977. (Hopetoun District Historical Society: Hopetoun.)

Eyre, E.J. (1838). Letter to the Editor. *South Australian Gazette and Colonial Register*, 14.7.1838, 3--4.

Kenyon, A.S. (1914). The story of the Mallee (part 1). *Victorian Historical Magazine*, 4, 23--56.

Mitchell, T.L. (1839). 'Three Expeditions into the Interior of Eastern Australia; with Descriptions of the Recently Explored Region of Australia Felix and the Present Colony of New South Wales.' 2 volumes. (Boone: London.)

Morton, W.L. (1861). 'Notes on a Tour in the Wimmera District, June and July, 1861.' Reprinted 1973. (Sunraysia Naturalists' Research Trust: Mildura.)

Neumayer, G. (1869). 'Results of the Magnetic Survey of the Colony of Victoria executed during the years 1858-1864.' (Schneider: Mannheim.)

Parker, E.S. (1841). 'Quarterly Journal from September 1st to November 31st (*sic*), 1841.' Series 11, Box 4, Public Record Office, Laverton, Victoria.

Parker, E.S. (1848). 'Annual Report 1848 (submitted to G.A. Robinson).' Series 11, Box 5, Public Record Office, Laverton, Victoria.

Sturt, C. (1833). 'Two Expeditions into the Interior of Southern Australia.' 2 volumes. (Smith, Elder: London.)

Tindale, N.B. (1974). 'Aboriginal Tribes of Australia: their Terrain, their Environment, Controls, Distribution, Limits and Proper Names with an Index on Tasmanian Tribes.' (Australian National University Press: Canberra.)

3. EXPLORATION AND SETTLEMENT

The following brief history of European exploration and settlement of the Victorian Mallee identifies only the major historical events that took place in the region. For a more complete account readers are directed to other publications, such as those cited at the end of this chapter.

Much of the information given here is derived from the survey report prepared in 1986 for the Council by Andrew C. Ward and Associates. This report includes an outline of the history of European occupation of the area, principally as it relates to the extant public land. (Further information has been provided by the Historic Places Section, Department of Conservation, Forests and Lands.) The consultant also ranked specific sites and artefacts according to their historical significance. Of the 166 sites recorded, 34 were considered significant at the State level and a further 22 of regional significance. Appendix II lists these according to the National Topographic Map Series 1:100 000 scale mapsheets, to which they are referenced in the report, and their significance. A copy of the report is available for inspection at the Council's offices or the Mildura Regional Office of the Department of Conservation, Forests and Lands.

Victoria's northern boundaries

When the *South Australia Colonization Act* was passed by the British parliament in 1834, the boundaries of the proposed colony were defined in terms of the coast and, presumably for want of any other landmarks, by latitude and longitude. The eastern boundary was set at 141°E. When the southern part of this line was surveyed, between 1846 and 1850, it was inadvertently set some two minutes of longitude too far west. The intended position of the meridian was established in 1868, in preparation for the marking of the border between South Australia and New South Wales, north of the Murray. The dispute that arose between South Australia and Victoria over the boundary south of the river continued until 1914, when the Privy Council ruled in favour of maintaining the *status quo*.

An Act of the British parliament in 1842 defined the 'Port Phillip District' of the colony of New South Wales as lying south of a line running 'in a westerly direction from Cape Howe to the source of the nearest tributary of the Murray' and thence downstream to the South Australian border. The Port Phillip District was separated from New South Wales in 1851 to become the colony of Victoria. In 1855 it was decreed that Victoria's northern boundary should run not in mid stream but on the left (south) bank of the Murray River. The mid-stream position is deemed to apply to the 10 km of river between 141°E and 140°58'E that forms part of the Victoria--South Australia border.

In October, 1982, the Australian High Court settled a dispute that first arose in 1873 concerning the location of the State boundary with respect to Beveridge Island - north of Swan Hill. In 1873, the colonial administrators undertook surveys and found that more water flowed through the northern channel around the island than the southern. As the northern channel was at that time the main stream of the river, the administrators agreed that it should be the river for the purposes of Victoria's boundary. In its recent decision, the High Court held that Beveridge Island would be in Victoria.

It also laid down guidelines for future decisions, in that the State boundary is fixed by the statutes of 1850 and 1855; the boundary is the southern bank of the River Murray, and only slow and imperceptible changes in the course of the river will alter the physical line. Sudden changes, whether caused naturally or artificially, do not alter the boundary; the State border will remain at the southern bank of the old river even if no water is flowing in it after the sudden change.

Discovery, Exploration, and Pastoral Settlement

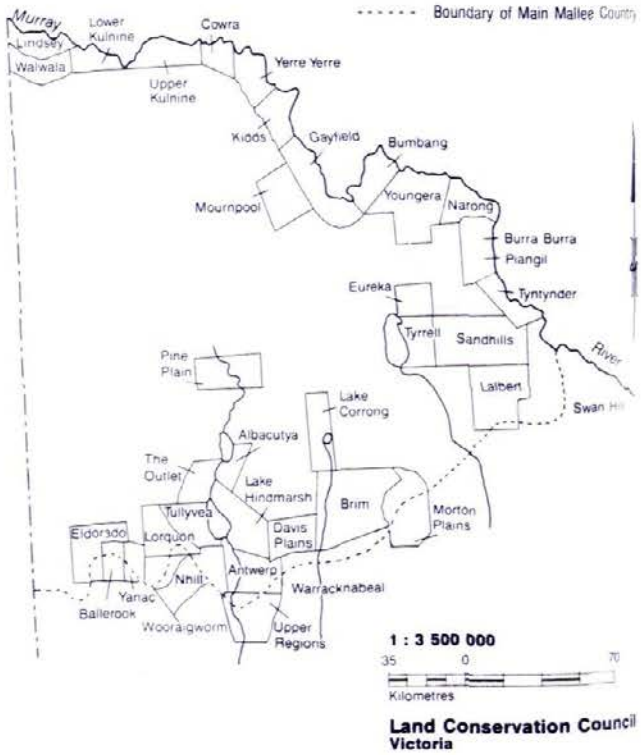
Captain William Charles Sturt (1830) and Major Thomas L. Mitchell (1836) were the first Europeans to discover, respectively, the northern and southern limits of the Mallee and in 1838 Edward John Eyre was thwarted in his attempt to traverse the region north from Lake Hindmarsh.

Expansion into the study area by squatters and their sheep was heralded by the occupation of Lake Boga in 1845 and Mildura in 1846. In 1847, the Reverend J.M. Clow occupied the Pine Plains area, and by 1848 squatters' grazing runs bordered the Murray River and the southern limits of the Big Desert (see Figure 4). Within another 17 years, squatters had occupied almost the whole of the Mallee area. Of the runs shown on the figure, most of Lindsey, Walwala, Upper Kulnine, Cowra, Gayfield, Mournpool, Bumbang, Pine Plain, and Lorquon remain on public land.

Between 1849 and 1851, assistant surveyor E.R. White surveyed the border between Victoria and South Australia (north of the 36th parallel) and the

Figure 4

SQUATTERS' GRAZING RUNS IN THE MALLEE, 1848



Source : A.S.Kenyon, 1912; 'The Story of the Mallee'.

route for the 142nd meridian road. He also surveyed a number of other routes and made several solo journeys across the Mallee. The 142nd meridian road linked the squatters' runs on the Murray River near what is now Merbein with those taken up along Outlet Creek. Sections of this route are still in use as roads and tracks.

Pastoralists initially had no legal rights to their pastoral runs and they simply squatted on Crown land. The British government gave official sanction to the illegal occupation of Crown land through Orders-in-Council in 1847. These provided for the granting of 14-year leases, with the provision that all existing occupiers were entitled to lease their holdings. No leases were immediately issued, however, and a further Order-in-Council, in 1850, decreed yearly leases.

In 1855, Victoria was granted self-government and control of Crown land passed to the new government. Yearly tenure continued until the Duffy *Land Act* of 1862 legislated for 9-year leases. These expired in 1870 and, under the *Land Act* 1869, squatters were able to purchase portions of their runs. In the Mallee some 11 955 acres, in blocks of 4 to 290 acres (1--117 ha), were bought at one pound per acre. By this means most of the stock-watering points in the Mallee were secured by pastoralists. The imprint of this legislation can still be seen on remaining public land. At 'Pine Plains', for instance, north of Wyperfeld National Park, the home paddock and key earth tanks are under freehold and some 31 000 ha of public land is held under grazing licence.

In many cases the squatters' grazing runs were speculative applications and little evidence of their occupation was found by Andrew C. Ward and Associates in the 1986 survey. The relics of 'Wonga Lake' within Wyperfeld National Park are an exception. The 'Gayfield' run near the Murray River was taken up in 1847. Portion subsequently became Kulkyne Station and a section remains as freehold. The homestead, built in about 1867, was razed by fire in 1982.

Under the legislation, pastoral occupation expanded dramatically. In 1853, 151 000 sheep grazed on some 2 million ha. This increased to 240 000 sheep on 2.8 M ha by 1861, and to 425 000 sheep on more than 3 M ha by 1871. Because of the uncertainty of tenure and the large size of runs, the spread of vermin went unchecked. Rabbits proliferated and ate the grasses and low shrubs and, combined with a run of dry seasons, almost denuded the land surface. Flocks were attacked by dingoes. Without secure tenure, pastoralists had little incentive to erect such improvements as vermin-proof fences to confront these problems. By 1883 the area occupied had dropped to 1.3 M ha and the number of sheep to only 122 000.

The *Mallee Pastoral Leases Act* 1883 was passed in response to squatters' demands for tenure. Under this Act the country on the southern fringes of the Mallee (the dotted line in Figure 4) was divided into allotments of up to 20 000 acres (8000 ha), and made available by auction under an annual rental for a 20-year lease. Compensation was to be paid for improvements to the land on expiration of the lease. In practice most allotments lay within the range of 200 to 500

hectares. Rents were fixed according to the actual numbers of stock carried.

In the interior of the Mallee, Crown land was divided into 'blocks', varying from 60 to more than 500 square miles in extent. These blocks were divided into 'A' and 'B' portions and leased by public auction. The successful bidder took either the A or B portion on a 20-year lease and the other on a 5-year lease. The block leased for 5 years had to be fenced and cleared of vermin. By 1889 the 5-year period had elapsed and some 2 million hectares of 'improved' Mallee land was returned to the government.

Agricultural settlement

The extent of the public land remaining in the Mallee today was largely shaped by the expansion of Victoria's wheat frontier from the Wimmera into the Mallee. Mallee country had been available for selection under *The Land Act* 1869, but the daunting task of clearing such a large expanse of dense scrub with hand tools had slowed down expansion of agricultural settlement during the 1870s and '80s. Settlement that did take place in these decades was on the fringes of the Mallee - around Birchip, Quambatook, and Swan Hill.

The aim of *The Land Act* 1869 was to replace the large pastoral areas with small cultivation blocks. The government initially granted settlers a 3-year licence to a maximum of 320 acres of land and in 1878 extended it to 6 years. During this period, selectors had to reside on the land, enclose it with fences, cultivate 10% of their blocks, and generally make improvements to the value of one pound per acre. They also had to pay an annual rent of one shilling per acre and after 3 (later 6) years a lease was granted. The selector could then purchase the land by paying a balance of 14 shillings per acre, or spread payments over 7 years. In 1878 this lease period was extended to 14 years.

When the first settlers moved into the fringes of the Mallee, 320 acres proved to be insufficient to produce viable holdings and the 320-acre limit was seldom adhered to. Selectors overcame it by selecting a number of blocks in family groups, and working these as one farm. Lands Department officials generally disregarded non-residence and adjoining blocks that were not fenced. It was subsequently recognized that 320 acres could not produce a living, and the *Mallee Lands Act* 1896 increased the maximum area of each selection to 640 acres. Although much of the land was subdivided into settlers' lots, several pastoral leases (including 'Glencoe', west of the Hattah--Kulkyne National Park) remain on public land in the Mallee.

Selectors of the fringe areas had to battle with the problems of drought, locusts, and rabbits. This last problem was to some degree mitigated after 1883, when settlement on the Mallee fringes and the clearing of land removed the main breeding ground of the rabbits. The *Mallee Pastoral Leases Act* 1883 also helped to reduce this problem and, in 1885, a rabbit-proof fence was erected. Once the rabbit problem had been controlled, a series of bad years intervened and kept

selectors' profits at a low level. Between 1896 and 1898, and in 1901--02 and 1904--05 rainfall fell below 300 mm.

Lack of capital also threatened many selectors. They needed considerable capital for clearing, fencing, erection of farm buildings, and the purchase of machinery such as strippers and winnowers. By the mid 1890s, a surplus of wheat on the world market reduced wheat prices to unprofitable levels. In addition, selection in districts such as Quambatook and Birchip preceded the construction of railways and selectors faced great difficulties placing their wheat on the market.

Settlers who ventured beyond the fringes of the Mallee faced the additional and daunting problem of mallee scrub. To merely fell and burn this hardy vegetation was insufficient, as the stumps produced new growth within a year or so. Each stump with its large root system needed to be grubbed. This was a slow, difficult, and expensive task. The technology to conquer the scrub was perfected in South Australia. The farmers rolled a tree trunk or steam-engine boiler across the standing scrub, snapping it off at the roots. After leaving it to dry for a few months, they burnt it.

The innovative Mallee roller (above) assisted in the development of the Mallee wheat fields, which was enhanced with the use of the stump jump plough (below).

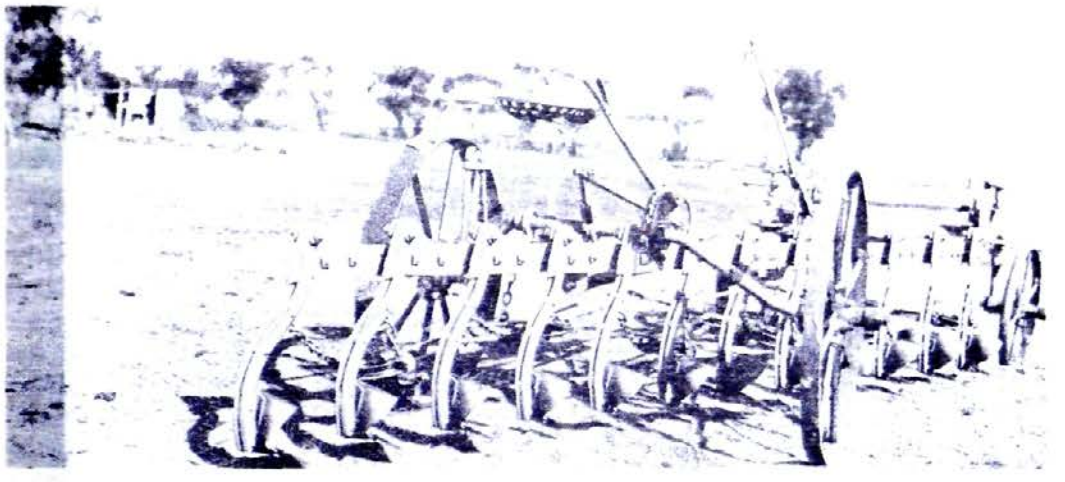
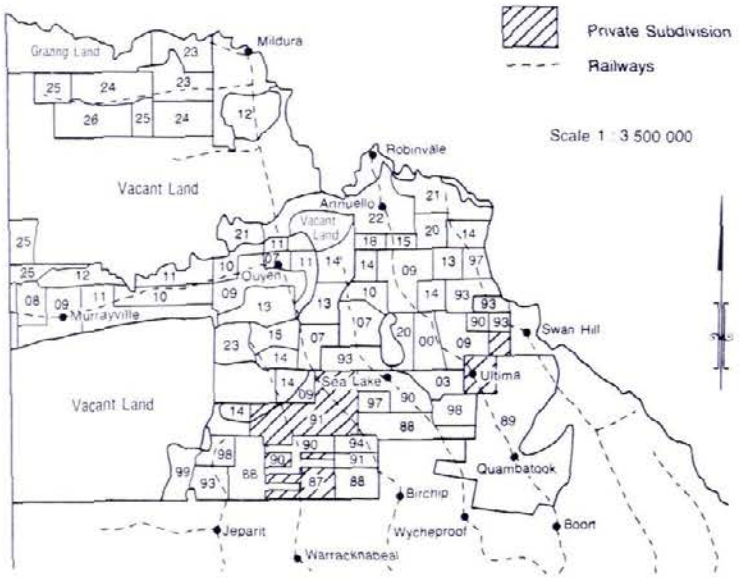


Figure 5

DATES OF OCCUPATION OF WHEAT AREAS



Source: A.J. Holt, 1947, "Wheat farms of Victoria".

Note: Numbers refer to the year of occupation, e.g. '88' being 1888; '25' being 1925.

This still left the roots in the ground, but these were tackled with the stump-jump plough, on which the shares were mounted on a hinged beam that tilted and rose out of the ground on meeting an obstruction before biting into the soil again once they had ridden over it. Stump-jumping harrows and wheat-strippers completed the conversion of the Mallee. The stripper was indispensable because it harvested the grain but left both wheat stalks and mallee shoots standing. After harvesting, these were burnt and, after 3 or 4 years of this treatment, the mallee roots finally died.

Victorian farmers had by now experimented with 'dry farming' and the apparent success of these methods gave settlers added confidence to settle in the dry Mallee. During the 1880s, they had slowly developed the technique of bare fallowing, in which the land was ploughed after the winter rains when it was soft and easily worked. It was ploughed again early the following autumn, and immediately sown. This process permitted earlier sowing than the previous methods, as farmers did not have to wait for suitable autumn rains to soften the soil. The fallow released soil nitrogen to stimulate plant growth and seemed to inhibit attacks of rust.

By the 1890s a further modification had been made. After deep ploughing in winter, some farmers worked the topsoil after each heavy fall of rain to form a moisture-conserving mulch. Those who used these techniques initially received better wheat yields than those who did not. Although the technique was eventually found to be unsound, it encouraged farmers by the turn of the century to believe they had a

firmer grip on their environment and that they could survive in areas, such as the Mallee, previously considered too dry.

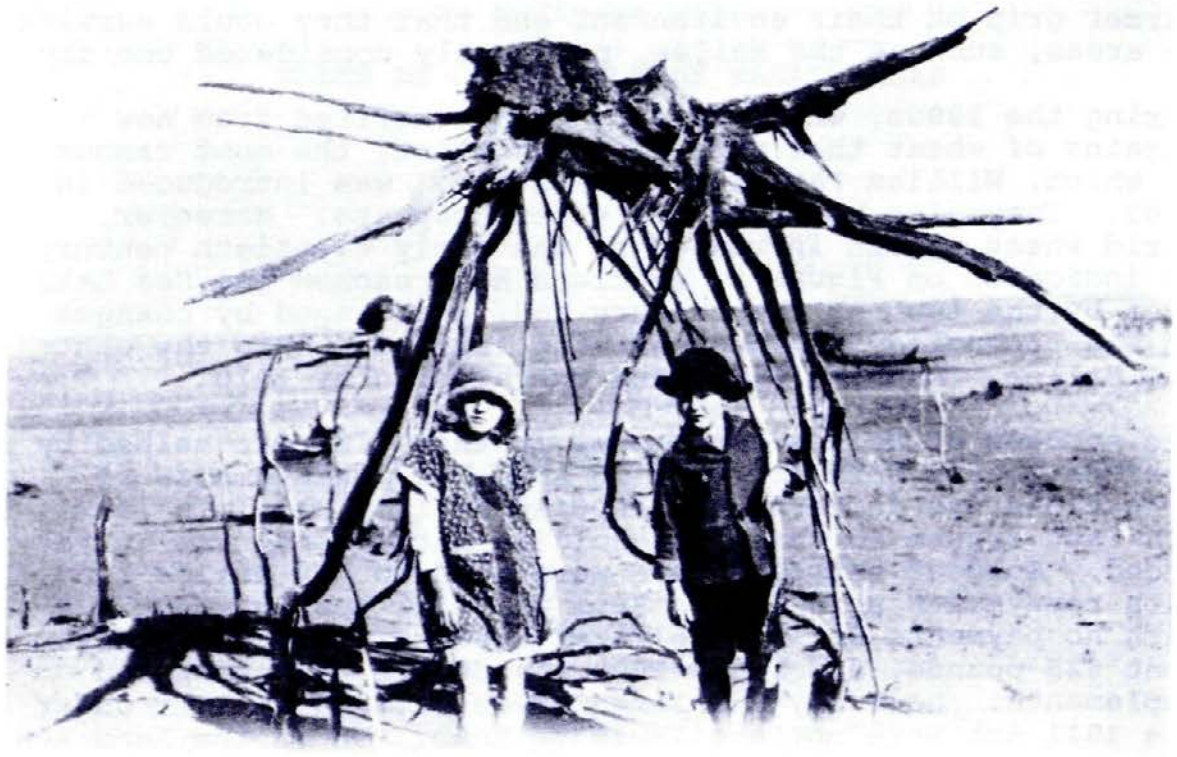
During the 1890s, wheat-farmers also benefited from new strains of wheat that were rust-resistant, the most famous of which, William Farrer's 'Federation,' was introduced in 1902. They also began to use superphosphate. Moreover, world wheat prices increased in the early twentieth century. As indicated on Figure 5, settlers had reached the Sea Lake area by the turn of the century and, encouraged by changes in the technology of wheat-growing, expanded into the central Mallee, reaching Ouyen and Murrayville by 1910.

The success of Mallee settlement at this time was helped by changes to the *Land Act*, and in 1911 the maximum size of selections was increased to 1600 acres (640 ha). In 1917 the last scheme in the area, Soldier Settlement, was introduced. Soldier settlers were permitted to buy Mallee land, with repayments spread over 36.5 years at low interest and with no payments during the first 3 years. They were also lent 625 pounds, and later 1000 pounds, to buy stock and implements. However, the large areas offered earlier under the 1911 Act were not available to them. Under the *Land Act* 1911 and the Soldier Settlement Scheme, settlement extended to parishes such as Meringur and Werrimull in the Millewa, and also into extremely marginal land - to the Parish of Berrook in the Sunset Country, and to Wennga and Conga Wonga west of Patchewollock in the Big Desert.

This last phase of Mallee settlement took place just prior to the series of disastrous drought years from 1913 to 1929 (see Figure 10 - back pocket) and a dramatic drop in the world price of wheat. By the Depression of the mid 1930s hundreds of Mallee farmers were in dire financial distress and their families were reduced to heartbreaking poverty. The situation was only saved by massive intervention by the State government. In the case of soldier settlers, loans from the government were written off and the more marginal ones had their leases revoked. These holdings either reverted to the Crown (in the Sunset Country and the Big Desert, for example) or were allocated to remaining settlers to provide them with larger, more viable holdings.

The greater proportion of the land designated for alienation by the Land Conservation Council in 1977 - such as in the Parishes of Nulkwyne, Wymlet, and Kia - had been occupied for settlement by the 1920s, as was the land at Berrook that is now used for cultivation under annual licence. Near Nowingi a failed settlement area was taken up under a long-term grazing licence.

The plight of Mallee settlers worsened in the 1930s due to massive dust storms. Ironically, these resulted from bare fallowing, which had given impetus to the original settlement. In the long term, bare fallowing destroyed the soil's organic matter, nitrogen was lost, and the soil broke down. The decline in fertility was masked for a time by the use of superphosphate, but once the soil's organic bindings were broken down, the wind blew away the smaller particles. Fur-



The plight of Mallee settlers was aggravated by loss of soil through severe wind erosion.

thermore, in their first years there, settlers harvested extensive areas of cypress pine for fencing material, particularly in the Millewa. It was not until the early 1930s that the Lands Department forbade the removal of cypress pine on Crown leaseholds.

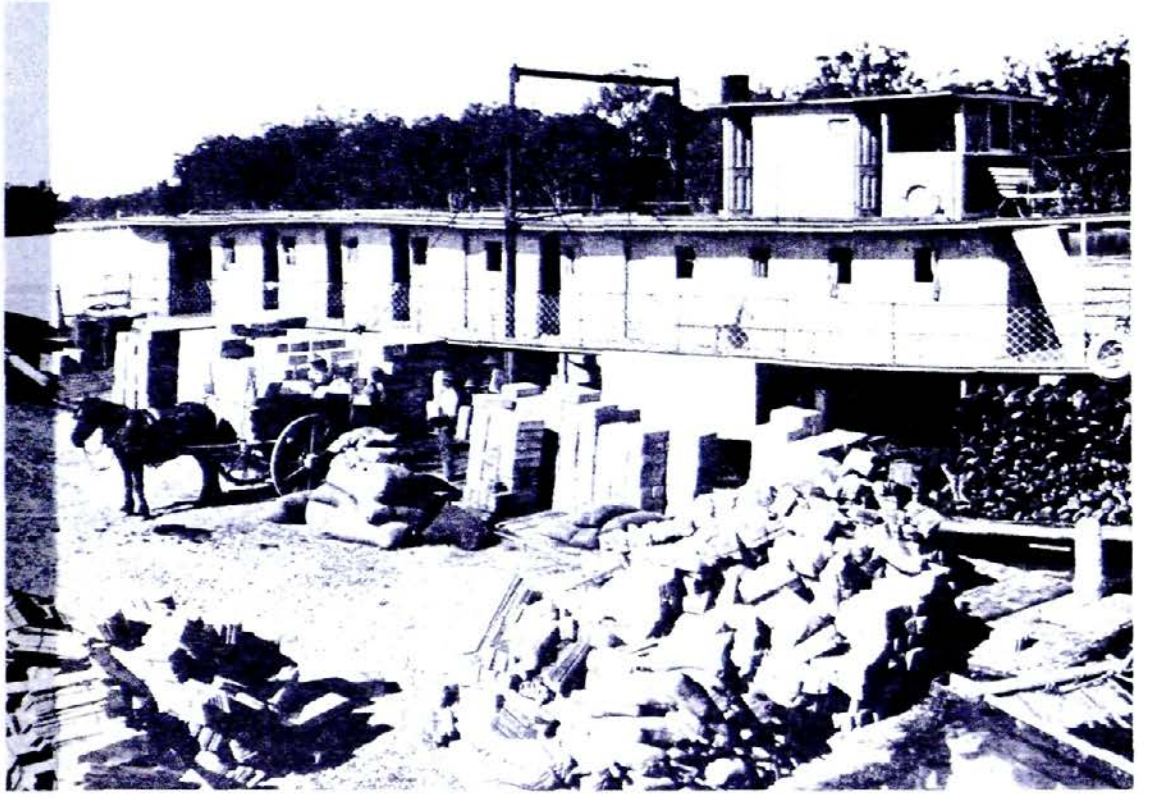
The final phase of Mallee settlement was thus blighted by environmental distress; but, largely due to enormous government assistance, settlement endured and by the late 1930s the Mallee had the largest area sown to wheat of any region of Victoria. By World War II, the limits of viable settlement in the Mallee had been reached, and thus the extent of public land was defined.

Soil conservation

The lessons of the 1930s dust storms were slow to be absorbed. Not until 1940 was a reluctant government convinced by Harold Hanslow, a Tongala irrigator and Commissioner of the State Rivers and Water Supply Commission, of the need to pass a *Soil Conservation Act*, which set up the Soil Conservation Board in 1940. The Board established a network of regional offices to advise farmers and publicize the results of erosion-control experiments at Walpeup and other Department of Agriculture research stations. In 1950, it was replaced by the Soil Conservation Authority, which was given greater powers and more resources.

Water

The problem of obtaining water for stock and domestic purposes dominated exploration and settlement of the area.



Loading dried fruit at Renmark. Riverboats played a significant role in developing the northern Mallee.

Squatters enlarged Aborigines' wells and natural soaks and catchments, built tanks from timber or iron, or excavated earth tanks, sometimes roofing them to reduce evaporation.

In 1899 a channel was constructed to drain storm water run-off from the plains around Birchip and take it to Sea Lake. This proved effective during the series of dry years and drought of 1895 to 1902, when water supplies elsewhere in the eastern Mallee failed. Water for settlers was taken by train to railway stations on the Ultima and Sea Lake lines during this period. Water trains remained a feature of Mallee life until the channel system of supply was fully established by the late 1920s.

The success of the Sea Lake channel led to the construction of other channels tapping storm-water run-off from the plains country, and large earthen tanks were excavated along their courses.

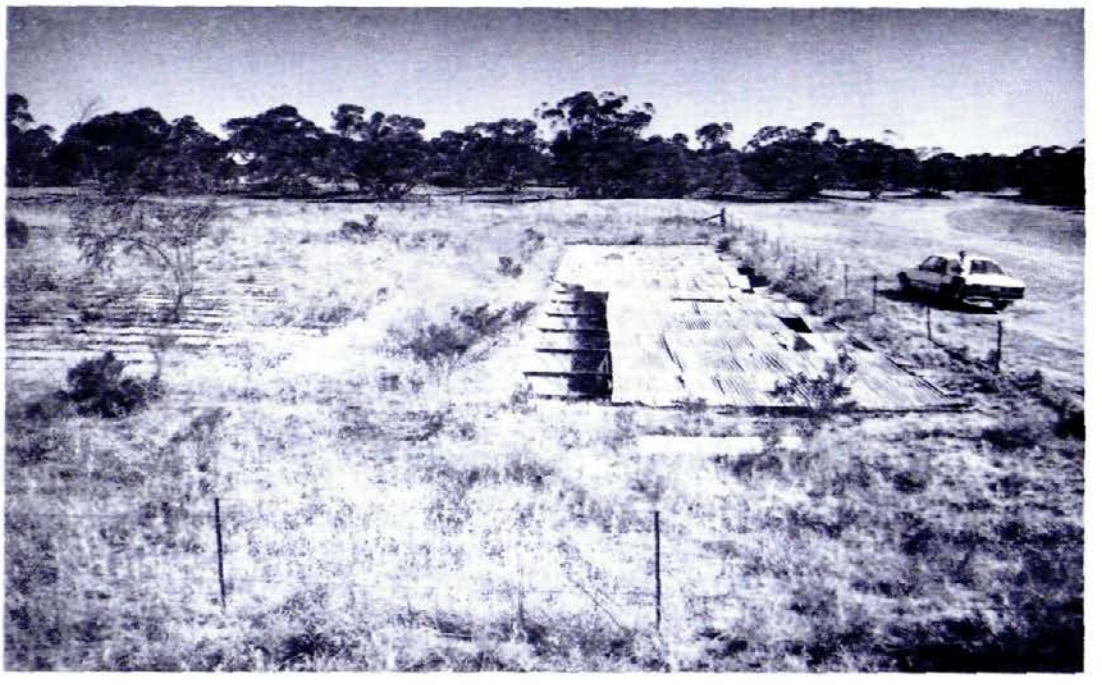
Rapid development of the Mildura irrigation settlement followed approval in 1887 of the Chaffey brothers' request to develop portion of the Mildura run (successor to the Yerre Yerre run shown on Figure 4). The settlement began producing fruit from the mid to late 1890s. Access to markets relied initially on river transport and, from 1903, on the railway.

At Hopetoun in 1891, E.H. Lascelles dammed Yarriambiack Creek to irrigate land around Lake Coorong by a system of pump-fed channels. He later attempted to establish orchards. By about 1915, however, salinity problems had brought this enterprise to a close.

Through the 1890s and until 1930 the government assessed the groundwater resources of the region by a program of boring. This defined the boundary of usable groundwater as between Underbool and the South Australian border. By 1915 this area contained 79 successful bores, supplying water to 2500 persons on farms and in townships. By 1930 the number had risen to 109. One, at Boinka, is artesian.

Although some of the bores have now been abandoned, most water for urban, domestic, and stock use west of Underbool is drawn from the groundwater resource.

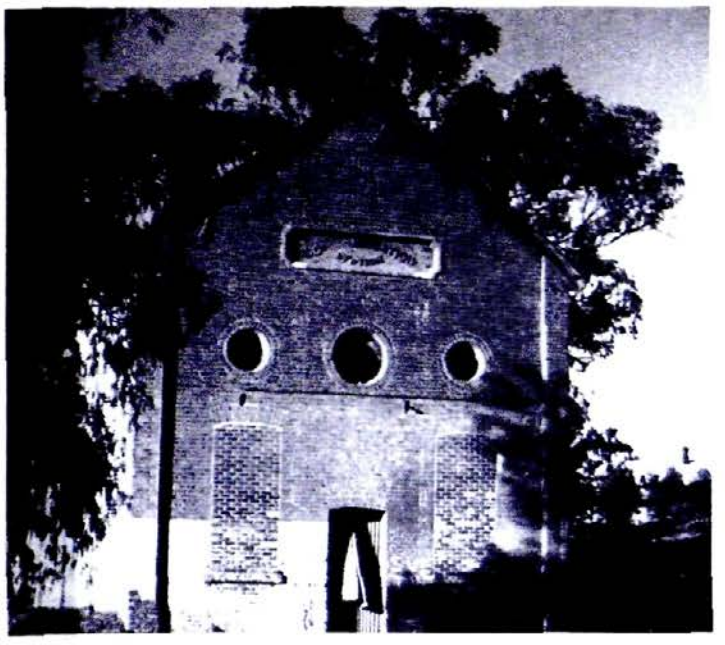
Catchment-fed earthen tanks were constructed where bore water was not available and for emergency reserves in case of drought. These, however, proved inadequate to meet the demands made on them as settlement extended and the need for stock water became urgent. Nevertheless, many of the tanks are still in use.



The Nowingi iron-clad catchment is one example of techniques used to obtain water in the Mallee for stock and domestic purposes.

From 1910 the then State Rivers and Water Supply Commission undertook the supply of water to the Mallee through bores, catchment tanks, artificial catchments, and channelled and piped supplies for domestic, stock, and irrigation purposes.

The Commission combined and extended local water supply systems and undertook major storage and channel works to form the Wimmera--Mallee Domestic and Stock Water Supply System. This collects water from the Grampians and delivers it to users as far away as Underbool, Robinvale, and Yungera. It is one of the most extensive gravitational water supply systems in the world. It was expanded from 1913 by the inclusion of pumps to push water to land above the gravitational level and in 1929 the supply was augmented by water from the Goulburn River through the Waranga Basin.



Kings Billabong pumping station, which played a significant role in pumping water for use in irrigating Mildura farms.

In the mid 1920s the Millewa settlement was supplied with water via open earthen channels, the water being pumped from the Murray River at Lock 9. Following an inquiry in 1966--67, this system was converted to pipelines, which were completed in 1975.

The provision of water to the Mallee has meant that livestock could be maintained permanently in the region and this has had a considerable impact on the agricultural enterprises here and on the use of public land - particularly through droughts. Fodder is now the major restriction to carrying stock under drought conditions.

Additional information about the water supply systems in the Mallee is provided in Chapter 6 - Water Resources and Utilization.

Closer Settlement

The ideal behind Victorian land settlement in the 1860s was the creation of a class of yeomen farmers. By the 1880s, this notion had been rejected by Victoria's more successful farmers in favour of land for extensive cultivation. The dream of smallholders died hard, however, and in 1898 and 1904 'closer settlement' legislation was introduced, under which large freehold estates were resumed by the Crown and subdivided into smallholdings. At the same time, however, private subdivisions abandoned the ideal of smallholdings.

From 1905 the State Rivers and Water Supply Commission was given the responsibility of subdividing irrigation blocks. In the Mallee, irrigation blocks were established at Swan Hill, Merbein, Red Cliffs, and Nyah and - after World War I - soldiers were settled on them. Again, the size needed to provide a living area was seriously underestimated and, as with dryland farms, severe distress and chronic indebtedness resulted. In 1938 debts were written off, block sizes were increased, and management of irrigated estates passed to the Lands Department.

Railways

Settlement around Birchip, Swan Hill, and Quambatook preceded the construction of railways. However, through special Acts of parliament in 1880 and 1884 authorizing the construction of new lines, the railway system was largely able to keep pace with later phases of settlement of the Mallee. Table 3 shows the years in which the early lines opened, and Figure 6 further indicates the rate of expansion of the railway system and its configuration.

Figure 6

MALLEE RAILWAYS

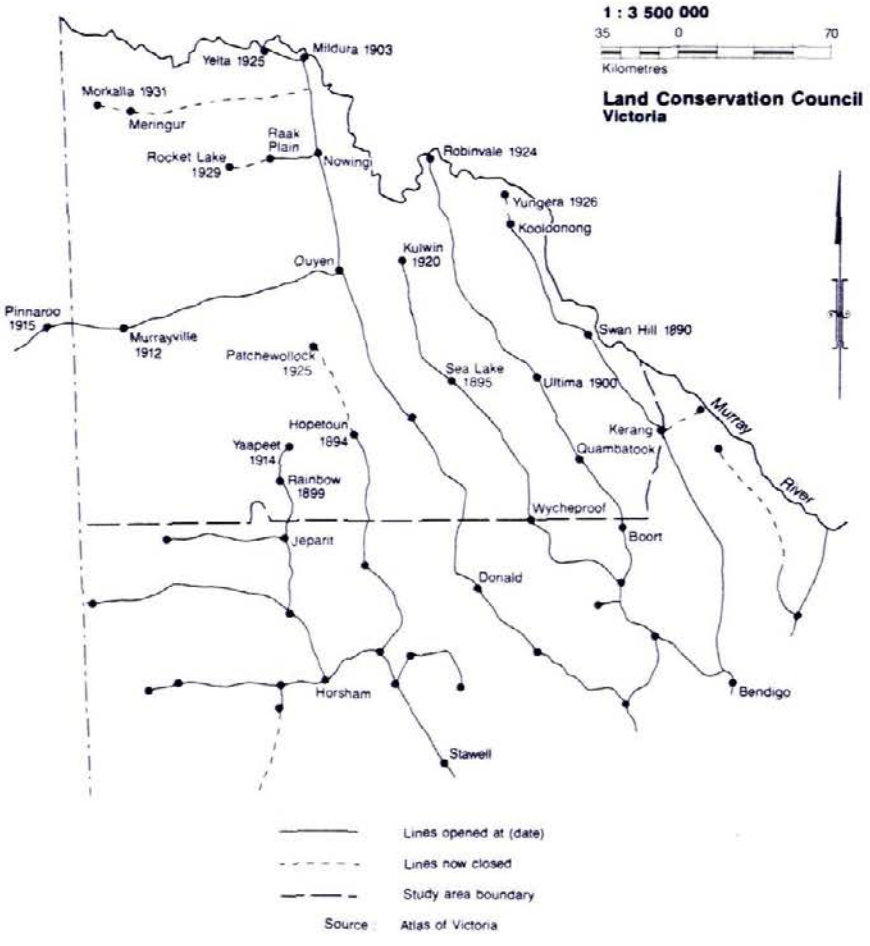


Table 3

RAIL SERVICES DURING EARLY SETTLEMENT

Temporary terminus	Year opened	Eventual terminus	
Swan Hill	1890	Yungera	(1926)
Hopetoun	1894	Patchewollock	(1925)
Sea Lake	1895	Kulwin	(1920)
Rainbow	1899	Yaapeet	(1914)
Ultima	1900	Robinvale	(1924)
Mildura	1903	-	-

The Murrayville line, opened in 1912, preceded settlement of Kow Plains, in the central Mallee, and linked with the South Australian rail system at Pinnaroo in 1915.

As the settlement of the Millewa progressed, the first section of the Millewa rail line was opened, from Red Cliffs to Werrimull, in 1924; it was extended to Morkalla in 1931.

The Millewa South line branched from the Mildura railway at Nowingi, and in 1929 extended some 39 km to Rocket Lake. A lack of water in the Sunset Country prevented continuation of this line, which was dismantled as far back as the Brunswick Plaster Mills' gypsum mine on the Raak Plains in the 1940s. The embankment and clearings for its sidings are still evident and the company running the existing gypsum mine uses the retained section occasionally, but most material is now taken out by road transport.

In their heyday, the railways were in common use for passenger travel and included special holiday services; they carried domestic water supplies (the last being to Torrita in February 1928) and wood for the boilers of the pumping stations. These services were gradually reduced over time, leaving mainly transport of bulk grain and superphosphate. After 1971 usage of many lines was further reduced to an 'as required' basis, and recently several lines were declared unviable and dismantling commenced. Many of the original railway station buildings are in good order and have been afforded State significance by the Council's consultant.

River transport

Riverboats made a significant contribution to development of the northern Mallee, being the main form of transport for produce and supplies in and out of the region between 1853 and the 1880s - that is, prior to the major expansion of the railway system. Several hundred river steamers were in operation on the Murray River in the 1870s, principally trading between Goolwa (near the mouth of the river) and Echuca (then the head of the railway line to Melbourne). A few boats continued to work until the 1950s, carrying timber, and now some have been refurbished for tourism.

Seasonality of river levels and consequent travel restrictions, together with the extension of the railway to Swan Hill in 1890, contributed to the decline of river transport.

Locks were constructed across the river to ensure sufficient depth of water for such transport. This work was undertaken following an interstate River Murray agreement in 1914, but by the time they were completed the era of the riverboat had passed. In all, six locks were constructed adjacent to the study area, one is operated by Victoria, through the Rural Water Commission, two by New South Wales, and three by South Australia.

Several *in situ* wrecks of riverboats were identified in the report to the Council. One, that of the 'Hero' at Boundary Bend, was considered to be among the most intact wrecks along the river and of State importance. At the time of the

report, work was in progress to remove it, probably to South Australia.

Forests and National Parks

For most of the nineteenth century, Victoria's forests were managed by the Lands Department. Although provision for the establishment of State forests and timber reserves was available from the 1870s, such reserves afforded little protection. As the Royal Commission on Forests reported in 1901, massive timber-cutting occurred under a 'vicious system of indiscriminate licensing' at ridiculously low prices. It was not until 1892 that a royalty system was adopted. A Conservator of Forests had been appointed in 1888, but his superiors treated him little better than a 'subordinate clerk of the Lands Department useful to give information and advice on forest matters of detail', and his efforts at forest conservation were constantly thwarted. Only in 1908 was a separate forest department created, and in 1918 the Forests Commission was established.

Without major timber resources, the Mallee suffered less from this neglect than did the more timbered regions of Victoria. Nevertheless during the nineteenth century considerable damage was done to river red gum forests along the Murray. In the 1880s the best red gum land was held under grazing leases from the Lands Department, and all the better forested areas inland were ringbarked to improve their grazing capacity. Only the frontages to the Murray River and other streams escaped, and even these were cut over for mill logs. In the late nineteenth and early twentieth centuries, the best remaining timber was cut for railway sleepers.

When irrigation works were established on the Murray River, the need to feed the boilers of the water pumps placed further pressure on the red gum resources as well as the extensive woodlands of black box. Timber from around Hattah--Kulkyne was cut to feed Mildura boilers. Extensive areas of black box woodland were felled on the upper river terraces in the vicinity of Cullulleraine to feed the boiler of the Millewa irrigation system; little evidence of these woodlands remains. With agricultural settlement, callitris pine was cut extensively for fences and farm out-buildings.

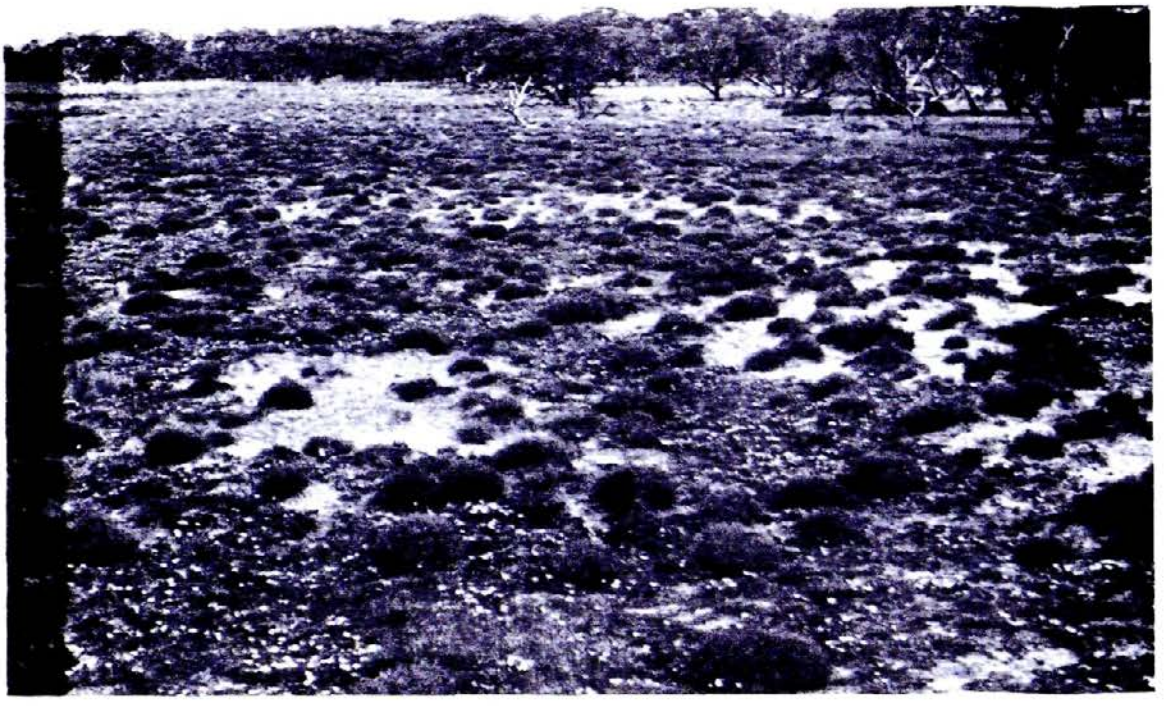
From the 1920s, the Commission stationed foresters in the Mallee at Ouyen, Swan Hill, Nyah, and Mildura, and attempted to re-forest callitris pine areas, although these efforts were largely unsuccessful due to the pressure of grazing by rabbits and stock and uncertainty as to the ecology of the plant - problems that still prevail. From the 1930s, harvesting of callitris pine from Crown land was restricted mainly to the removal of dead timber. At the same time foresters experimented with planting non-endemic species. At the Timberoo forest in the early 1930s, for instance, red ironbark, yellow gum, silky oak, and southern mahogany were among the species planted.

By 1932 the District Forester at Swan Hill noted that all the red gum in the Parishes of Annuello, Bumbang, Tol Tol, and Nerandrie had been cut out.

Parks

As early as 1909, an area of 3840 ha was temporarily reserved as a site for the Wyperfeld National Park. This was mainly due to the efforts of Arthur Mattingly, who visited the area in September 1907 and vigorously promoted its value as a park. In 1921 the reservation was made permanent, and by 1957 the park was enlarged to 55 904 ha.

In the Hattah--Kulkyne area wildlife had little protection well into the 1930s. In 1932 the District Forester commented on the abundance of wildlife in the Hattah Lakes, but complained that 'some sportsmen do not hesitate to take advantage and blaze away with shot guns into flocks of wild ducks on these lakes'. Foresters were not alone in their concern for wildlife, and in the late 1930s the Field Naturalists' Club of Victoria and the Royal Ornithological Union lobbied for wildlife protection here. In 1941, 16 800 ha in the Hattah area was declared a sanctuary for game. In the late 1950s, conservation groups - the Victoria National Parks Association and the Sunraysia Field Naturalists' Club - campaigned for a national park here, and in 1960 the Hattah Lakes Park of 17 800 acres (7200 ha) was declared.



Parks contain representative examples of native vegetation communities - shrubland of sea-heath, Pink Lakes State Park.

The Land Conservation Council investigated the Mallee area in 1972 and published its final recommendations on the use of public land here in 1977. Map 8 indicates the present pattern of public land use, which is described in the balance of this report.

References

Dingle, T. (1984). 'The Victorians: Settling.' (Fairfax, Syme and Weldon: Melbourne.)

Duncan, J.S. (ed.) (1982). 'Atlas of Victoria.' (Victorian Government Printer: Melbourne.)

Forests Commission, Victoria (n.d.). Correspondence to Annual Reports. *Victorian Public Records Office Series* 10058.

Holt, A.J. (1947). 'The Wheat Farms of Victoria. A Sociological Study.' (School of Agriculture, University of Melbourne.)

Kenyon, A.S. (1912, reprinted 1982). 'The Story of the Mallee.' (Wood Publications: Rainbow.)

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

Senyard, June (1970). 'Birchip: Essays on a Shire.' (Shire of Birchip.)

Torpey, D. (compiler) (1986). 'The Way It Was; A History of the Mallee 1910--1949.' (Sunnyland Press: Red Cliffs.)

News report, *The Age*, 23 October 1982.

Part II

PHYSICAL AND BIOLOGICAL RESOURCES

4. LANDSCAPE EVOLUTION AND SOILS

In the previous descriptive resources report, the geology and physiography of the region were described in separate chapters. The following account attempts to integrate these and indicate how contemporary landforms express geological processes.

This brief description of landscape evolution in the area is more readily understood by reference to Table 4 (Geological Time Scale), Figure 8 (Tertiary Stratigraphy), Map 3 (Generalized Geology), and the geological map sheets for the area (available from the Department of Industry, Technology and Resources).

Table 4

GEOLOGICAL TIME SCALE

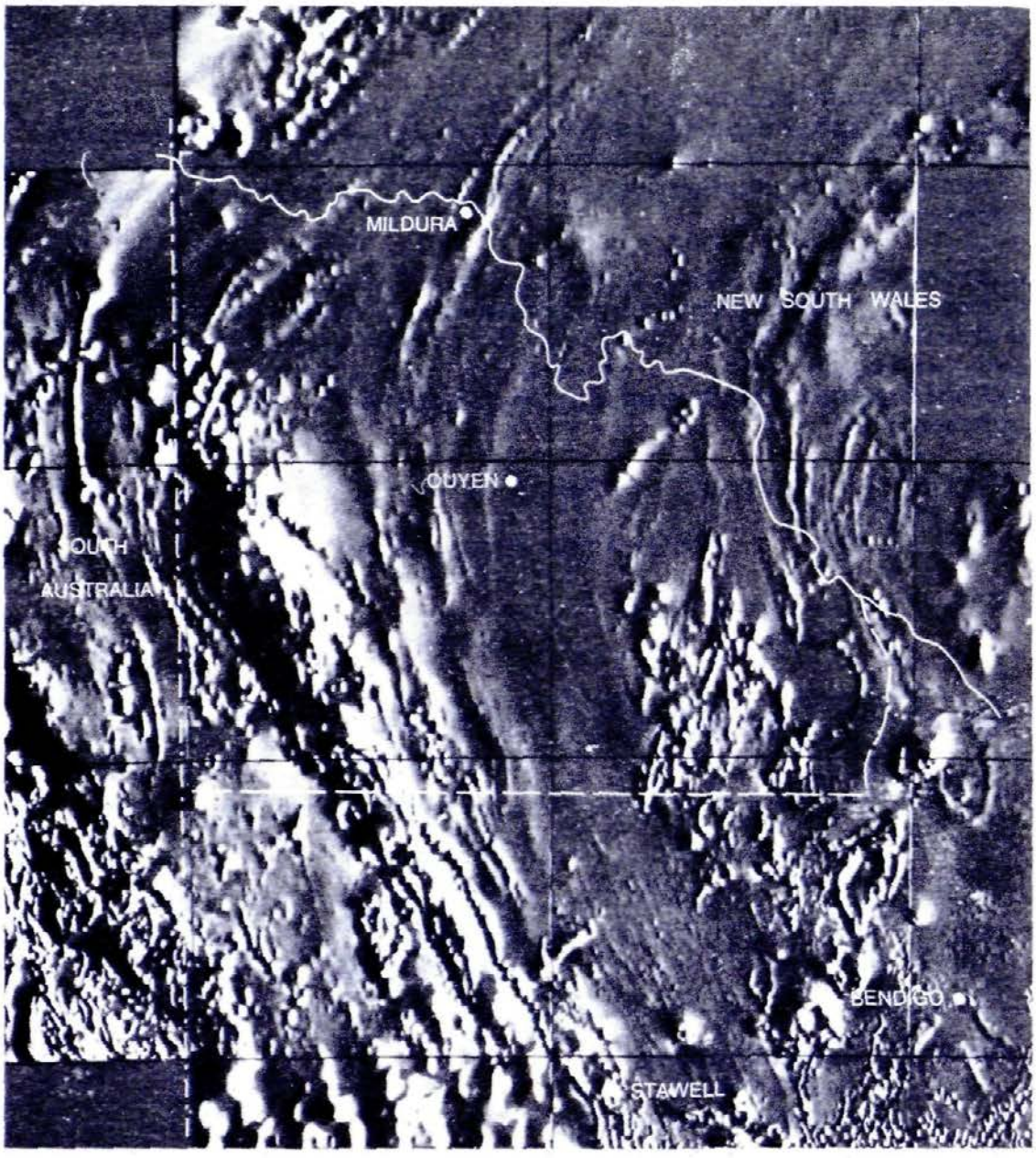
Era	Period	Epoch	Age (million years)
Cainozoic	Quaternary	Holocene	0.01
		Pleistocene	1.8
	Tertiary	Pliocene	5
		Miocene	24
		Oligocene	37
		Eocene	54
		Palaeocene	65
Mesozoic	Cretaceous		143
	Jurassic		212
	Triassic		247
Palaeozoic	Permian		289
	Carboniferous		367
	Devonian		416
	Silurian		446
	Ordovician		509
	Cambrian		575
Precambrian	Not outcropping in Victoria		

GEOLOGY

The study area covers much of the south-eastern Murray Basin - an extensive but relatively shallow basin containing a Cainozoic sedimentary sequence comprising (in order of depo-

Figure 7

IMAGE OF MAGNETIC VARIABILITY



Reproduced with the permission of the Director of the Bureau of Mineral Resources, Geology and Geophysics.

sition) fresh-water, marine and aeolian, and evaporite sediments, resting on an early Tertiary erosion surface that was cut into Palaeozoic and Mesozoic rocks. Two major breaks resulting from relatively brief periods of non-deposition and erosion interrupt the sequence. The total thickness of the Cainozoic sediments increases from about 200 m in the south-east to about 600 m in the north-west of the area.

Palaeozoic to Cainozoic

Only one small surface exposure of basement (pre-Tertiary) rocks occurs in the area. This is an outcrop of Devonian granite near Lake Boga. As a result, nearly all the infor-

mation on the basement beneath the area comes from drill holes. These have intersected Cambrian greenstones, Lower Permian glacial sediments, and Cretaceous fresh-water sediments. Additional information can be inferred from the Palaeozoic rocks outcropping along the basin margin in the highlands to the south and from geophysical techniques, particularly aeromagnetic surveys.

The structural trends of the basement rocks beneath the Murray Basin, for instance, are indicated in Figure 7, which is an image compiled by the Commonwealth Bureau of Mineral Resources from several aeromagnetic surveys. The image is a computer-generated composite of a number of surveys of magnetic gradients. These gradients, or rate of change of magnetic intensity, have been plotted to highlight the magnetic features by illuminating them from the east. The white areas indicate their eastern or 'illuminated' edges; the dark grey or black areas show their western or 'shadowed' edges; and lighter grey ones indicate the locations of relatively non-magnetic rocks. The magnetic responses of rocks are mainly due to the presence of small amounts of magnetic material in them, which indicates the rock type.

The narrow, curved features in the centre of the image reflect the regional bedding trends of the basement sedimentary rocks. The broad feature aligned north-west from the vicinity of Stawell traces the continuation of the Stavely greenstone belt in which the new open-cut gold mine at Stawell is located. The small, stipple-like features in the south appear to be volcanic plugs.

Additional information has also been derived from gravity surveys; nevertheless, detailed knowledge of the basement rocks beneath the basin remains very poor.

Prior to the development of the Murray Basin, a north-flowing drainage system, similar to today's, had been incised into the early erosion surface and well-defined valleys extended up into the highlands - particularly in the east of the area. The surface itself was gently inclined to the north-west. Two north--south faults - the Hindmarsh Fault, with a total downthrow to the west of as much as 100 m, and the Leaghur Fault, with a total downthrow to the east of up to 50 m - together with the north-east trending Danyo Fault and the north-west trending Murrayville Fault cause substantial local modification to the generally smooth shape of the basement. These structures were active throughout the Cainozoic, and the consequent displacements of the basement are the total of the movements over that time.

Cainozoic

Tertiary Period [Palaeocene to Pliocene]

Development of the Murray Basin began in the early Tertiary (Palaeocene) with the deposition of fresh-water sediments, the Renmark Group, to the west of the study area (Figure 8). This depositional environment transgressed to the east and south, and by the Eocene had reached the ultimate margin of the basin. The Renmark Group comprises a lower sandy unit,

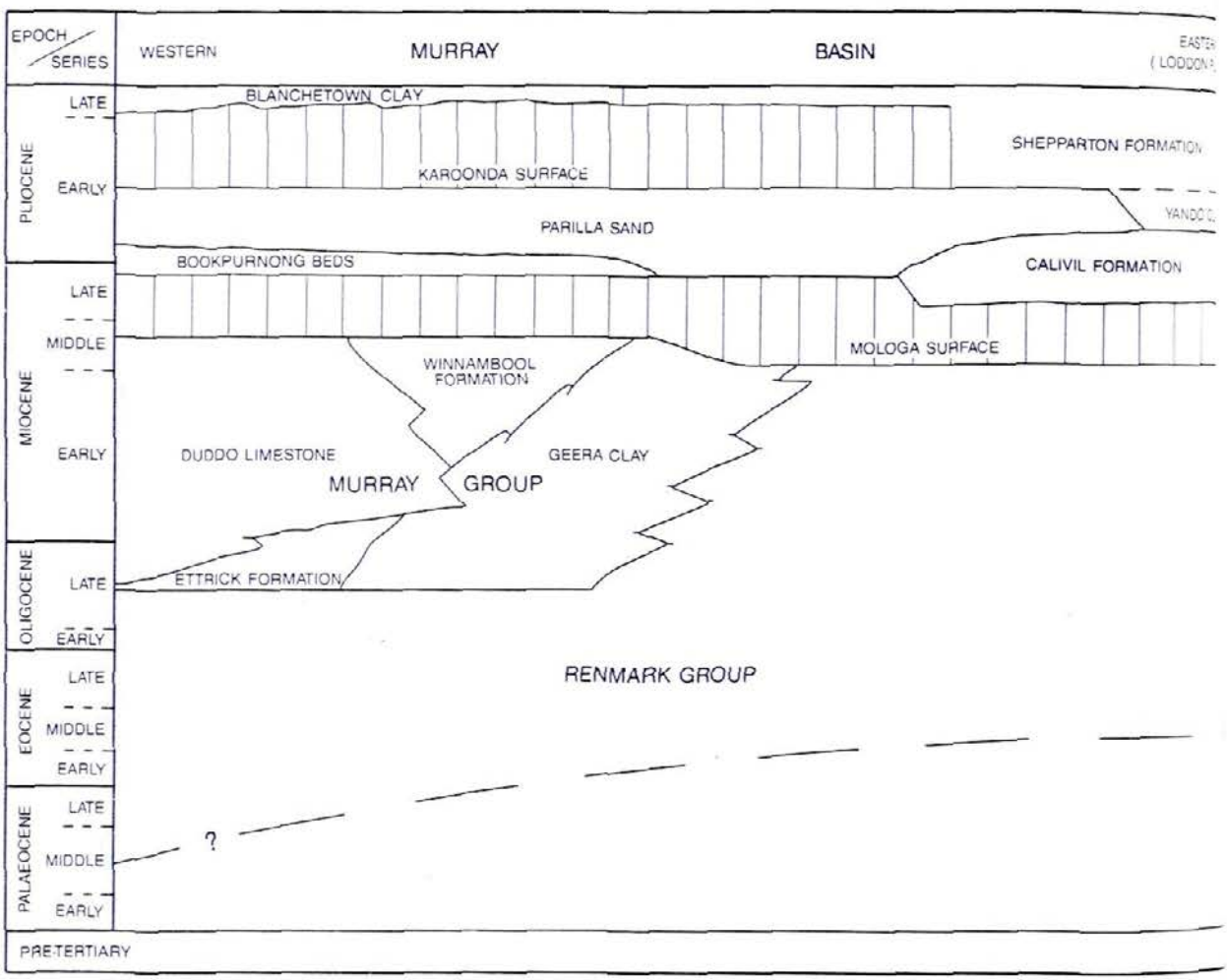
the Warina Sand, and a more widely distributed upper, predominantly finer-grained, coal-bearing unit, the Olney Formation. Its maximum thickness of about 300 m occurs near Mildura.

Between the late Oligocene and middle Miocene, the sea transgressed from the west and a marine sequence, the Murray Group, was conformably deposited over the Renmark Group. The fresh-water conditions of the Renmark Group, however, persisted in the east until the middle Miocene, particularly in the Yando Trough, a slowly subsiding north--south trending trough that lies to the east of the Leaghur Fault. The basal unit of the Murray Group is the Ettrick Formation (formerly called the Ettrick Marl) - a grey, fossiliferous marl with occasional thin beds of marly limestone and calcareous clay. This grades eastwards into the Geera Clay, a shallow marine or lagoonal deposit comprising sparingly fossiliferous dark grey to black clay.

Movement along the Hindmarsh Fault during this time had a dominant influence on sedimentation as the sea deepened on the western or downthrown side of the Fault, and a sequence

Figure 8

TERTIARY STRATIGRAPHY



Modified from Macumber, 1983

of shallow, marine bryozoal limestone and marly limestone, the Duddo Limestone, was deposited there. The increased marine influence was accompanied by an eastwards shift of the Geera Clay deposits. At the same time, a sequence of glauconitic marl and marly clay including shellfish, the Winnambool Formation, was deposited in the near-shore environment between the Duddo Limestone and the Geera Clay. The Duddo Limestone - which attains a maximum thickness of about 130 m in the north-west - today is an important aquifer and, together with other formations in South Australia, forms part of the Murray Group aquifer system.

The sea retreated and no sedimentation occurred throughout the middle and late Miocene. The resulting planar surface, the Mologa Surface, then extended across the ancestral Loddon plain. As the base level dropped with the retreating sea, a north-flowing drainage system was again established in the east of the area. Valleys, including those of the ancestral Loddon and Avoca Rivers, were then incised into the Mologa Surface and the highlands to the south.

In the late Miocene, marine transgression recurred, the base level rose, and the drainage system was gradually backfilled with fluviatile deposits - the Calivil Formation. In the upper reaches of the old drainage system, this formation today occurs as valley deposits (deep leads) comprising coarse sand and gravel up to 60 m thick covered by more recent sediments. Downstream, it usually occurs as alluvial fan deposits comprising sand sheets and may be up to 20 m in thickness. The present Loddon Valley, however, shows its deep-lead origin and character through much of its length. Deposition of a marine sequence associated with the late Miocene transgression, the Bookpurnong Beds, began in the west a little later than did the fluviatile sedimentation of the Calivil Formation in the east. The sequence is commonly glauconitic and comprises fossiliferous clay, clayey marl, calcareous silt, and clayey sand. It is up to about 70 m thick near Mildura.

During the early Pliocene, the marine transgression reached its maximum and fresh-water deposition was confined to the eastern edge of the study area. A 'blanket' of fine- to coarse-grained, sparingly fossiliferous, shallow, and (in places) paralic marine sand averaging 60 m thick, the Parilla Sand, was laid down over much of the area. It conformably overlies the Bookpurnong Beds in the west and both grades laterally into and overlies the upper parts of the Calivil Formation in the east. At its inland limits it has been subdivided into three members: the Kerang Sand at the base, the overlying Tragowel member (white clay), and the Wandella Sandstone at the top.

The sea retreated towards the end of the early Pliocene, leaving long, prominent, north--south trending ridges on the upper surface of the unit. These are regarded as being strand-line dunes marking successive shorelines of the receding sea. A period of non-deposition then followed in the western and central parts of the area, during which the Parilla Sand was subjected to lateritic weathering. As a result, its uppermost surface, the Karoonda Surface, was

silicified and ferruginized and thereby rendered resistant to subsequent erosion. This type of weathering suggests that a monsoonal climate prevailed at that time.

In the east, however, fresh-water sedimentation was uninterrupted throughout the Pliocene, with the Calivil Formation being conformably overlain by the fluviatile and lacustrine sediments of the Shepparton Formation. The lower portion of the latter is a mottled red and grey clay, the Yando Clay, which is a non-marine coastal-plain equivalent of the upper part of the Parilla Sand. The upper part of the formation is a yellow-brown clay that is, in part, a lateral equivalent of the Blanchetown Clay.

Quaternary Period - Pleistocene

About 2 million years ago, a major world-wide climatic change began to develop, initiating the Pleistocene Epoch - which comprises a series of glacial and interglacial stages. Extensive ice sheets developed in the higher latitudes while many mountainous areas throughout the world, including the Kosciusko Plateau of Australia, were glaciated. The change, however, was not abrupt in a global sense, and not until the mid Pleistocene did its direct influence become apparent in the Mallee. From then on, the effect of the reduced water budgets (drought) resulting from the widespread glaciation first became apparent with the development of arid-climate landforms.

Pre Pleistocene to early Pleistocene, however, was a time of extensive lacustrine sedimentation.

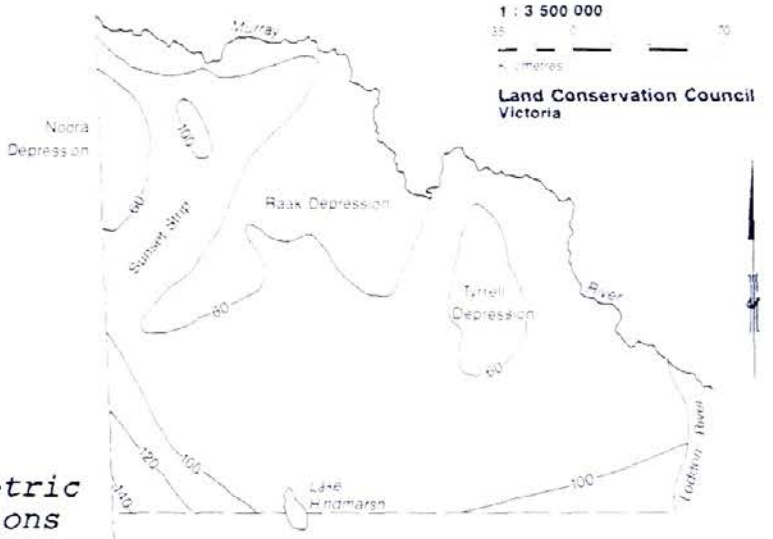
During the Plio-Pleistocene, relative uplift of a geological structure in South Australia, the Pinnaroo Block, caused the damming of the ancestral Murray drainage system and the subsequent deposition of the Blanchetown Clay, a fresh-water lacustrine deposit comprising olive-grey clays and silt. Fine-grained, dolomitic limestone, the Bungunnia Limestone, is sometimes present at the top of the sequence, while brown coal occurs at its base in the Tyrrell Basin. This is a distinct structural feature formed as a result of down-warping by some 30 m to the east of the Tyrrell Fault (a north--south trending monocline to the west of the present Lake Tyrrell. Previously, and on Map 3, this has been described as the 'Tyrrell Warp'. Current drilling, however, indicates that it is best described as a fault).

Deposition of the Blanchetown Clay occurred in lakes that were usually confined to the corridors between the Parilla Sand ridges or to structural depressions. During higher water levels these might have coalesced to form the one huge Lake Bungunnia, which extended from about Swan Reach in South Australia to near Robinvale. The formation's outcrop pattern is deeply embayed - being strongly influenced by the Danyo and Tyrrell Faults, both of which were active during its deposition.

The Danyo Fault formed the eastern boundary of the Sunset Strip (see Figure 9), a long thin promontory of older Tertiary sediments that protruded into Lake Bungunnia, while the

Figure 9

GENERAL ELEVATIONS



Numbers on these isometric lines give the elevations in metres above sea level.

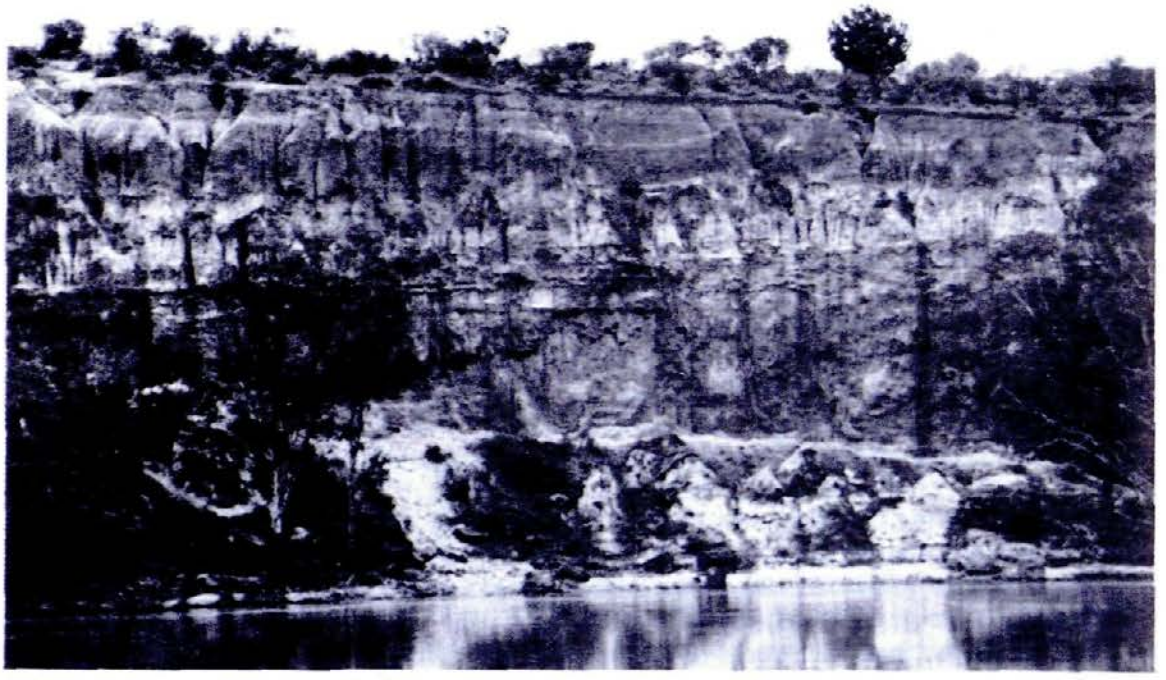
Tyrrell Fault formed a similar, but broader, intrusion to the west of Lake Tyrrell. The maximum recorded thickness of the Blanchetown Clay is 34 m beneath the Raak Plain. Palaeomagnetic evidence indicates that it ranges in age from more than 2.4 million to about 700 000 years BP (or from Plio-Pleistocene to mid Pleistocene).

Blanchetown Clay deposition ceased and arid conditions associated with the several glacial maxima, interrupted intermittently by wetter interglacial periods, prevailed between the mid Pleistocene and the Holocene. A veneer of aeolian and saline lake deposits was laid down during this time, and these now cover most of the study area. Recent alluvium deposits along the Murray and other rivers - that is, the upper part of the Shepparton Formation - and outcrops of the Parilla Sand, particularly to the east and west of the Avoca River, cover the remaining parts. The Parilla Sand outcrops themselves are also usually mantled with a thin aeolian veneer.

Exposed laterized Parilla Sand dunes.

Of the main aeolian units, the more widespread are the Woorinen Formation, which occurs mainly in the central and northern parts of the area, and the Lowan Sand, which comprises much of the Sunset Country and the Big Desert. Other more localized aeolian landforms were also formed at this time.

The Woorinen Formation consists of red-brown clayey sand and calcareous sandy clay. It typically occurs as low, closely spaced, longitudinal east--west trending dunes, although featureless plains are also present. Six palaeosols have been identified within it. The clay occurs as sand-sized pellets indicating that it was, at least in part, derived from interdune corridors where fluctuating saline water tables provided conditions favourable for its aggregation.



Exposed section of the Woorinen Formation.

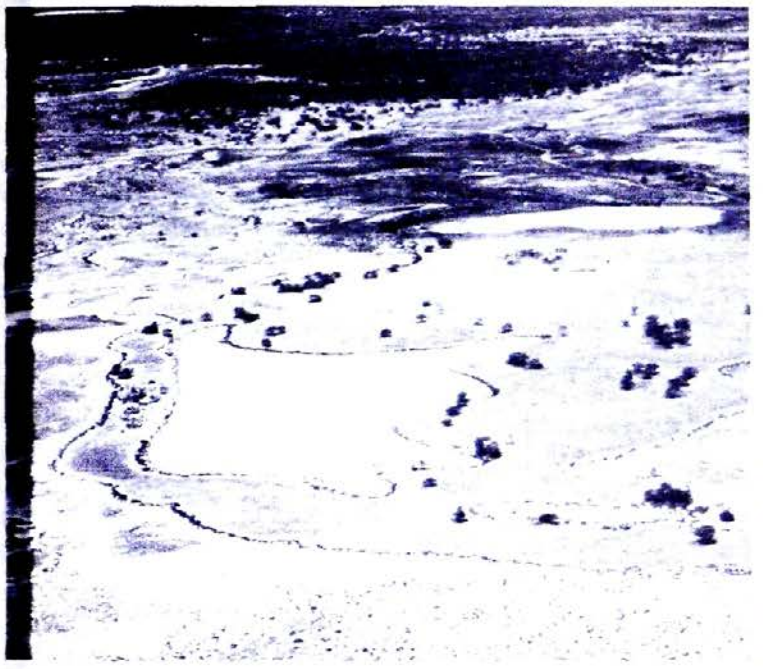
The Lowan Sand comprises fine- to medium-grained quartz sand eroded from the underlying Parilla Sand. It is usually light yellow in outcrop but orange when fresh, and forms a variety of irregularly shaped dunes, including parabolic and longitudinal types; sand-plains are also present. The Lowan Sand is not overlain by other units and at the margins of the Big Desert and Sunset Country it overlies small areas of calcareous red clays - presumably belonging to the Woorinen Formation.

The saline lake deposits comprise laminated gypseous clay. Some 4 to 5 m of these sediments were deposited in the Tyrrell Basin, and the term Tyrrell beds has been applied to them. Similar sediments occur at Lake Crosby and the Raak Plain. The unit sometimes includes a layer of gypsum that was precipitated *in situ* from groundwater - the Yamba Formation. The saline conditions necessary for deposition of the lake deposits were also conducive to lunette development. As a result, an extensive system of varyingly aged lunettes overlies the Blanchetown Clay to the east of Lake Tyrrell.

Lake Tyrrell remained full from 50 000 to 32 000 years BP and at that time it formed the western part of a much larger body, called Lake Chillingollah. This extended some 35 km to the north-east and had a depth of 13.5 m above the current lake floor; its estimated salinity was between 30 000 and 50 000 mg per litre - well below the current 250 000 mg per litre (sea water is 35 000 mg per litre). A major change in hydrological conditions took place at about 32 000 years BP and arid conditions prevailed until 28 000 BP. A red-brown lunette formed on the eastern shore of Lake Tyrrell during this time. From 28 000 to 20 000 years BP the climate was generally wetter, but from 20 000 to 16 000 years BP arid conditions were again current and a grey lunette developed over the earlier red-brown one.

Quaternary Period - Holocene

A renewed lake-full episode occurred in the early Holocene, but the lakes were much smaller than Lake Chillingollah. Lake-full conditions were attained at different times in different parts of the area but - in general - took place between 13 000 and 7 000 years BP. A feature of the current geological environment is its delicately balanced hydrological relations, in particular its saline groundwater levels.



Salina complexes, or boinkas, are legacies of saline groundwater changes that occurred during the Pleistocene.

Throughout much of the time since the Blanchetown Clay was deposited, the groundwater table has been close to the ground surface. Consequently, any variation to it has had a marked impact on landforms and many distinctive features in the area depend on it to a large extent. Features such as salinas, salina complexes or boinkas (page 66), and lunettes are legacies of saline groundwater level changes that occurred throughout the latter half of the Pleistocene.

PHYSIOGRAPHY

Extending north and north-west from the Victorian Highlands is the vast flat to gently undulating expanse called the Murray Basin plains, a major physiographic division of the

State. It is subdivided into three broad regions: the Riverina plain, which includes the Murray Valley and the plains east of the Leaghur Fault; the Mallee dune-field to the west of this fault; and the Wimmera plain south of the Mallee. The study area incorporates the Mallee dune-field and minor parts of the Riverina plain.

The Mallee dune-field is basically a gently undulating plain inclined very slightly to the north-west; it is somewhat upwarped west of the Leaghur Fault and rather downwarped east of the Danyo Fault and the Tyrrell Fault. Relative relief rarely exceeds a few metres, although the large irregular parabolic dunes of the 'deserts' and the upwarped Gredgwin and Cannie ridges to the west of the Leaghur Fault attain heights of about 30 to 40 m. Much of the Mallee is mantled with aeolian deposits, usually moulded into a variety of dune types. Distinctive ridges, which can be traced for tens of kilometres, are aligned north-nor-west (north--south trending) across its southern and central parts. Smoothly outlined ephemeral lakes in the southern half of the region are vestiges of enfeebled or defunct drainage systems whose sources lie in the higher country to the south. A string of raggedly outlined gypseous lake-beds to the east of the Danyo Fault marks a zone of groundwater discharge. The name 'boinka' has recently been applied to these features.

The Riverina plain here chiefly comprises the entrenched floodplain of the Murray River. It consists of a thin strip of alluvium together with the confining valley walls and is rarely more than a few kilometres wide. It achieves its maximum width in the study area about 25 km downstream from the Darling--Murray junction.

Physiographic Evolution

The physiography of any area is the product of geomorphic processes that involve many factors - principally geology, climate, and time. An essential characteristic of all three is change. Consequently, the physiography of an area is dynamic - responding to ongoing or new geomorphic processes. Evidence of this constant evolution is often retained in relict landforms.

The oldest relict landforms in the study area are remnants of the huge north--south trending coastal dunes formed on the surface of the Parilla Sand as the Pliocene sea retreated south-westwards. Subsequent lateritic weathering rendered the upper part of the dunes resistant to erosion. The climate at that time would probably have been monsoonal.

These ridges have strongly influenced the physiographic evolution of the area and today they either outcrop as prominent ferruginous sandstone ridges or underlie broad subdued undulations beneath the aeolian veneer. The corridors between the ridges have also strongly influenced the physiography because, as topographically low areas, they have been the preferential sites for lakes and drainage systems. As a result, over time, significant thicknesses of fine-grained alluvial sediment have accumulated in many of them (these can be interpreted on Map 7 - Land Systems).

In the mid Pleistocene, the effect of the global climatic changes related to glaciation became apparent in the area. Aeolian landforms developed during the arid periods accompanying the various glacial maxima, and sediments deposited after that time indicate increasingly saline conditions. Two of the aeolian landforms, the linear dunes of the Woorinen Formation and the clay-rich lunettes, bear the imprint of several cycles of mobilization and stabilization. For instance, up to six successive palaeosols comprise the subsoil of some linear dunes, while younger grey lunettes overlie older red ones at a number of locations.

The clay lunettes and Woorinen Formation dunes were formed, respectively, along the shores of the lakes and in interdune corridors. The process involved the concentration and crystallization of salt in the soil where the groundwater table met the ground surface. Increased salt concentration caused clay particles to form sand-sized aggregates or pellets, which were then blown away to accumulate as neighbouring dunes or lunettes. Seasonal groundwater tables higher than those of today would be required for this process to operate.

As well as the clay-rich lunettes, quartz sand lunettes were constructed on the leeward side of relatively high-energy beaches during lake-full conditions. An interlayering between quartz and clay bands in some lunettes indicates alternating arid and wet conditions. Other dune types developed in the arid periods - the irregular parabolic or 'jumbled' dunes peculiar to the Lowan Sand and the weakly oriented dunes formed in the aeolian veneer, particularly towards the southern and eastern margins of the area. The general source for these dunes is the Parilla Sand, often with admixtures of loess, alluvium, or copi.

Less widespread are the transverse gypseous dunes of the Raak Plains and other gypsite or 'copi' flats and the highly siliceous linear dunes of the Big Desert and southern Sunset Country. All these various landforms developed during the late Pleistocene and many of them are the products of the several arid periods accompanying glacial maxima. The last major phase of aeolian activity was probably completed about 16 000 years BP.

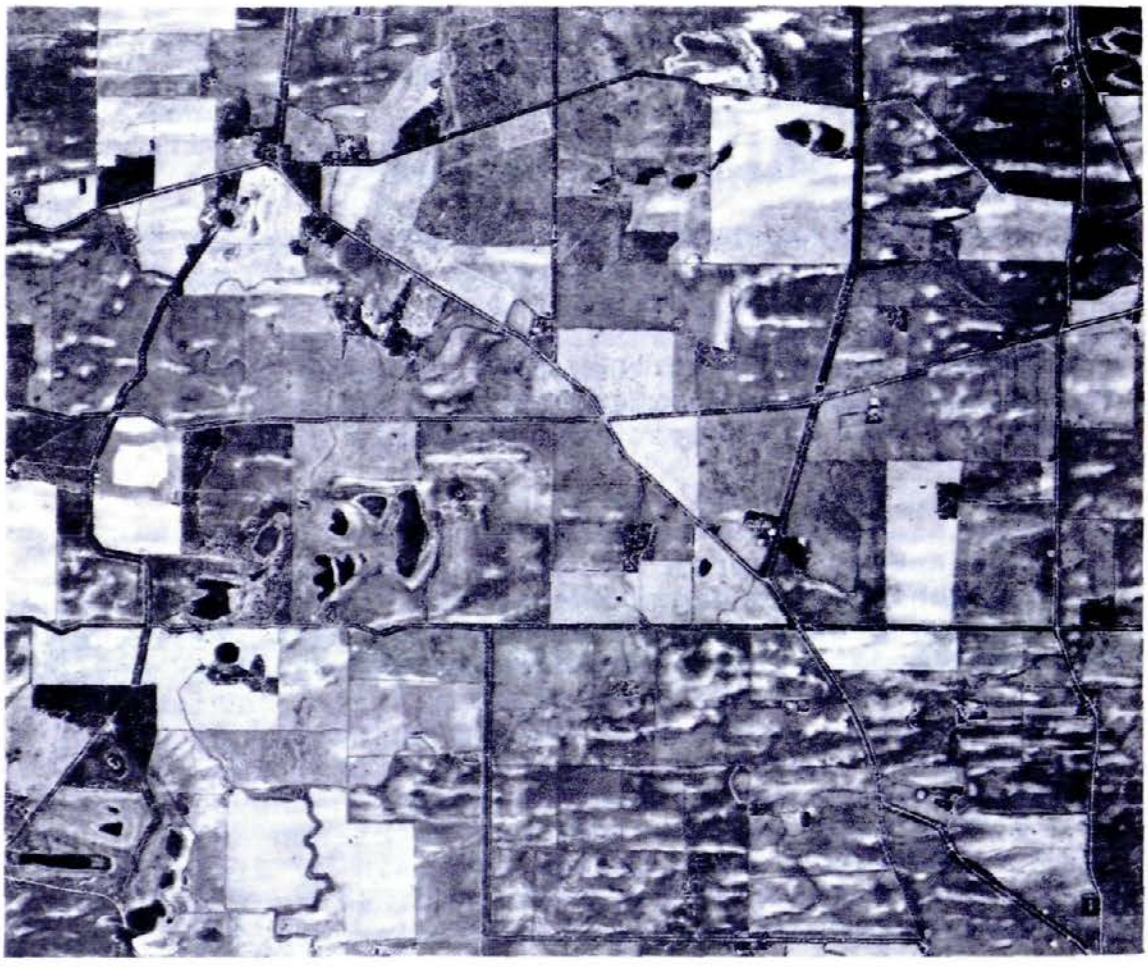
The interglacial periods were times of higher water budgets, and the Parilla Sand, because of its high permeability and role as an unconfined aquifer, was central to the geomorphic processes taking place. The generally high permeability of the formation (together with that of its thin aeolian cover) results in rapid infiltration of precipitation. This, in conjunction with the area's high potential evaporation, limits surface run-off to times of heavy rainfall, and indigenous surface drainage has rarely developed in the Mallee. The Parilla Sand was, and remains, an unconfined aquifer throughout most of the area, unless overlain by fine-grained sediments - where it becomes a semi-confined aquifer; this occurs at such locations as the inter-ridge corridors.

Two major drainage systems occur in the area: the streams entering from the higher country to the south; and the Mur-

ray. The first group comprises Tyrrell and Lalbert Creeks and the Wimmera River with its anabranch - Yarriambiack Creek. The flows of these streams are now, and were even during times of higher water budget in the past, inadequate to counteract the constant water loss from infiltration and evaporation and they terminate in a string of lake basins. On the other hand, the Murray River, which is fed from very large catchments, has almost always been able to overcome such water loss; surface flow of the river is augmented by groundwater discharge.

The lake basins of the Mallee have undergone a major hydrological change over the last 50 000 years. These years included two periods when water depths were much greater than today and the currently grassed plains such as Wirringren Plain were extensive lakes - one between 50 000 and 32 000 years BP and the other between 13 000 and 7 000 years BP.

During these periods, water tables were also higher and groundwater discharge complexes or boinkas at such places as the Pink Lakes and Raak Plains would have covered a wider area than today. For instance, many grassed depressions in this general area have truncated linear dunes on their western margins - indicating that they were lakes after the last phase of aeolian activity. The grassed plains and salina--gypsum flat complexes between Nyah and Manangatang are also considered to be palaeo-groundwater discharge landscapes.



The grassed plains interspersed with salina--gypsum flat complexes between Nyah and Manangatang.

The Mallee's low relief and shallow, largely unconfined, regional aquifer (the Parilla Sand) mean that any increase in water budget quickly results in intersection of the water table and topographically low areas. Because of this very sensitively balanced hydrological environment, human intervention, by removal of vegetation, has become an important agent in the geomorphic process. It increases infiltration, which causes the water table to rise and so leads to the reactivation of the old discharge features. Indications from around Lake Tyrrell suggest that it might have occurred from as far back as 22 000 years BP through extensive burning. However, the only documerted impact is that of clearing for agriculture, during last century. A further effect of that activity has been the remobilization of dunes.

Landforms

More detailed descriptions of the various landforms discussed above are given in the following paragraphs.

North--south ridges

These features, which trend towards a NNW-SSE direction, are usually 6 to 40 m high and 1 to 1.5 km across with slopes between 1 and 3%; their lengths vary from 1 km to more than 50 km. They are most apparent in the south-central part of the area, where they control the courses of Outlet and Yarriambiack Creeks. However, aerial photographs and satellite images indicate they are more widespread, albeit often masked by an aeolian veneer. They form the upper surface of the Parilla Sand and are the laterized remnants of foreshore dunes of the retreating Pliocene sea. They are frequently covered with the linear dunes of the Woorinen Formation and the irregular dunes of the Lowan Sand.

The Cannie and Gredgwin ridges are exceptions, having been formed tectonically by uplift along the Leaghur Fault. The Tyrrell Fault to the west of Lake Tyrrell is also a tectonic feature.

Linear dunes

Linear dunes - also described as tear-drop dunes in the 1974 report - are strongly aligned east--west and form a striking feature of the landscape. They are the most numerous of the aeolian landforms. Most are 80 to 120 m wide, 2 to 10 m high, and 0.5 to 3 km - but typically 1.5 km - long. They are often regularly spaced, with their crests about 300 m apart, and are asymmetric in section - the south slope being steeper than the north slope. The dunes consist of pale to dark reddish yellow or brown calcareous sands and clays and are typical landforms of the Woorinen Formation.

These dunes are almost certainly formed parallel to a predominantly west wind, although the asymmetric shape is probably the result of the south-westerlies being stronger than the north-westerlies.

Each dune has a long history during which it has remained in the same position, although it has periodically been built

up, eroded, and stabilized, as shown by the series of palaeosols that are characteristic of all exposures of the subsoil so far examined. The immobility of the linear dunes is further indicated by their lack of tuning-fork or 'Y' junctions. (Wind blowing across a sand dune forms eddy currents on the lee side. Should these eddies extend across to a parallel and smaller dune, movement of any destabilized portions of the latter trends back into the lee of the larger dune, eventually merging with it to form a Y-shaped junction.) By contrast, Y junctions are present in the small areas of linear dunes developed from the siliceous sand of the Lowan Sand at such locations as the Pink Lakes.

Irregular dunes

These elongated and sharply curved dunes include parabolic and sub-parabolic types, with the apex to the east. Their average dimensions often exceed those of the linear dunes, and impressive razor-backed prominences more than 30 m high are common. They consist of greyish yellow quartzose sands. Irregular dunes are typical landforms of the Lowan Sand and within the study area they are confined to the Big Desert, where the parabolic form is best developed, and the southern part of the Sunset Country. They are inherently unstable and prone to remobilization if disturbed.

Irregular dunes, Big Desert.

Weakly oriented dunes

Low mounds, characteristically less than 500 m across, with slopes of between 1% and 3%, are widespread in the south-west. They are aeolian landforms, but the conditions under which they were formed are not fully known. It is, however, possible that the moister climate in the south-west might have supported sufficient vegetative cover to prevent linear dune formation.

Lunettes

These aeolian landforms are smooth crescent-shaped dunes developed on the eastern side of lake basins in southern Australia. In plan, they are concave to the west, which is

Saltpan in the foreground and copi rise in the centre, with a fringing lunette in the background.

the incident direction of the prevailing wind, and are aligned at right angles to it. Their soil profiles indicate complex oscillations of past hydrological sequences, varying through periods when deep and relatively fresh water had concentrated clean quartz sand on the eastern beaches of the lakes prior to its formation into down-wind dunes, to arid saline conditions when gypseous clay aggregates or pellets were developed and blown into the same dune feature. Lunettes can thus vary from dominantly clay types to dominantly quartz sand types. Cross-section profiles associated with these types differ, and range from that of the quartz foredune with a steep leeward slope to the steep slope on the windward side found on a clay or gypseous clay lunette. The impure quartz lunette is a compound type and is more or less symmetrical in section.

The size of the lunette bears a strong relation to the size of the basin from which the material was derived. Thus, a small lake less than 1 km in diameter may have a lunette only a few metres high, whereas larger basins frequently carry lunettes more than 15 m high; at Lake Tyrrell they are up to 40 m in height.

Plains

Small plains are frequent throughout the aeolian landscape of the Mallee and consist mainly of clayey material of the Woorinen Formation and Lowan Sand. Alluvial plains occur along the streams that penetrate the Mallee. They are best developed, however, along the Murray River in the Hattah--Kulkyne area and around Neds Corner, where they are incised by numerous meanders and billabongs. Meander patterns are still discernible on the higher terrace near Neds Corner.

Plains of older alluvium (the Shepparton Formation) occur in the south-east.

Lake basins

Low-lying lake basins occur along current or past drainage lines. They typically have a smooth elliptical outline with a relatively sharp break in slope along the western shore, which represents an ancient or modern cliff, while the eastern shore is defined by lunettes. Although generally dry, they are, or have been, subject to ephemeral flooding and/or groundwater discharge and so, periodically, sufficient water has occurred in them to produce their regular outline. Sediments in most of the dry lake basins are dominated by clays, with silts and sands being more prominent towards the eastern shore. In lakes such as Lake Tyrrell, which intersects the groundwater table, a salt-encrusted surface has developed.

Playas and salina

Where ephemeral lakes are fed by streams carrying fine clay and salt but never receive sufficient volumes of water to overflow, the resultant bodies containing saline clayey sediments are called 'playas'. If a salt crust forms on the lake surface it is known as a 'salina'.

Groundwater discharge complexes or boinkas

At the lower end of the regional groundwater flow system within the northern Mallee landscape, large groundwater discharge complexes occur within broad depressions. The landscape within the depression is strikingly dissimilar from the surrounding Mallee landscape. It contains its own distinct suite of landforms, which include sand-plains, gypsum flats, gypsite (copi) hills, salinas, and various types of source-bordering dunes. Because of its disparate nature, the discharge complex has been recognized as a landform in its own right and given the name 'boinka' (after Macumber - 1983). A boinka is a landform complex containing a combination of individual landforms, and the term is not intended

Boinkas in the northern mallee.

to apply to discrete forms such as salinas, lake-lunettes or gypsum flats, which may exist on their own or be part of a boinka.

SOILS

The relations between geology, landforms, and soils are described below and shown in Table 5. Landforms on this table correspond with those described in Land Systems (Chapter 9).

Table 5

COMMON RELATIONS BETWEEN GEOLOGY, LANDFORM, AND SOIL

Woorinen Formation

E	Sandy red duplex soils (Dr 4.33)
P	Calcareous earths (Gc 1.12)
	Calcareous clays in the south-east (Ug 5.24)
	Sandy red duplex soils in the north (Dr 4.33)
R,W	Calcareous earths (Gc 1.12)
	Calcareous clays in the south-east (Ug 5.24)
	Red duplex soils (Dr 2.33)

Lowan Sand

E,P,R	(East--west dunes dominant)
	Pale sands overlying reddish yellow clayey sands (Uc 2.21)
I,P,R	(Irregular dunes dominant)
	Yellow duplex soils (Dy 5.42)
	Pale sands overlying yellow sands (Uc 2.21)

Tyrrell Beds

P	Gypseous clays (Ug 5.28)
L	Red duplex soils (Dr 2.33)

Shepparton Formation

F	Grey clays, sands, loams (Ug 5.22, Uc 1.21, Um 1.41)
P	Red duplex soils (Dr 2.33)
L	Red duplex soils (Dr 2.33)

Landform key

E	East--west dune
F	Present floodplain
I	Irregular dune
P	Plain above flood level
R	Stranded beach ridge, usually trending north--south
W	Weakly elongated (or weakly oriented) dune
L	Lunette

Notes:

1. Brackets indicate classification by Northcote (1979), in which the first division is between uniform (Ug, Ue, and Um), gradational (Gc), or duplex (Dr, Dy) soil profiles.
2. The landform symbols correspond with those in Table 11.

Woorinen Formation

The 'Mallee soils' of the linear dunes of the Woorinen Formation in the central and northern parts of the area are characterized by gradual increases with depth in contents of clay, carbonates (lime), and soluble salts. Many layers usually occur within the upper few metres, representing materials deposited and weathered episodically during the Quaternary. Some buried layers have relatively low permeabilities. Loess gives rise to calcareous clay soils, whereas mixtures of loess and wind-blown coarser-grained materials give rise to calcareous earths and sandy duplex soils.

Calcareous clays are more widespread towards the south-east, where they predominate on plains and on the lower slopes of ridges and weakly oriented dunes. The upper material, usually less than 1 metre thick, is chemically alkaline, friable, and relatively fertile.

Calcareous earths are more widespread, predominating on plains and ridges in the centre and north. Soil surfaces are usually reddish-brown, friable, alkaline, and moderately fertile. There is a great variation in depth to visible lime deposits and in lime content. In the west, limestone often occurs at or just below the surface, particularly on low-lying plains. In these low areas, groundwaters could well have promoted the formation of limestone. Forms vary and include massive sheets, nodules, cemented nodules, and marl, all of varying hardness. Their genesis, distribution, and effects on plant growth, however, remain obscure.

Sandy duplex soils occur most widely on east--west dunes, where sand surfaces, often about a metre thick near the dune crests and thinning downslope, are underlain by, and sharply differentiated from, compact sandy clays. Although the two layers are likely to be of different ages, the soils are regarded as being duplex for practical purposes. Root penetration into the compact layer is largely confined to cracks. Chemical reaction tends to be neutral in the upper half metre, and fertility and water retention are relatively low.

In some northern areas, such as to the west of the Raak Plain, the dunes are very closely spaced, the upper sand layer is looser and deeper, and the underlying material is softer, less clayey, and less calcareous. In this country, sandy duplex soils are also dominant on the inter-dune flats. Red duplex soils that are heavier (more clayey) with loamy surfaces occupy a small proportion of the plains between the more widely spaced east--west dunes, and of the ridges and weakly oriented dunes, where they tend to occupy the upper eastern slopes.

Lowan Sand

The Lowan Sand of the Big Desert and southern Sunset Country is mainly sandy wind-blown material. Chemical reaction tends to be weakly acidic near the surface, becoming alkaline below 1 m, where flecks of lime occur. Water retention is low and fertility is particularly low.

North--south ridges affect the distribution of closely spaced east--west dunes near Patchewollock.

Where the east--west dunes dominate the landscape, considerable development of the soil profile has taken place. The upper metre or so, mainly off-white sand, overlies reddish yellow clayey sand, which is mottled at depth. By contrast, the irregular dune country has loose yellow sand subsoils, obviously less weathered. These soils indicate that the east--west dune landscape is older, and that it has been remobilized in places to form belts of irregular dunes.

In the western part of the Big Desert, low sites between east--west dunes and the north--south ridges often produce dark tones on aerial photographs, possibly as a result of particular vegetation types. On these flats the Lowan Sand overlies obviously stratified lagoonal deposits, often of sandy clay texture. The clays are highly weathered and include prominent columns coated with clay, strong mottling, and hard blocks of limestone at depth. Where the clay is less than about half a metre from the surface, the columns have notably domed tops, a characteristic of solonetz soils (a Russian term). Deep root penetration is virtually confined to a regular network of cracks at about 30-cm intervals. The clays occasionally occur at the surface.

To the east of Outlet Creek, where east--west dune landscapes predominate, there are frequent flats and ridges with

Red duplex soils may occur between the widely spaced east--west dunes.

reddish loams and abundant limestone nodules. These may represent inliers of the Woorinen Formation.

Tyrrell Beds

The soils on large plains derived from the late Quaternary saline lake deposits in the regional depressions comprise gypseous clays that are saline in the subsoils; on the present lake-beds they are saline both in the subsoil and at the surface. These large clay plains, interspersed with sandy east--west dunes, occur to the north of Lake Tyrrell and the Raak lakes. They also occur to the south of the Raak lakes and thence intermittently south-westwards as far as Cowangie. Field observations to the north of the Raak Plain show that the gypseous clay plains may be interspersed with slightly elevated plains of nodular limestone, on which grey calcareous earths have developed.

Clayey lunettes to the east of the lake-beds are common, particularly in the central areas. Red duplex soils usually occupy the lunettes and also the intervening flats in the case of multiple lunettes. Yellow duplex soils have been noted near Ouyen.

Shepparton Formation

Floodplain soils along the Murray and other rivers and streams are usually grey clays, sands, and loams with little profile development, often with marked small-scale lateral changes in texture, characteristic of young stream deposits.

Plains or terraces above flood level originally had red duplex soils, but in many areas the loamy topsoils have been removed by erosion, leaving scalded plains (clay pans).

Lunettes beside many of the lakes have red duplex soils, again severely eroded. Grey clays have also been noted on lunettes to the east of Lake Albacutya, covered in places by Lowan Sand.

Features of Geological and Geomorphological Interest

Six geological or geomorphological features in the Mallee have been listed by the Victorian Division of the Geological Society of Australia as being of national or State significance. These are listed in Table 6.

Table 6

FEATURES OF NATIONAL AND STATE SIGNIFICANCE

Significance	Feature	Land tenure	Comment
National	Lake Tyrrell	Uncommitted	Largest salt lake in Victoria Transverse gypsum dunes on lake-bed Lunettes show two phases of deposition Archaeological importance Blanchetown Clay outcrops to west
	Kerang Lake and lunette system	Water supply and drainage Wildlife reserves Uncommitted Freehold	First described by Major Mitchell in 1836 Many well-developed lunettes
State	Hattah Lakes system	National park	A natural system of anabranch lakes and associated channels
	Big Desert and Red Bluff	Wilderness Wildlife reserve Uncommitted	Irregular dune systems Prominent outcrop of Parilla Sand at Red Bluff
	Pink Lakes	State park	Extensive area of salt pans, flats, and sand dunes
	Nyah West railway cutting	Rail reserve	East--west dunes of the Woorinen Formation, with buried soils dated by radiocarbon

Lake Tyrrell - of national significance.

The study area contains a number of other features of interest. These include: the Devonian granite outcrop at Lake Boga, which is listed by the Society as of local significance; cliffs along the Murray River; the boinkas on the Raak Plains; Rocket Lake; the terminal lakes of the Wimmera River; ferruginized sandstone outcrops probably used by Aborigines as a source of ochre; and limestone outcrops near Berrook.

References

Bowler, J.M. (1983). Lunettes as indices of hydrologic change: a review of Australian evidence. *Proceedings of the Royal Society of Victoria*, 95, 147--68.

Bowler, J.M., and Magee, J.W. (1978). Geomorphology of the Mallee region in semi-arid northern Victoria and western New South Wales. *Proceedings of the Royal Society Of Victoria*, 90, 5--12.

Brown, C.M., and Stephenson, A.E. (1986). Murray Basin south-eastern Australia: subsurface stratigrapic database. *Bureau of Mineral Resources, Geology and Geophysics Report* No. 262.

Hills, E.S. (1975). 'The Physiography of Victoria.' New Edition. (Whitcome and Tombs Pty Ltd: Melbourne.)

Joyce, E.B., and King, R.L. (Eds.) (1980). 'Geological Features of the National Estate in Victoria.' (Geological Society of Australia Inc.: Victoria.)

Lawrence, C.R., and Abele, C. (1976). In Geology of Victoria, ed. J.C Douglas, and J.A. Ferguson. *Geological Society Aquifer, Special Publication* No.5.

Macumber, P.G. (1983). 'Interaction between Groundwater and Surface Systems in Northern Victoria.' Ph.D. thesis. (University of Melbourne: Melbourne.)

Northcote, K.H. (1979). 'A Factual Key for the Recognition of Australian Soils.' (CSIRO and Rellim: Adelaide.)

Rowan, J.N., and Downes, R.G. (1963). A study of the land in north-western Victoria. *Soil Conservation Authority, Victoria, T.C.* No.8

Russell, J.S., and Isbell, R.F. (Eds.) (1986). 'Australian Soils: The Human Impact.' (University of Queensland: St Lucia.)

5. CLIMATE

The climate of north-western Victoria is, according to Koepen's climatic classification, semi-arid, with a low but reasonably uniform rainfall and a relatively low mean annual temperature. Significant summer rains sometimes fall. As the region has a generally low relief with only minor topographical variation little climatic change occurs across it. Rather, a general gradation from south to north-west leads to the north-west being drier and marginally hotter. The region's comparatively pleasant winter climate makes it attractive for visitors during that season (see Chapter 11).

Rainfall

The mean annual rainfall decreases from about 400 mm in the south to less than 250 mm in the north-west. Field observations over a number of years indicate that a reduction of 10% or more in the area's average rainfall during the growing season significantly affects agricultural production.

Table 7

DISTRIBUTION OF RAINFALL THROUGHOUT THE YEAR AT SELECTED STATIONS

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mildura (1934--87)													
Av. rainfall (mm)	25	21	18	19	26	22	28	27	25	34	23	21	289
Av. number of wet days	4	3	4	5	7	7	9	9	7	7	5	4	71
Av. fall per wet day (mm)	6.3	7.0	4.5	3.8	3.7	3.1	3.1	3.0	3.6	4.9	4.6	5.3	4.1
Ouyen (1913--87)													
Av. rainfall (mm)	20	25	22	22	32	29	31	34	33	37	26	24	335
Av. number of wet days	3	3	3	5	7	8	9	10	8	7	5	5	72
Av. fall per wet day (mm)	6.7	8.3	7.3	4.4	4.6	3.6	3.4	3.4	4.1	5.3	5.2	6.0	4.7
Rainbow (1905--87)													
Av. rainfall (mm)	20	25	20	25	36	34	38	42	36	38	27	22	363
Av. number of wet days	2	2	3	4	7	7	9	9	7	6	4	3	63
Av. fall per wet day (mm)	10.0	12.5	6.7	6.3	5.1	4.9	4.2	4.7	5.1	6.3	6.8	7.3	5.8
Quambatook South (1887--87)													
Av. rainfall (mm)	21	20	25	28	34	36	36	37	33	38	28	22	358
Av. number of wet days	2	2	3	4	6	7	8	8	7	6	4	3	60
Av. fall per wet day (mm)	10.5	10.0	8.3	7.0	5.7	5.1	4.5	4.6	4.7	6.3	7.0	7.3	6.0
	Agricultural Growing Season												

Map 6 indicates mean annual rainfall distribution and is based on all records from stations with 30 or more years of records. The 25-mm isohyets are shown as lines of best fit; minor variations for individual stations may occur. The distribution across the region shows a north-west--south-east trending depression between Lake Tyrrell and Red Cliffs, which correlates closely with the Tyrrell and Raak topographical depressions. Correspondingly, the highest rainfall in the region is in the south-west, west of Rainbow, which is also the area of highest elevation (see Figure 9, on page 57), indicating the effect of the topography across the region despite the fact this only varies by about 100 metres.

Rainfall distribution throughout the year for selected stations is given in Table 7. The wettest month is generally October. About 60% of the yearly average falls between May and October, the growing season for most of the agricultural crops. The table reflects the heavy summer thunderstorms that occur in the south-western and central parts of the region, where the average rainfall per wet day during February is about twice the 12-monthly averages at Ouyen and Rainbow.

Drought

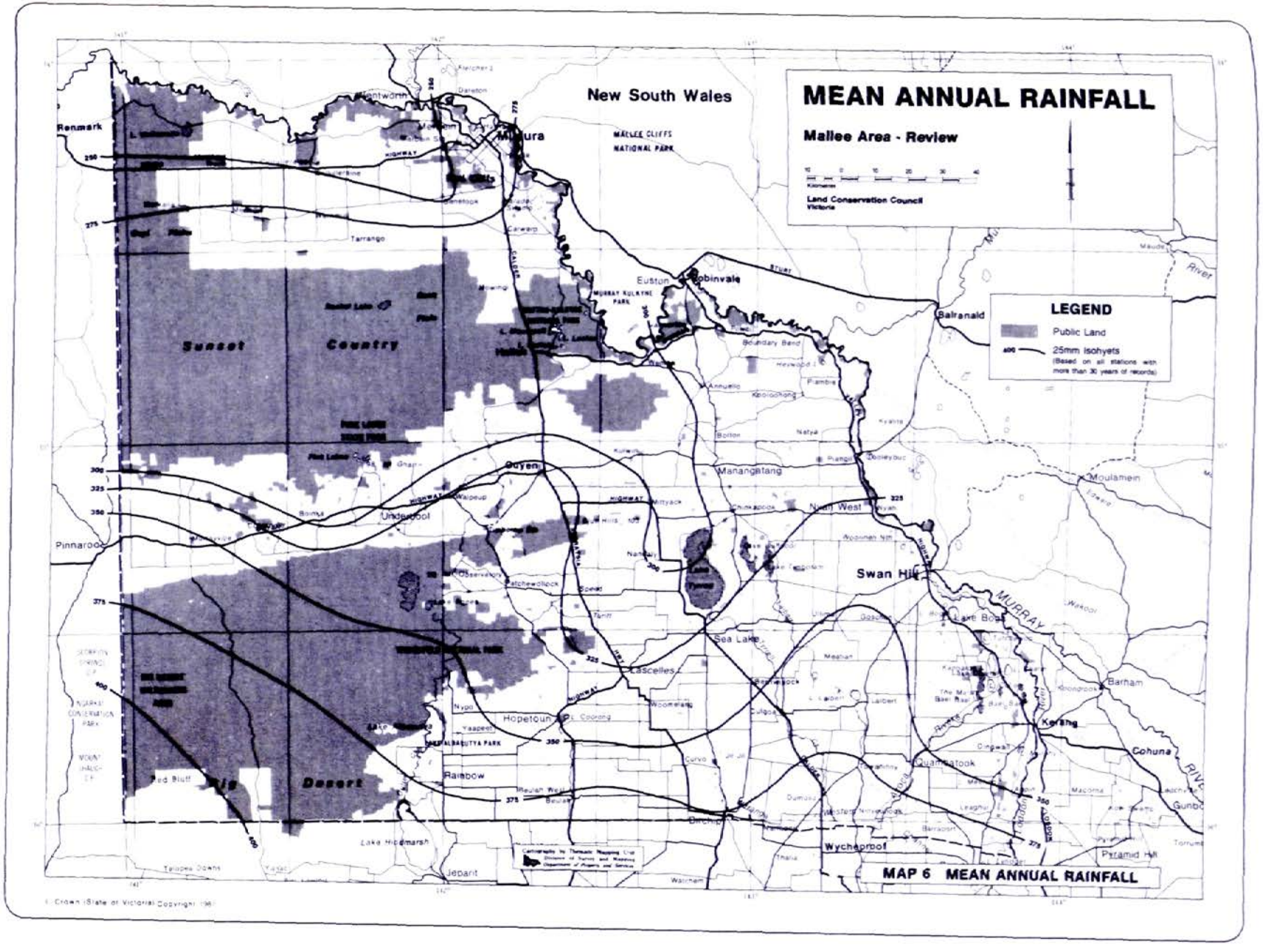
Droughts, or prolonged periods of low rainfall, are natural features of the Mallee. They may vary in length from a few months to a number of years and most of the native flora and fauna have mechanisms or behaviours that respond to such conditions.

Faunal populations are affected by periods of drought, which change their habitats and food supplies. Studies have shown, for example, that during the 1982 drought the decline in the availability of food due to a lack of plant growth contributed to the deaths of more than 40% of the kangaroo populations in north-western Victoria and the Kirchega National Park in New South Wales.

Deterioration of habitats during drought is further exacerbated in areas with a heavy infestation of rabbits, or where grazing by domestic stock occurs. Droughts in inland Australia frequently lead to an influx into northern Victoria of some birds usually associated with arid environments. These include species such as the black honeyeater, crimson chat, black kite, and black falcon. For waterfowl, the drying out of some water sources during drought will concentrate birds on the remaining permanent water bodies, and may limit breeding activity.

Aridity imposes the most important restriction on agricultural production and, even in years of average rainfall, dry spells during the growing season (April--May to October--November) limit crop and pasture yields.

Droughts are difficult to define statistically. However, at least eight very severe droughts have been recognized over the period of collection of reliable records - during 1895--1902, 1913--15, 1918--20, 1925--30, 1942--45, 1966--68, 1971--73, and 1981--83 - as illustrated in Figure 10, which



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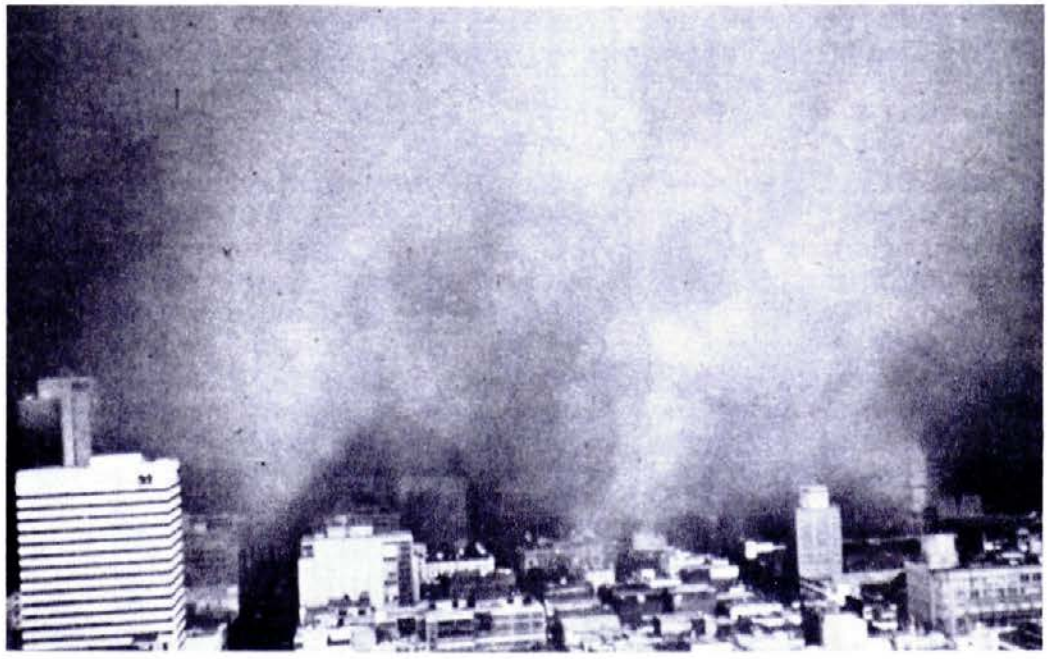
may be found in the back pocket. The annual rainfall total is less important when defining a drought than the total rainfall during the growing season (May to October). As Figure 10 shows, Ouyen received only 27 mm of rain in the growing season in 1914 - 169 mm less than the station average. In 1967, the rainfall for the year totalled only 109 mm, although it mostly fell during the growing season. By contast, 1971 received above-average rains for the year, but only about 60% of the average growing-season rainfall. The breaking of the 1971--73 drought is interesting in that 1973 recorded a massive 684 mm for the year - more than twice the annual average. Although recurrent drought is normal, it has nonetheless had a severe effect on pastures, crops, soil stability, and water supply.

During drought periods, plant growth and ground cover on agricultural land deteriorate and winds can cause widespread soil erosion. This problem is not so extensive on vegetated public land unless grazing has disturbed the ground cover.



On 8 February 1983, winds brought dust from the Mallee to Melbourne - and dumped about 140 000 tonnes of soil.

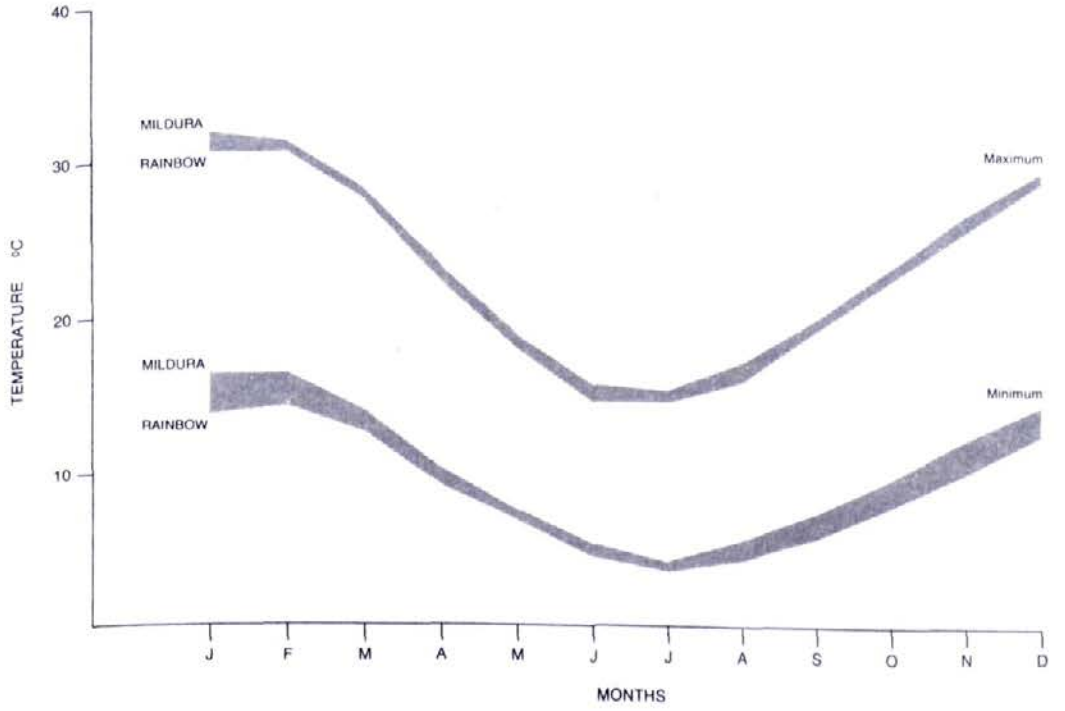
Temperature

Mean monthly maximum and minimum temperature ranges for selected stations in the Mallee are given in Figure 11. These demonstrate that the region experiences hot summers and mild winters, with temperatures slightly higher throughout the year in the northern part of the study area (Mildura) than in the south (Rainbow). Temperature records from other stations in the Mallee area indicate that the mean maxima and minima generally fall within these ranges.

At Ouyen, for instance, mid way between Mildura and Rainbow, temperatures closely approximate those recorded at Mildura, although Mildura's minimum during the summer months is slightly higher. Temperatures frequently exceed 34°C during summer, and many stations commonly exceed 40°C.

Figure 11

MEAN MONTHLY MAXIMUM AND MINIMUM TEMPERATURE
Mildura and Rainbow



There is often a wide diurnal variation, and frosts occur frequently between May and September. Heavy frosts in the Mallee have killed extensive areas of native scrub as well as caused considerable damage to horticultural crops.

Wyperfeld National Park experienced very severe frosts, with temperatures down to -8°C, during the winter of the 1982 drought. The impact on native vegetation was severe, and thousands of hectares of mallee scrub and heath were affected, especially in the interdune swales. It is possible that the drought might have aggravated this impact. The interaction of these influences and of fire is currently under investigation.

Preliminary investigations have shown that frost-killed adult banksias (*Banksia ornata*) failed to produce coppice shoots and few seedlings germinated.

Many adult *Leptospermum coriaceum* were also killed, but they produced coppice from the base of the dead stems or suckers from lateral roots. However, adult plants of yellow, dumosa, and narrow-leaved red mallee, although damaged, rarely died. Severely affected mallees coppiced mainly from the lignotuber; those less severely affected produced shoots along the length of the stems.

Evaporation

Mean annual evaporation greatly exceeds rainfall throughout the Mallee and ranges from 1300 mm in the south to just over 1500 mm in the north. Evaporation is usually greatest dur-

ing January, when monthly values range from 230 mm in the south to 250 mm in the north, as measured by water loss from an Australian Standard Tank. This is an evaporimeter consisting of an open-topped vessel 0.91 m in both diameter and depth; water loss depends upon temperature, humidity, and wind speed.

Evaporation is an important factor in the management of the Wimmera--Mallee Stock and Domestic Water Supply System. During summer, it is about 10 times the mean monthly rainfall, while in winter the two are nearly equal. Water is released into the supply system during late autumn, winter, and early spring to minimize losses through evaporation and seepage.

Winds

Winds in the Mallee usually blow from the northern, western, and southern sectors. Summer northerlies are hot and dry, but winds from the west and south-west are cooler.

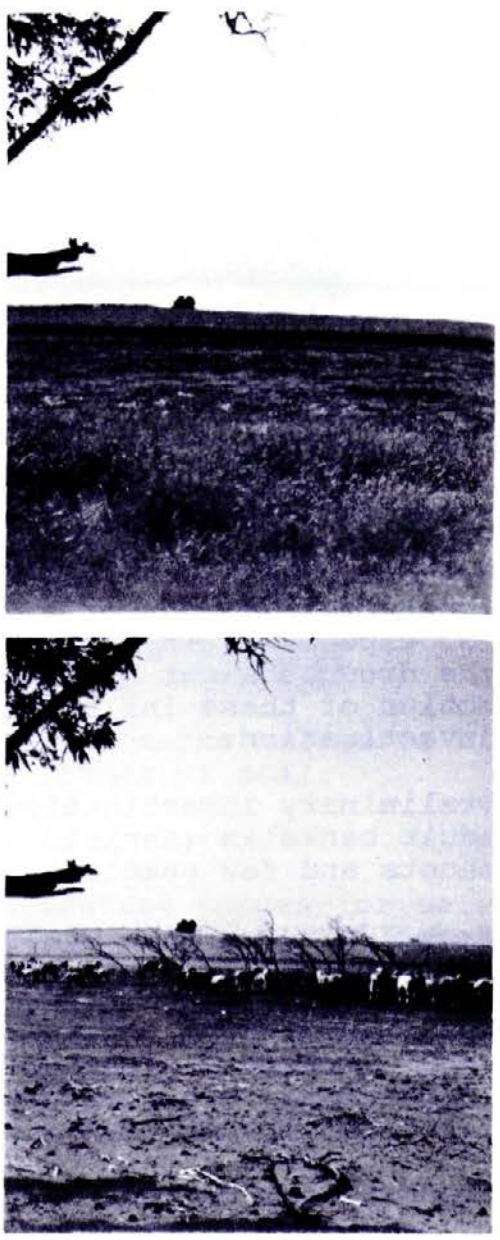
In winter, south-west to north-west winds dominate, with the greater strengths (of between 11 and 20 km per hr) occurring in the afternoons. Winds from all directions have similar strength and temperature characteristics during this season.

On several days each year, gale-force winds blow, creating the periods of greatest wind erosion in the Mallee farmlands.

Fires in the Mallee are often started by lightning during the hot dry summers and are fanned by the strong winds prevailing at that time. Their frequency and extent in the 'desert' areas are indicated on Maps 11 and 11a. Many of the fires devegetate large areas of sand country, but, unless the soil surface is mechanically disturbed by such agents as machinery or livestock, little wind erosion of the dunes occurs. Fires are discussed further in Chapter 16, Hazards and Conflicts.

Growing season

The limited amount of rain, its unreliable nature, and high summer evaporation combine to restrict the crop-growing potential of the region. A reduction of rainfall during critical growing periods can severely restrict crop yield.



Variation in rainfall can markedly affect agricultural capability here.

Generally, crop yields are limited by lack of moisture in late spring, and good rains are needed in September--November to produce heavy crops. The south of the region has a more favourable moisture supply than the north, reflecting the gradation in rainfall and temperature regimes across the Mallee. While relatively small alterations to soil moisture levels may be critical for crops, the sparse and xeromorphic native trees and shrubs with deep root systems are not nearly so dependent on surface moisture.

Horticultural production along the Murray River, although largely reliant upon irrigation, is also affected by local or seasonal weather variations. High rainfall in spring and summer can cause severe damage to grapes through diseases such as downy mildew. Control can be achieved by spraying, but is both expensive and time-consuming. Hail and frost also cause problems here and in dryland farm areas in some years.

References

Linacre, E., and Hobbs, J. (1977). 'The Australian Climatic Environment.' (Wiley: Brisbane.)

O'Brien, T.P., *et al.* (1986). The impact of severe frost on Mallee eucalypts, *Banksia ornata*, and *Leptospermum coriaceum* at Wyperfeld National Park. *Proceedings, Royal Society of Victoria*, 98(3).

Robertson, G. (1986). The mortality of kangaroos in drought. *Australian Wildlife Research*, 13, 349--54.

6. WATER RESOURCES AND UTILIZATION

As discussed in the previous chapter, the Mallee has a semi-arid climate: annual rainfall ranges from about 400 mm in the south to less than 250 mm in the north and is fairly evenly distributed. The availability of water to such an area is critical to its agricultural development. However, only the Murray River provides a permanent natural supply of surface water and, in other than dry seasons, the Loddon and Avoca Rivers also contribute.

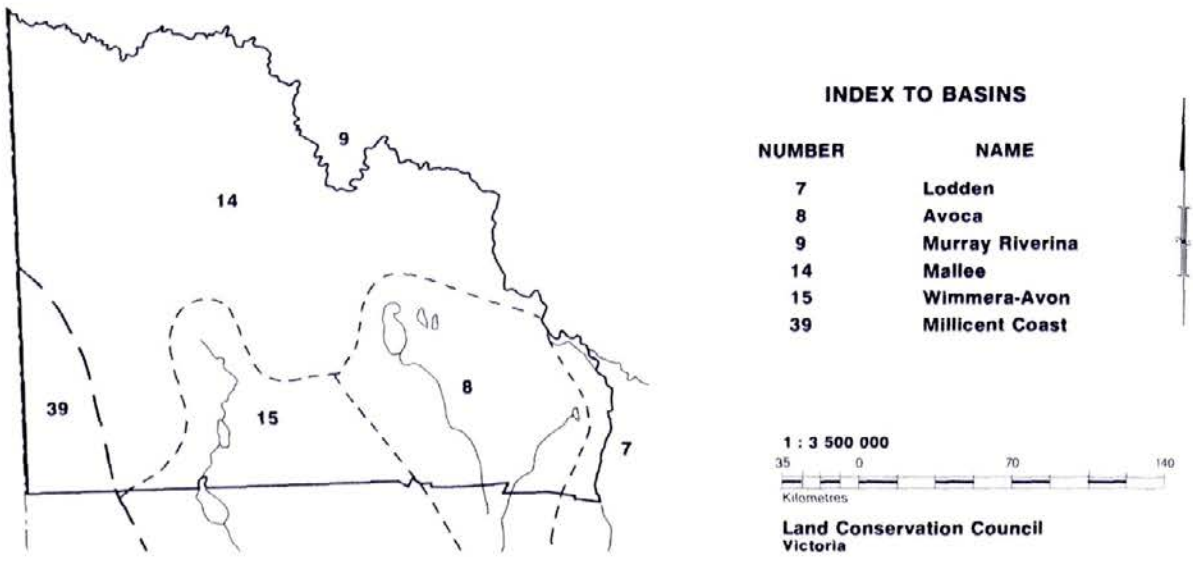
Although the Murray River is technically outside the study area, its waters are important to the region for supplies for stock, domestic, and irrigation purposes, for recreation, for plant and animal distribution, and through its flood effects. Its southern anabranches, however, such as the Lindsay River, Wallpolla Creek, and Little Murray River, are included.

Surface Water

The Murray forms the northern boundary of the Mallee area, which encompasses parts of five surface drainage basins - as defined by the Australian Water Resources Council: Loddon, Avoca, Wimmera--Avon, Mallee, and Millicent Coast. These are indicated on Figure 12. Streams of the Loddon, Avoca, and Wimmera--Avon basins flow northwards, but only the Loddon River basin produces a net surface run-off from within the study area in normal or wetter seasons to flow into the

Figure 12

SURFACE DRAINAGE BASINS



Murray River. The other drainage systems usually terminate in lakes or shallow depressions that fill either intermittently or seasonally.

stream flow

The quantity of water that an area yields as stream flow is related to the amount of rainfall it receives and to the proportion of this rainfall that is ultimately lost through seepage, evaporation, and transpiration.

With its porous aeolian sediments and semi-aridity, the Mallee lacks any reliable run-off from rainfall. Streams in and adjacent to the study area derive the greatest proportion of their flow from catchments located outside its boundary. Stream-gauging information for its three major rivers - the Murray, Avoca, and Loddon - is set out in Table 8.

Table 8

STREAM FLOW

Station	Records	Annual discharge (ML) Maximum	Minimum	Mean
Avoca River				
Coonooer	1889--1985	408 000	428	86 600
Quambatook	1963--1985	129 000	3 480	47 600
Loddon River				
Appin South	1927--1985	300 000	4 920	87 500
Kerang	1925--1985	461 000	36 200	188 000
Murray River				
Swan Hill	1909--1985	8 820 000	1 170 000	4 160 000
Euston	1929--1985	43 400 000	1 750 000	9 160 000

Note: The stations are listed in order of location on the stream, the first-mentioned being upstream of the second station.

No reliable data are available for the minor streams - Outlet, Yarriambiack, Tyrrell, and Lalbert Creeks - which in wet years flow north into the Mallee until they terminate in shallow depressions comprising, respectively, Lake Albacutya and the lake system in the Wyperfeld National Park, Lake Coorong, Lake Tyrrell, and Lake Timboram. Under normal conditions the Avoca River is also terminal, discharging into Lake Bael Bael, part of The Marshes Wildlife Reserve - D8 on Map 8.

The Murray River, too, is markedly affected by seasonal conditions. Records since gauging began at Swan Hill (in 1909) show that the Murray ceased to flow there for short periods in 1914, 1915, and 1923. Subsequent regulation of the river (Hume Weir, 1936, and Dartmouth Dam, 1980) has now enabled a flow to be maintained at all times, despite several severe droughts. The Loddon and Avoca Rivers, however, often stop flowing within the study area, although some flow is usually maintained in their upper reaches.

Surface water quality

Suitability of water as an environment for aquatic life or for various uses depends greatly upon its quality. Factors characterizing water quality include temperature, turbidity, hardness, levels of dissolved oxygen, colour, organic matter content, and concentration of total dissolved solids (TDS). The TDS content, or salinity, describes the concentration of various salts - principally sodium chloride (common salt) - and is a common indicator of the quality of water for domestic and agricultural uses; it also serves as a means of comparing streams. Another common measure of salt concentration is the electrical conductivity of the salt solution. This is discussed further in Chapter 16 - Hazards and Conflicts.

Table 9 illustrates how rising TDS levels limit the uses to which water can be put. In general, 1000 mg TDS per litre is the upper limit for water for domestic use, while under certain conditions sheep can tolerate up to 16 000 mg per L.

Table 9

WATER SALINITY

Salinity (mg TDS per L)	Usage
Less than 1000	Commonly suitable for domestic and industrial use, and for livestock and irrigation. The limit for vegetable production is about 1000 mg per L. (The salinity of Melbourne's water is 100 mg per L; Adelaide's is 300 mg per L.)
1000--3000	Brackish water. Maximum salinity humans can normally tolerate is around 2000 mg per L. The threshold salinity for the growth of most plants is 3000 mg. This water is suitable for all livestock, and some domestic and limited industrial uses. Use for irrigation is possible under favourable conditions.
3000--7000	Increasingly brackish water. Suitable for most livestock (poultry, up to 3500; pigs, up to 4500; horses, ewes with lambs, and dairy cattle, up to 6000 mg per L), but very limited for domestic and industrial purposes.
7000--16 000	Salty water. Beef cattle will tolerate up to 10 000 mg per L. The maximum for sheep on green pasture is 16 000 mg per L.
More than 16 000	Unsuitable for livestock.
35 000	Sea water.

Increasing salinity can also modify or destroy natural wetlands, the principal effects being modification to the food chain and the ability of the vegetation to provide refuge or breeding habitats for wildlife - at high TDS readings the ecosystem loses its original species diversity and ecological value.

No studies have been conducted on the effects of various salinity levels on aquatic fauna. It can be surmised, however, that the native fauna here have evolved with some tolerance of increased salinity, given the large variations in stream levels that prevailed prior to regulation of the Murray River. Most native fish can tolerate salinities up to about one-third that of sea water.

All streams in the State carry base levels of salt derived through natural processes such as weathering of rocks, rainfall, and groundwater discharge. With the high variability of flow in the Mallee streams, however, salinities fluctuate; high flows reduce salinity through dilution, and when stream flow is low evaporation tends to increase the concentration of salt. Table 10 indicates the range in salinities in the more permanent streams of the Mallee for the same stations listed in Table 8.

Table 10

STREAM SALINITIES

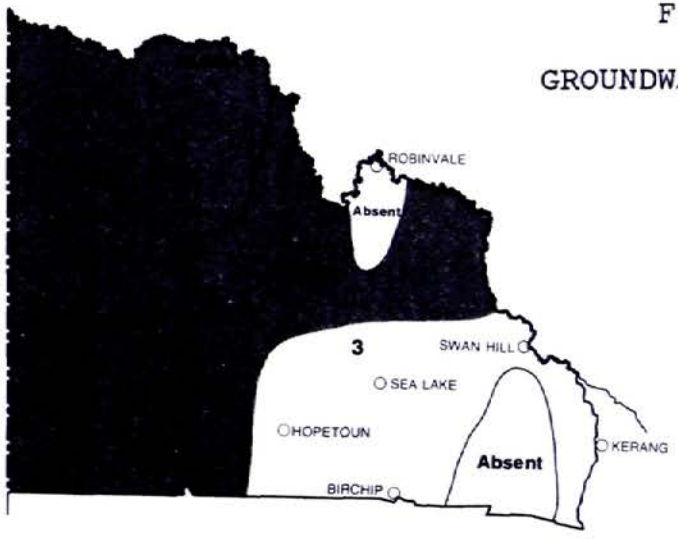
Station	Records commenced	Annual discharge (ML) Maximum	Minimum	Mean
Avoca River				
Coonooer	1976	7920	203	3618
Quambatook	1963	7800	168	1980
Loddon River				
Appin South	1977	3060	220	1038
Kerang	1976	2580	70	517
Murray River				
Swan Hill	1976	1350	73	203
Euston	1976	280	88	165

Altogether, some 262 000 tonnes of salt are added to the Murray River each year from the relatively undisturbed catchments of those rivers upstream of Echuca. However, because the amount of salt is diluted with large volumes of water, the Murray waters have low salinity levels. Even at Swan Hill, where natural inflows of salt are augmented by salt arising from irrigation drainage and from seepage from groundwaters under the irrigation areas (Barr Creek, east of Kerang, alone contributes 160 000 tonnes of salt annually), the Murray River averages about 200 mg TDS per L.

Salinity in the Avoca River varies greatly with stream flow. During dry periods the river may become quite saline - up to 7900 mg TDS per L in some reaches - while during floods the water quality improves to around 200 mg TDS per L. Average quality is about 2000 mg TDS per L.

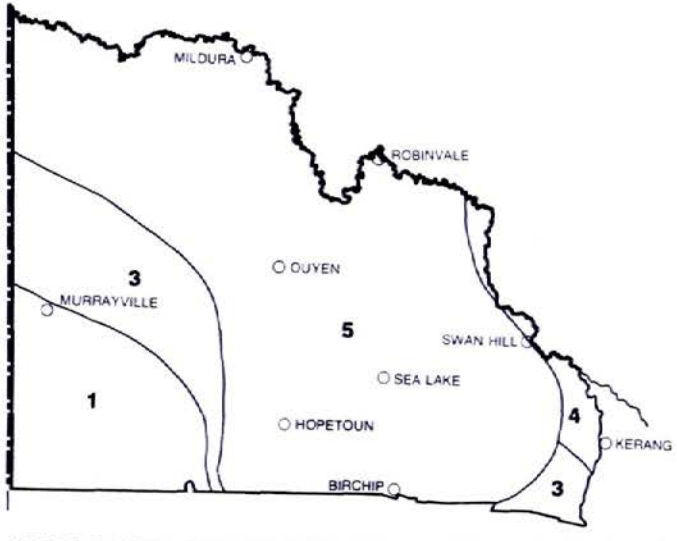
Figure 13

GROUNDWATER RESOURCES



RENMARK GROUP SANDS

DUDDO LIMESTONE AND WINNAMBOOL FORMATION



PARILLA SAND AND (IN THE EAST) THE WUNGHNU GROUP

WATER QUALITY CLASSES

	mg / l TDS		mg / l TDS
1	< 1 000	4	7 000 - 14 000
2	1 000 - 3 000	5	> 14 000
3	3 000 - 7 000		Areas expected to be reasonably high yielding

1 : 3 500 000

35 0 70 140 km

Kilometres

Land Conservation Council
Victoria

At Appin South the salinity in the Loddon River averages 1040 mg TDS per L. Water from this river is sometimes diluted with higher-quality water from the Murray River before delivery to Kerang for domestic use.

Groundwater

Most of the water in any region occurs below the surface as groundwater. How this water can be used depends upon its salinity and on the volumes that can be extracted, which in turn depend upon the type of rocks or strata in which it is stored, their permeability, and the rates of recharge.

In the Mallee, the search for groundwater began in the 1880s and an official program of exploratory drilling continued during the period 1908--15. The groundwater proved to be of good quality in the south-west, but mainly saline elsewhere.

The study area lies towards the centre of the large sedimentary Murray Basin, which acts as a closed groundwater basin (one in which no groundwater flows to the sea or across the basin's boundaries). The groundwater has originated in a number of ways - by recharge from areas located outside the study area, such as immediately to the north of the Dundas highlands south of the study area, by recharge from streams, and by rain-water seeping down through the sediments. The bulk of the recharge occurs within the Mallee, probably during wetter years. Local recharge also appears to be the major cause of dryland salting here.

In the south, groundwater movement is generally northerly, while movement in the north is to the west. Regional groundwater discharge in the central Mallee creates numerous saline lakes and discharge complexes (boinkas). Discharge also occurs to the Murray River (particularly downstream of Loxton in South Australia, where some 250 000 tonnes of salt seep annually from normal groundwater discharge). Indeed, the Murray River is the ultimate repository for all salt carried by the groundwater system.

The Loddon River basin comprises an additional suite of aquifers, which are recharged primarily from the south Loddon plains but also from the highlands to the south. The central and northern parts of the Loddon plain are also a regional discharge zone of saline water.

The Mallee portion of the Murray Basin contains four main aquifers or aquifer systems. They are, from deepest to shallowest, the sands of the Renmark Group, the Duddo Limestone and Winnambool Formation of the Murray Group, the Parilla Sand, and the Shepparton Formation. Figure 13 gives the water-quality classes of each. Bores into those parts of the aquifers indicated by shading in the figure would be expected to be reasonably high-yielding and capable of supporting irrigated agriculture.

Sands of the Renmark Group

While this group is almost continuous throughout the study area, its groundwaters have not yet been fully explored as

the sands generally lie 300 to 400 m below the surface. Drilling and bore-development costs are high. Discharges of up to 38 litres per second have been pumped from screened bores in this aquifer, and the salinity of the water is generally less than 14 000 mg TDS per L.

Usable-quality groundwater has been reported in the Carwarp-Yatpool area (south of Mildura). In the Natya--Yungera area east of Robinvale, exploratory drilling in the late 1960s indicated the presence of water with a salinity of 3000--5000 mg TDS per L in these sands. This aquifer offers potential for further groundwater development.

Duddo Limestone--Winnambool Formation

The Duddo Limestone and the closely related, but less permeable, Winnambool Formation are semi-confined to confined aquifers. The former is a principal source of groundwater in the Murray Basin and provides water for town, industrial, irrigation, and stock purposes in an area of about 5800 sq. km in Victoria and South Australia. Its location is now well mapped.

Both permeability and porosity of the Duddo Limestone are relatively high, giving it excellent properties as an aquifer. No special methods are involved in tapping it and boreholes do not require casing. Measurements show that the water moves from recharge areas in the south, north, and north-west towards the Murray River, entering it downstream from Loxton.

This limestone aquifer occurs in a continuous unit 45--120 m thick, at depths ranging from 70 to 130 m. Salinities are often less than 3000 mg TDS per L. The better quality water in this aquifer occurs west of the Wimmera River system however; at Hattah it is quite saline.

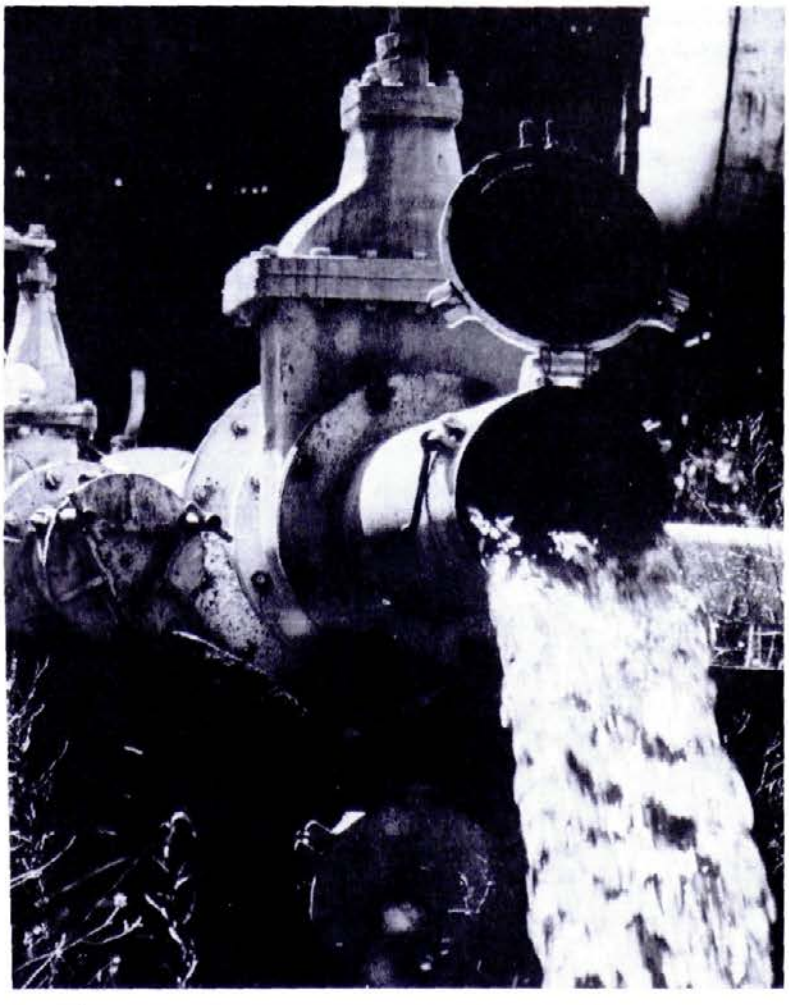
A difference in permeability between the Duddo Limestone and the Winnambool Formation is reflected in the yields and salinities of each. Discharge rates from a 15-cm-diameter bore are always less than 6.3 L per sec. for the latter and range from about 12.6 to 100 L per sec. for the Duddo Limestone. The low hydraulic gradient for the Winnambool Formation suggests that the groundwater moves very slowly. Its salinity is also high, ranging from 5000 to 35 000 mg TDS per L.

A sharp boundary separates the groundwaters of different salinities to the south of Underbool, where the Hindmarsh Fault controls the change from the Duddo Limestone to the Winnambool Formation. To the north of Underbool a broad salinity transition zone trends to the north-west.

Parilla Sand

The Parilla Sand is an unconfined to semi-confined aquifer throughout most of the Mallee. The static water level of the aquifer usually lies at depths of 0 to 40 m below ground level, sloping towards the Murray River and, in places, discharging into it. The unit is generally 40 to 100 m thick and in places in the north is semi-confined beneath lacust-

Groundwater flowing from a pump - near Murrayville.



rine Blanchetown Clay sediments that may be up to 40 m thick but generally much thinner.

Salinity of the groundwater varies greatly, but is generally between 25 000 and 45 000 mg TDS per L. Upward leakage from the deeper aquifers, seepage from streams and lakes, and rainfall may account for local variations. The fresher, unconfined water in the Parilla Sand was once exploited by dug wells, from which discharges of less than 1.25 L per sec. were obtained; but, because of its salinity, it is not normally used.

The Parilla Sands have been identified as contributing to most of the dryland salting problems in the region.

The Shepparton Formation

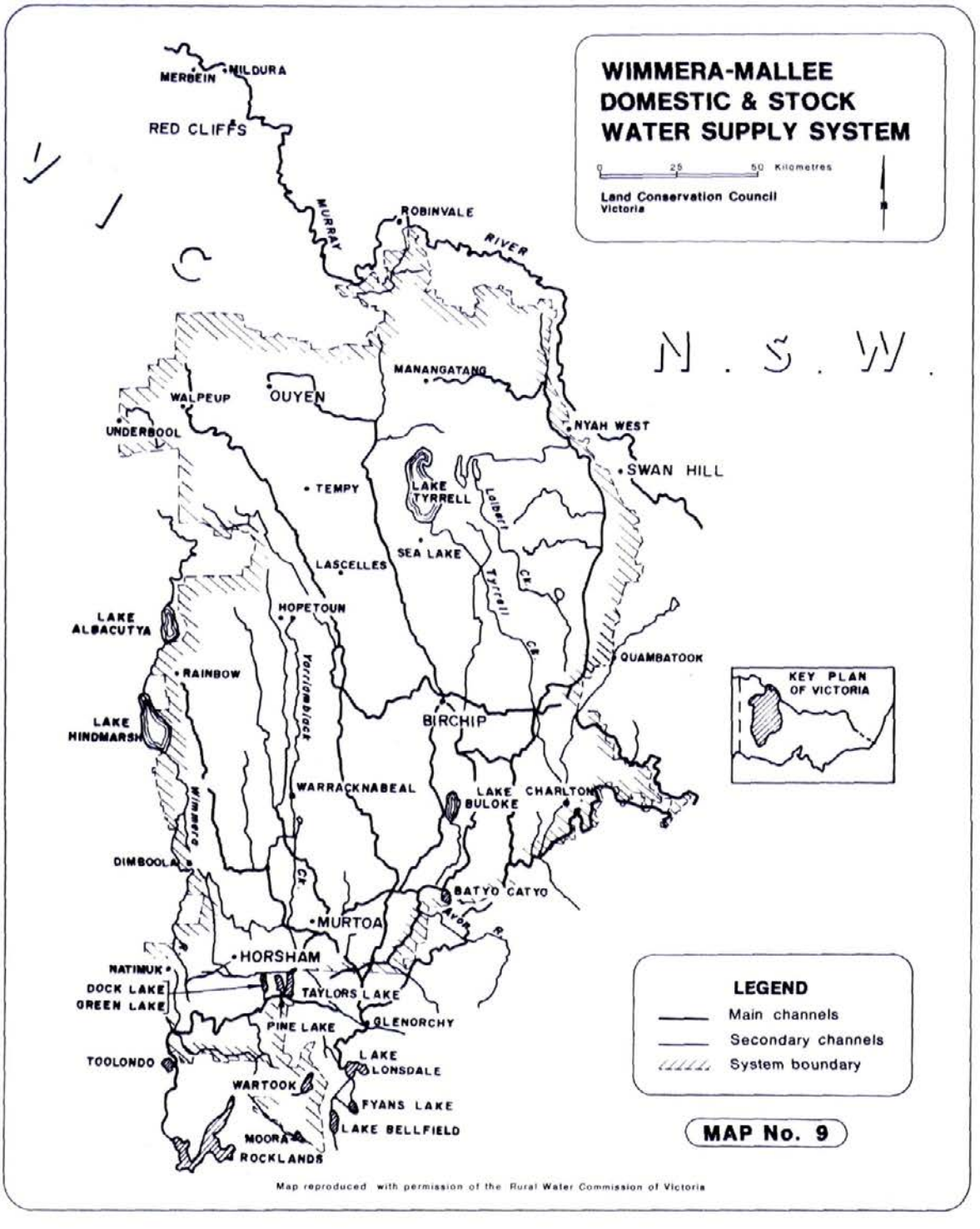
Shallow aquifers occur in this group (indicated as Wunghnu Group on Figure 13) in the far east of the study area. They consist of sand and gravel beds acting as confined and unconfined aquifers, scattered among silts and clays. The shallow sand beds are known to follow the distributory pattern of the ancestral drainage systems, which emerge from the same valleys in the Great Dividing Range as the existing streams occupy. The formation occurs mainly in the Loddon and Avoca River valleys.

Salinity of the Shepparton Formation groundwater generally increases northwards from the highlands. In the lower

reaches of the Loddon River, salinities close to the surface exceed 20 000 mg TDS per L.

WATER UTILIZATION

Due to the absence of any significant independent surface water supplies away from the Murray River, most of the agriculture of the region relies heavily on the Wimmera--Mallee Domestic and Stock Water Supply System (see Map 9) operated



by the Rural Water Commission (RWC). This system - an extensive network of dams, channels, and large storages - harvests water mainly from the Grampians region south of the study area, and distributes it to the central and eastern parts of the Mallee and Wimmera. Water from the Loddon and Goulburn Rivers to the east augments the system.

A number of important irrigation areas, both large-scale government schemes and small private operations fed from individual pumps, have been developed along the Murray River. The river is also the source of urban water supplies for the many communities established along it.

In 1962, the River Murray Commission investigated a proposal to construct a dam on the Murray River at Chowilla in South Australia, about 8 km from the Victorian border. If built, the dam would have backed water up the River almost to Wentworth, inundating large areas of public and freehold land. Investigations for the project were well advanced, and freehold land that would be affected had been acquired by the authorities involved at the time. The scheme was shelved in favour of the Dartmouth Dam on the Mitta Mitta River in north-eastern Victoria. This was completed in 1980. Due to technical and economic considerations, it now seems unlikely that the Chowilla project will ever be undertaken as originally proposed.

Although the Commission has proposed that new studies be undertaken into possible projects at Chowilla, at present it has no resources to commit to these studies. Land acquired for the project in Victoria is currently leased back, by the RWC, to farmers for grazing and other purposes, mostly under 15-year leases. The recently formed Murray-Darling Basin Commission is successor to the River Murray Commission.

Landholders adjacent to streams or water bodies may be authorized by the RWC to divert water for irrigation, domestic and stock supply, and other purposes. Appendix III contains information on all private surface water diversions within the study area, both for irrigation and for domestic and stock purposes. There are only a few private diversions authorised for industrial purposes.

Away from the rivers and outside the supply zones of water-supply systems, groundwater is the only reliable source of water. In the west, some is used for irrigation; outside the public supply systems west of Underbool, at Telopea Downs, and at Rainbow, some is used for domestic and stock supply; and some at Murrayville, Nhill, Cowangie, and a number of smaller towns is used for urban supplies and for industrial purposes such as salt-harvesting. The availability of good-quality groundwater obviated the need to extend the stock and domestic water system into these areas.

For an area 40 km wide, 20 km either side of the Victoria--South Australia border, the groundwater resource has been protected from unregulated large-scale withdrawals (which could threaten supply to existing users) by the enactment, in 1985, of a Border Agreement (Groundwaters) signed by both governments. A joint Review Committee has been established

to oversee the management of groundwater resources within this border area.

Stock and Domestic Water Supplies

History

The history of settlement of the Mallee is closely linked with the provision of adequate water supplies. Without an assured supply, the present level of development would not have been possible and the nature of the agricultural enterprises would have been different - with greater emphasis on dryland farming and fewer head of livestock being carried.

The first scheme to regulate and control water in the north-west of the State was initiated around 1856 by the Wilson brothers of Longerenong, who dammed the Wimmera River to divert water into Ashens and Yarriambiack Creeks. The first major water storage for the Wimmera River system - built in the Grampians in the head of the Mackenzie River, to form Lake Wartook - was completed in 1887.

In the dry period culminating in the 1902 drought, the system partially failed, and this led to the damming, in 1903, of Mount William Creek east of the Grampians to form Lake Lonsdale. By this time, a number of rural Waterworks Trusts had been established, and divided control of the headworks caused disagreement and problems relating to finance and rate collection.

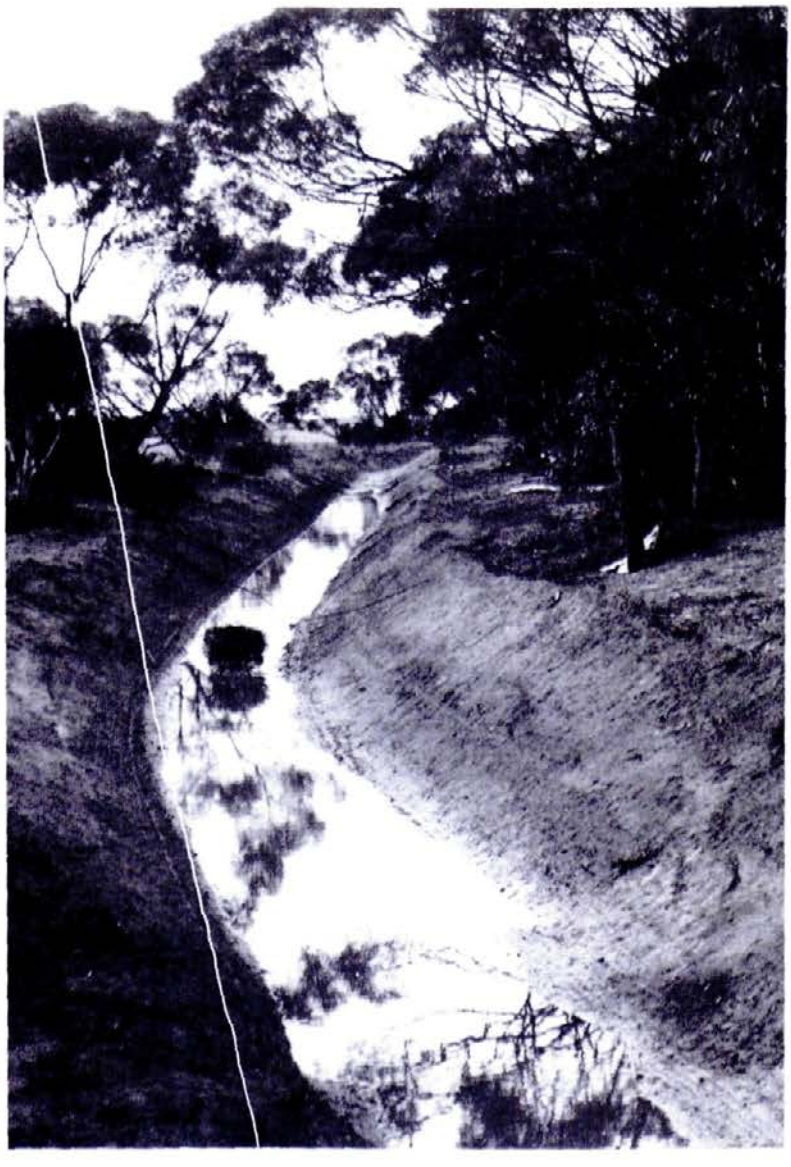
The *Water Act* 1905 was passed in an endeavour to co-ordinate distribution and utilization of available supplies. All the natural streams and waters in Victoria were declared the property of the Crown. Under the provisions of the Act, the then State Rivers and Water Supply Commission took control of the scheme in 1906 (and remained the responsible Authority until July 1984, when the RWC was formed).

Construction of major channels and storages followed, with the largest storage, Rocklands Reservoir, being completed in 1953. Rocklands is located on the south-flowing Glenelg River and water from it is diverted north through a tunnel. The last storage to be constructed as part of the Grampians headworks was Lake Bellfield on Fyans Creek in 1966. In 1971, a pipeline diverting some of the flow from the south-flowing Wannon River to Lake Bellfield was constructed.

Since 1923, water has been supplied to the Millewa district, on the plains west of Mildura, by pumping from the Murray River. This system was reconstructed once after the drought in the mid 1940s and again in the early 1970s, when the inefficient earthen channels and storages were replaced with pipelines and impervious on-farm storages. Prior to this work, about 95% of the water pumped into the system was lost through evaporation and seepage.

Operation of the systems

The Wimmera--Mallee Domestic and Stock Water Supply System is one of the most extensive gravitational supply systems in



The Wimmera--Mallee Domestic and Stock Water Supply System includes some 16 100 km of open channels.

the world, covering a total of 28 500 sq. km and supplying 20 500 farm dams in 15 760 holdings through a total length of 16 100 km of open channels (RWC 9600 km, private 6500 km). The system also supplies domestic water for 51 towns (38 operated by RWC and 13 by Water Boards or local government bodies). Irrigation areas in the Wimmera are also supplied.

Water from the headworks storages in the Grampians is released during the cooler and wetter months of late autumn, winter, and early spring to minimize losses through seepage and evaporation. All farm dams and town storages are filled once a year and this volume of water must then last until the following year. The northern-most points in the system receive water first and those nearest the headworks last.

The Millewa System supplies water to about 126 holdings on a total area of 227 000 hectares. Water is initially pumped from the Murray River to Lake Cullulleraine and is then repumped to a balancing storage and piped reticulation system. Subsequent to the completion of the pipelining in the 1970s, a continuous pressurized supply of water for domestic and stock use has been available.

Other smaller systems include the Carwarp--Yelta and Tyntynder North Waterworks Districts. About 153 dams are filled in the first District and 104 are filled in the latter.

In areas not supplied by these public systems, stock and domestic water is obtained from groundwater bores and rainwater. A number of private diversions have also been installed on the Murray River and the large grazing licences on public land utilize catchment tanks (dams).

Proposed pipelining

The current release from the headworks to provide for the Wimmera--Mallee Domestic and Stock System is about 166 070 megalitres a year (including 30 000 ML for irrigation near Horsham and Murtoa in the Wimmera). Only about one-third of the water released into the whole system is delivered to the users; the balance is lost through seepage and evaporation.

Studies have indicated a level of overcommitment of the system and at present its security is inadequate. In practical terms, it could be expected that, at current demand levels, the system would suffer major water restrictions on average about one year in every 40. In those years, the normal damfill flow of water would not be available in all parts of the system, and road or rail transport would be necessary to deliver emergency supplies.

Demand over recent years has increased at an annual rate of 1.5 to 2% through increased domestic consumption, the introduction of feedlots for stock, and extra dams, thus further eroding security.

Possible means of restoring security of the system and meeting future requirements include reducing irrigation usage in the Wimmera, constructing additional storages in the Grampians, and improving the efficiency of the system and on-farm distribution by pipelining. The Rural Water Commission has undertaken a number of detailed investigations since 1982 and has concluded that pipelining is the most economical and environmentally acceptable way of restoring security and meeting increased demand.

The supply district north of Sea Lake (about one-third of the whole system) was identified as having the highest priority for pipelining and, in 1985, a detailed feasibility study and an outline design were prepared. An estimated annual saving of some 70 000 ML of water would be achieved from pipelining this area. At present about 80% of the water released into the northern Mallee is lost.

Benefits of the scheme include the restoration of adequate security of supply (to meet existing irrigation requirements and new urban, domestic, commercial, and stock demands), the cessation of seepage and associated salinity, the availability for cropping of land currently occupied by channels, savings in operations and maintenance costs, and improved quality of water to consumers. A large number of public tanks are currently filled by means of the existing open-channel system. Should pipelining of the system proceed,

additional facilities may be required to maintain water supplies to the public tanks or other reservoirs.

A reduction in the loss of water from the supply system would also allow considerable scope for enhancing the environment of the Wimmera River, which currently has significant water-quality problems. A flushing flow could be reserved for non-consumptive use in all but the driest years, and the scheduling of flows could be based on natural conditions.

At present, funding arrangements are still being considered by the government and no assurances have been given that the scheme will proceed. West of Rainbow, water is piped to about 10 000 ha of farmland by gravity from the town's storages and a small section of pipeline to service 20 000 ha is currently being constructed near Chinkapook (Parish of Eureka).

Urban water supply

Some 26 towns in the study area receive water from the Wimmera--Mallee Domestic and Stock System, and the RWC controls and operates the water supply to all of them except Underbool, where control rests with the Walpeup Shire Council.

Most towns have an elevated service storage into which water is pumped from a main earthen storage, thus enabling reticulation through the town by gravity.

A number of other urban centres are supplied by pumping from the Murray River. The towns of Murrayville and Cowangie draw water from groundwater bores. Details of all urban water supplies are set out in Appendix IV.

As well as reticulated supplies, most residents use rainwater collected in tanks as a supplementary supply for such domestic uses as drinking, cooking, and washing.

Irrigation

Irrigation is of vital importance to communities in the north and east of the study area. The major urban centres of Mildura, Swan Hill, and Kerang have developed and grown in response to the need to provide services to the large irrigation areas that surround them. Government irrigation schemes cover about 30 559 ha in the study area, and private diverters irrigate a further 22 000 ha.

The government schemes are located along the Loddon River (near Boort and between Kerang and Swan Hill) and along the Murray River (at Nyah, at Robinvale, and in the Red Cliffs--Merbein district). These schemes are controlled by the RWC. Another scheme in the Mildura region is controlled by the First Mildura Irrigation Trust. This Trust, the only one of its type in Victoria, was established in 1896 to manage and develop the irrigation areas set up by the Chaffey brothers, the pioneers of irrigation development in northern Victoria. The Murray River is the source of supply for all the government schemes except for Boort, which receives water from the Waranga--Goulburn and Loddon storages.

A feature of private irrigation diversions along the Murray River is the number of co-operative water supply developments, wherein farmers share irrigation headworks and structures such as main supply channels and pumping stations. These schemes help to stop the proliferation of private pumping facilities along the river.

In 1985/86, government schemes delivered 290 000 ML of water. Private diverters used another 175 850 ML, with most of this being pumped direct from the Murray River, by both individuals and co-operatives.

Most of the irrigated land in the east is used for pasture enterprises while the rest mainly supports horticulture.

In the western Mallee, especially in the area around Murrayville and Cowangie, groundwater is used for the irrigation of about 815 ha. Bores here tap the Duddo Limestone and are authorized to extract a total of about 5100 ML per annum.

The disposal of excess water draining from irrigated land, the irrigation methods adopted in the past, and alterations to the groundwater tables brought about by agricultural practices have caused a number of problems in the Mallee, particularly in the form of salinity. These are discussed in Chapter 16 - Hazards and Conflicts.

Water Supply and Public Land

Most of the towns within the supply zone of the Wimmera--Mallee System have an elevated reservoir, into which water is pumped from an earthen storage. Many of the channels and town storages are located in small reserves of public land, and in its 1977 recommendations the Council proposed no changes to the use of these areas.

Some of the water supply and irrigation systems also use public land. The Millewa district in the north-west of the study area, for instance, is supplied from the Murray River, via Lake Cullulleraine and a storage at Bambill South, and then by pipelines to individual farms.

Supplies for the irrigation districts in the Kerang region are drawn from the Torrumbarry system. This diverts water from the Murray River at Torrumbarry, east of the study area, to the Loddon River at Kerang, whence it flows through a system of natural lakes connected by channels. These include the Reedy Lakes, Lake Charm, Kangaroo Lake, and Lake Boga (respectively O20, O12, O10, and O9 on Map 8) and water for irrigation and domestic use is drawn from them. Other lakes receive fresh water intermittently from the water-supply system. The lakes also play an important role in flood mitigation.

The lakes mentioned above, which would normally be dry for long periods, now receive assured supplies of fresh water and consequently have considerable value for recreation and nature conservation. Around Kerang, many species of waterbirds use and breed in them; the Second (Reedy) Lake contains Victoria's largest colony of white and straw-necked

ibis. Duck-hunting is an important recreational activity on many, and Lakes Boga (09) and Cullulleraine (01) are used extensively for boating, swimming, and fishing.

In 1977, the Council identified 17 areas in the region (01--017 on Map 8) to be used principally for the storage and distribution of water for irrigation and domestic purposes, but also for nature conservation and recreation to the extent consistent with the water supply functions.

A further four lakes - Tchum Lake, Little Lake Charm, Reedy Lakes, and Cullens Lake (018 to 021 respectively on Map 8) - are important for both water supply and wildlife conservation and (although set aside as water-supply areas) their management takes into account the other function through consultancy with the Department of Conservation, Forests and Lands. Lake Murphy and Lake Yando (D11 and D12) are similarly important for both water supply and conservation, and have been set aside as wildlife reserves, their management taking account of the water supply function.

The dryland farming districts of the Mallee contained a large number of public tanks (dams) filled by the channels of the Wimmera--Mallee System. Most of these tanks are located in water reserves, although some are on road reserves and channel easements.

Extension of the channel system to private tanks on farms, and the use of road transport rather than droving to move stock, obviated the need for many of the tanks. The Council investigated their use in 1977 to assess requirements and to clarify uncertainty as to the public or private status of a number of them. After consideration of such factors as road-making and maintenance, fire-fighting, the needs of landholders in fringe areas, public use, regulation of the water distribution system, and private diversions, some 170 tanks in the Mallee were retained for public purposes and will continue to be filled through the water-supply system. Small reserves containing these public tanks were set aside by the Council; these are indicated as 023 to 0194 on Map 8. Those tanks required for private purposes are filled by the RWC after it accepts an application for a diversion licence.

Wetlands

Regulation of natural water supplies for irrigation and stock and domestic use, combined with the establishment of extensive agricultural areas, has changed the nature of many of the Mallee's streams and wetlands. While some of these changes might have benefited some native plants and animals, others have made the wetland areas of the Mallee less suitable as habitat for native species.

Changes to streams include the following.

- Seasonal flow regimes have altered. Water is stored in dams at times of high flow and released at times of low natural flow. For the Murray River and wetlands associated with this stream, high summer flows and reduced winter flooding are causing concern, particularly in

regard to the health of river red gum forests. Locks on the river, installed to assist the movement of water craft, have permanently inundated and killed small areas of river red gum.

- Flows have fallen. Stream flows are diverted for off-stream uses such as irrigation and stock and domestic use. The Wimmera River--Outlet Creek system provides an example. Historical records indicate that, last century, the waters of the Wimmera River reached as far north as Wirrengren Plain about every 20 years, but they have not reached that far since the early 1920s. The viability of the vegetation associated with the lakes system through the Wyperfeld National Park is now of concern.

- Erosion and sedimentation, arising from the removal of vegetation, have occurred.

- Past stream 'improvement' works have involved removal of snags, plant growth, and other obstructions to flow. This has increased the rate of flow in some cases, but on the other hand has removed habitat for native fish.

- The proliferation of some plant species has been favoured by the altered conditions.

- Salinity of the water has increased through reduced seasonal flushing-flows.

Changes to wetlands include the following.

- Incorporation of wetlands into water-distribution systems has assured regular supplies of water to them,

Changing flow in the Murray River may adversely affect the health and vitality of river red gum forests and wetlands.

and this has provided extra habitat for water-birds and aquatic animals; for example, the Kerang Lakes are now important water-bird breeding areas. However, permanent inundation of some wetlands has killed the river red gum and black box trees that surrounded them, and at Kings Billabong (D1 on Map 8) periodic drying has been important in the past in maintaining the diversity of water-birds that characterized the area. The billabong is now rarely dry.

- The diversion of water away from some wetlands has meant that they are now dry for longer periods than under natural conditions. This has taken place intentionally or otherwise - for instance, through the construction of levees for flood mitigation, such as along Tyrrell and Lalbert Creeks.

- Increased salinity problems in some wetlands have been attributed to the raising of regional groundwater levels, to a lack of fresh-water flushing flows (such as at Cullens Lake), and to the use of wetlands as saline water evaporation basins.

- Some wetlands have increased in area due to the accumulation of irrigation run-off. In some instances, such as at the Sunraysia drainage basins, prolonged inundation has caused the death of trees on the fringes of the wetlands.

- The assured availability of water in previously dryland areas - such as through the construction of tanks in many small blocks of public land - has the potential to change the composition of the native fauna in the area. Some parcels of land, for instance, may now carry higher populations of kangaroos than previously, because of the presence of water.

Although water regulation and distribution works have altered wetland conditions in a number of circumstances, the RWC, in co-operation with the Department of Conservation, Forests and Lands, has attempted to preserve and enhance wildlife habitat wherever practicable. Further comments on the effects of water regulations are provided in the chapter on hazards and conflicts.

Environmental flows

Water is supplied to a number of wetlands from the RWC's distribution system according to a set of operating rules, and at a nominal price compared with normal irrigation supplies.

The question of permanent allocations of water for environmental purposes has in recent years been addressed in two major inquiries - by the Parliamentary Public Works Committee, which reported on water allocations in northern Victoria in 1982, and by the Salinity Committee, which completed that first inquiry and reported its findings to Parliament in 1984. Proposed changes to water legislation by the Department of Water Resources also address this issue.

Among other things, the Salinity Committee recommended that the annual allocation for the conservation of flora and fauna should be 25 000 ML from regulated resources and that the Department of Conservation, Forests and Lands should develop management strategies for each wetland in northern Victoria. To date, the particular wetlands involved and the volumes, charges, and conditions under which water would be supplied have not been determined.

Following a suggestion from the RWC that, in many years, big volumes of surplus water flows would be available in excess of the 25 000 ML, the Salinity Committee also recommended that water for nature conservation should receive high priority for the use of these flows. Such surplus water for the Mallee area would be available in the Murray River.

In its final recommendations for the Wimmera Area (November 1986), the Land Conservation Council expressed its belief that a significant proportion of any water saved through the proposed pipelining of the Wimmera--Mallee water-supply system should be designated for environmental use in the Wimmera River.

Rather than depend on the allocation of environmental flows from irrigation or other water-supply systems, certain wetlands in the Mallee would benefit if provisions were made to modify existing flood-mitigation works. Heywoods Lake (I42 on Map 8), for instance, no longer receives flood-waters from the Murray River because of levee banks and a dam built for adjoining farmland, and the black box stands here are deteriorating.

Recreational use of water-supply areas

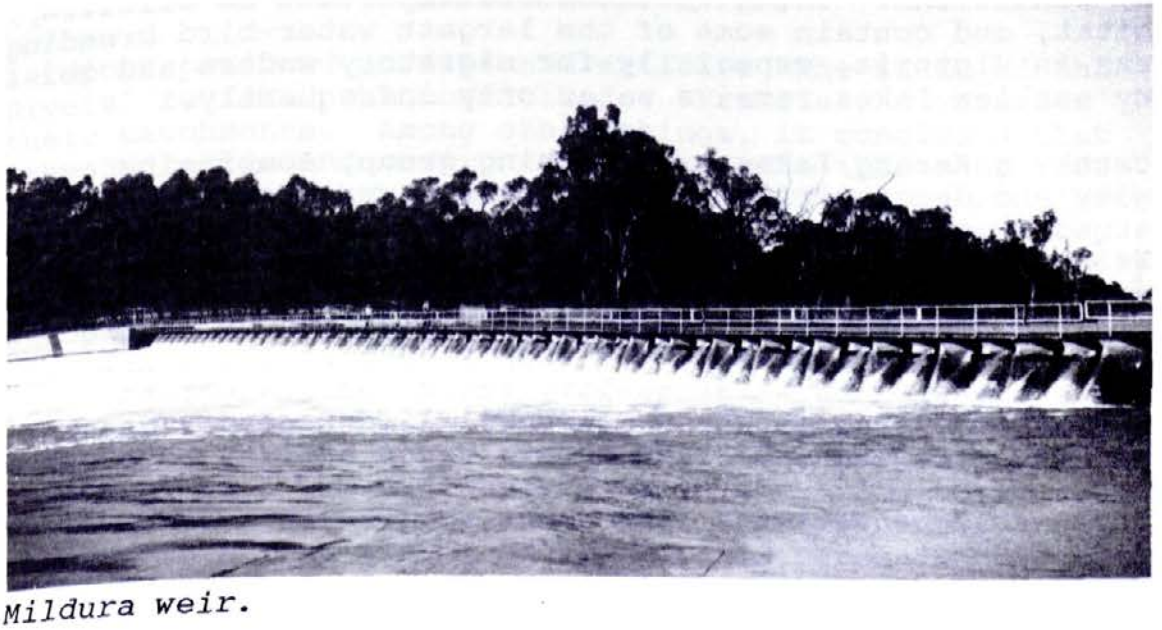
Depending on the availability of supplies, surplus flows from the Wimmera--Mallee Domestic and Stock System provide water to a total of 13 lakes approved for recreational use. Six of these - Green Lake (E7 on Map 8), Lake Lascelles, Walpeup Lake (L20), Underbool Lake, Tchum Lake South (L38), and the Yarriambiack Creek at Beulah - lie within the Mallee area. In some cases the local community has established facilities to service the recreational use of the lakes, and there is now an expectation that water supplies would continue to be made available.

Victoria has declared a total of 10 wetland areas under the Ramsar Convention (Convention on Wetlands of International Importance especially as Waterfowl Habitat). Three of these are contained or partly contained within the study area - Hattah--Kulkyne lakes, Kerang Wetlands, and Lake Albacutya. The area and capacity of all the water-bodies greater than 50 ML in size in the study area are tabulated in Appendix V.

Wetlands of particular interest are described below.

Murray River

The construction of water storages in the upper reaches and tributaries of the Murray River has reduced the frequency and duration of floods during the winter and spring months.



Mildura weir.

In addition, flows during summer and autumn are now greater than under natural conditions. There has been concern for many years that these alterations to river flow may be having an adverse effect on the regeneration and growth of river red gum and box species within forests along the river such as the Nyah and Vinifera forests, Belsar Island, Hattah--Kulkyne, Kings Billabong, and Lindsay and Wallpolla Islands. Further comment is provided in Chapter 13, Forest Produce.

The impoundments in the Murray River and its tributaries and the consequent changes in both flow and thermal regimes have had a marked effect on native fish, many of which require specific minimum water temperatures and floods as triggering mechanisms for spawning and the subsequent survival of eggs and young. The gradual elimination of the great anabranch or backwater systems of the river and its tributaries by water-control schemes, including the construction of levee banks that effectively reduce the floodplain area, has reduced the extent of waters that previously provided the necessary space and food for the young of many fish species.

Fish such as Murray cod and golden perch have only reproduced in large numbers when extensive floods have occurred at spawning time.

The Rural Water Commission and the Department of Conservation, Forests and Lands are co-operating in an interdepartmental State Working Group that, since 1979, has been examining measures that may overcome the problems of reduced winter--spring flooding. The River Murray Commission also recently published the results of a comprehensive survey of wetlands along the Murray River floodplain, and is currently conducting a study of riparian vegetation along the river.

Kerang Wetlands

Many of the lakes here form part of the water distribution system and now hold water for longer periods than under nat-

ural conditions. These wetlands are important as wildlife habitat, and contain some of the largest water-bird breeding areas in Victoria, especially for migratory waders and ibis. Many smaller lakes receive water only infrequently.

Recently a Kerang Lakes area working group, comprising community and departmental representatives, was formed and charged by government with the responsibility of developing a Kerang Lakes area management plan. This is expected to address, among other things: the problem of rising salinity in Lake Charm caused by rising groundwater and by its location as a terminal lake in the supply system; the question of water supply and water quality in Cullens Lakes; the rising groundwater in The Marshes Wildlife Reserve; and the long-term management of Lake Boga.

Hattah--Kulkyne National Park

The lakes in this National Park are a series of depressions lying on the floodplain of the Murray River. They fill during periods of high river flow, when water flows into them through Chalka Creek, an anabranch of the Murray River. During this century, the lakes have received water on average once every 2--3 years.

Over the last two decades, the upstream reaches of Chalka Creek have been deepened to permit more water to flow to the lakes and regulators have been installed to prevent water flowing back to the Murray during periods of low river flow, so as to increase the amount of water available for domestic and stock use at Hattah. These measures might have compensated for the lower frequency of high levels in the Murray River that has occurred through regulation, as the lakes in the park remain valuable water-bird habitat.

Lake Albacutya--Outlet Creek

The Wimmera River flows from the highlands of central Victoria into Lake Hindmarsh on the edge of the study area. In wet years, Lake Hindmarsh overflows into Outlet Creek, which then carries water to Lake Albacutya. Records show that, since the turn of the century, Lake Hindmarsh has overflowed on at least 12 separate occasions. Lake Albacutya last filled in 1975.

The course of Outlet Creek continues north from Lake Albacutya, and the river red gum and black box woodlands associated with the creek are an important feature of Wyperfeld National Park. The creek last flowed into the park between 1975 and 1977, but did not fill the whole wetland system here.

Over the years there have been a number of proposals to increase water flow to the downstream end of the Wimmera River system. A feasibility study carried out by the RWC in 1980 indicated that proposals to augment supplies to Lake Albacutya were impracticable, due mainly to the large volumes of water required, the high capital cost, and the limited agricultural benefits obtainable. This, however, may change if pipelining of the Wimmera--Mallee system proceeds.

State of the Rivers

A report produced in 1984 and entitled 'The State of the Rivers' reviewed the condition of Victoria's rivers and their catchments. Among other things, it concluded that 'the hydraulic and environmental characteristics of most Victorian rivers have changed dramatically since settlement. Moreover the present condition of many of the rivers and their frontages is unsatisfactory and is becoming steadily worse with every flood.' Streams within and adjacent to the study area are no exception.

Deterioration of the State's rivers has stemmed from a lack of understanding about stream-flow characteristics and the effects of various activities on both the waterway and the catchment as a whole. Human interference to natural aquatic systems has created imbalances that result in drastic changes to stream flows, sediment yield, groundwater, water quality, habitat, and other environmental values.

River Improvement Trusts have been established since the 1950s to attempt to remedy these problems and to try to re-establish stable stream regimes. Works undertaken by the Trusts include:

- erosion-prevention and control works on the bed and banks of streams, such as planting trees and other vegetation and installation of rock beaching
- maintenance of adequate carrying capacity - for example, by the removal of snags and accumulated erosion sediments

There are two River Improvement Trusts in the study area - Avoca and Pental Island. The former Trust produced a 'Master Plan' for the Avoca River in 1985, which included a proposed management strategy for the whole catchment. Major problems identified in this catchment include:

- cumbungi growth and associated siltation
- accumulation of debris and snags
- the growth of vegetation along floodways, including lignum and regeneration of other native species
- deterioration of natural drainage paths caused by farming activities
- unco-ordinated construction, operation, and maintenance of levees and other flood-mitigation works
- flood damage
- altered water balances in natural lakes and swamps
- salinity

Many of the problems listed above aggravate flood damage. The main function of the Pental Island River Improvement

Trust is to construct and maintain a system of levee banks to protect rural lands on Pental Island from flooding. The Trust is continuing with a program of levee construction, as funds permit.

Throughout the study area clearing of the original vegetation for agriculture has caused groundwater levels to rise, and saline groundwater has moved into streams. Clearance of vegetation also results in increased soil erosion.

The Murray and Loddon Rivers are regulated for water-supply purposes and carry artificially high volumes of water in the summer--autumn months. In some instances, this has resulted in tree death and increased bank erosion.

References

Avoca River Improvement Trust (1985). 'Avoca River Master Plan - Final Report.'

Cadwallader, P.L., and Backhouse, G.N. (1983). 'A Guide to the Freshwater Fish of Victoria.' (Government Printer: Melbourne.)

Dexter, B.D., Rose, H.J., and Davies, N. (1986). River regulation and associated forest management problems in the River Murray red gum forests. *Australian Forestry*, 49(1).

Government of Victoria (1987). 'Salt Action: Victoria's Strategy for Managing the Salinity of Land and Water Resources.' (Draft) (Government Printer: Melbourne.)

Grenfell, P.L. (1975). 'Water Supplies in the Wimmera--Mallee.' (Report to Longerenong Agricultural College: Dooen.)

Land Conservation Council Victoria (1974). 'Report on the Mallee Study Area.' (Government Printer: Melbourne.)

Lawrence, C.R. (1975). Geology, hydrodynamics and hydrochemistry of the southern Murray Basin. *Memoirs of the Geological Survey of Victoria*, No.30.

Macumber, P.G. (1980). The influence of groundwater discharge on the Mallee landscape. In 'Aeolian Landscapes in the Semi-arid Zone of South Eastern Australia'. (Australian Society of Soil Science: Riverine Branch.)

Macumber, P.G. (1983). Interactions between groundwater and surface systems in northern Victoria. Ph.D Thesis, University of Melbourne.

McNab, R.F. (1939). The romance of the Wimmera-Mallee water supply system. Report in *Spillway*, an unpublished internal bulletin of the State Rivers and Water Supply Commission, Victoria.

McNab, R.F. (1944). 'The Early Settlement and Water Supply of the Wimmera and Mallee.' (Report to State Rivers and Water Supply Commission, Victoria.)

Myers, R.D. (n.d.). Classification of Victorian inland water bodies - physical and chemical characteristics. *Ministry for Conservation, Victoria, Environmental Studies Series, Publication* No. 361.

Parliamentary Salinity Committee (1984). 'Salt of the Earth: Final Report on the Causes, Effects and Control of Land and River Salinity in Victoria.' (Government Printer: Melbourne.)

Pressey, R.L. (1986). Wetlands of the River Murray below Lake Hume: report to the River Murray Commission. *Rural Water Commission Environment Report* No 86/1.

Rural Water Commission of Victoria (1985). 'Detailed Feasibility Study and Outline Design for Pipelining Northern Part of Domestic and Stock System.'

Rural Water Commission of Victoria (1985). 'Study of Future Management of Barr Creek and Catchment.' (T & H Hunter Pty. Ltd.: Melbourne.)

Rural Water Commission of Victoria and Water Resources Commission of New South Wales (1986). 'Murray River Flood Plain Management Study.' (T & H Hunter Pty. Ltd.: Melbourne.)

Standing Consultative Committee on River Improvement (1984). 'The State of the Rivers.' (Government Printer: Melbourne.)

State Rivers and Water Supply Commission (1984). 'Victorian Surface Water Information to 1982.' (Government Printer: Melbourne.)

Water Resources Council, Victoria (1978). 'Flood Plain Management in Victoria.'

7. VEGETATION

No vegetation mapping or detailed descriptions of the plant communities were undertaken for the Council's 1974 report on the Mallee area, and discussion was limited to a very general description of the component species of the major structural forms. From the outset of this review, the Council recognized that it required a comprehensive study of the vegetation on public land, to provide an objective base for future land-use decisions.

The Department of Conservation, Forests and Lands undertook a major study to determine the nature and location of the plant communities on public land in the Mallee area and to prepare a floristic map of the region. Interpretation of aerial photographs and Landsat images was undertaken by Mr I. Roberts, and Mr D. Parkes co-ordinated the sampling of the vegetation types and the analysis of the information to determine the vegetation communities.

Commencing in the Big Desert in spring 1985, the study continued until early 1987. Analysis of the information and compilation of the results were completed in October 1987. In all, some 1300 individual plots (quadrats) were included in the analysis. No such intensive investigation of a large expanse of semi-arid vegetation has been undertaken elsewhere in Australia.

The Council also employed botanists to provide information on the nature and status of the vegetation on the small blocks of public land within this predominantly agricultural region. In particular, Mr D. Ashwell mapped and described the vegetation on the floodplain of the Murray River. Information from these studies was integrated with that compiled by Mr Parkes and others within the Department.

Concurrent with the vegetation survey, the National Parks and Wildlife Division of the Department undertook surveys of the fauna of the region. The habitat of most species of native fauna is strongly vegetation-dependent, and the plant communities described in this chapter are the same as those described in Chapter 8 (Fauna) as faunal habitat.

Map 10,'Floristic Vegetation', indicates the complexity of the vegetation on public land in the Mallee area. It is, however, a simplification of the situation and some stylization has been necessary where the communities occur as complex mosaics of small patches or in thin bands. Because of the vast area to be covered and limited access, not all boundary information has been checked on the ground and future modification may be necessary. The Department is preparing a series of 1:100 000 map sheets that will incorporate necessary amendments.

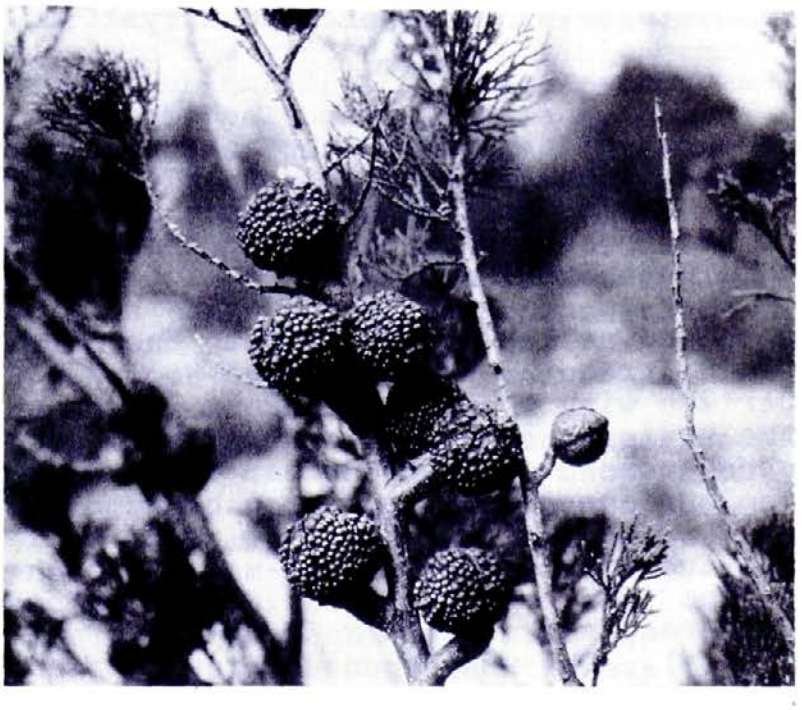
The name 'mallee' (of Aboriginal origin) is used generically for certain eucalypt species, for the vegetational formation in which they occur, and for the region in Victoria that was predominantly covered by this vegetation.

Mallee vegetation is confined chiefly to parts of Western Australia, South Australia, western New South Wales, and north-western Victoria. It comprises a dense scrub of several layers of dwarf to tall shrubs and low trees. Mallee eucalypts are characterized by their growth form of several slender trunks, usually 3 to 6 m high, arising from a single large underground lignotuber ('mallee root') and producing an umbrella-like crown. In the study area the uniform canopy of mallee scrub covers vast areas of sand-hill country.

Ground flora in mallee scrub consists of grass hummocks or bushes and semi-shrubs and/or annual grass and perennial herbs. Interspersed with the mallee are considerable areas of dry heath, grassland, and saltbush, as well as succulents on the beds of salt-pans and gypsum flats.

Open stands of small trees usually 5 to 9 m in height and widely separated are termed woodlands. In the study area, the woodlands on the floodplains comprise principally eucalypts, while those on drier sites are formed chiefly by species of *Casuarina* and *Callitris* with a range of associated small trees.

The semi-arid climate is the major influence on the vegetation of the Mallee, and most species show adaptations to dry conditions. High soil salinities are also important in some places. Many ephemeral plants appear in winter and spring.



Many plants in the Mallee show adaptation to semi-arid conditions - leaves and cones of scrub cypress pine.

In the eastern half of the study area and in large expanses of the west, the original scrub has been cleared for agriculture, but occurrences along roads and in reserves preserve remnants of the original vegetation and provide diversity to an essentially agricultural landscape.

Grazing by rabbits and livestock over a large proportion of the remaining native vegetation has also had a major impact, leading, in many cases to changes in composition, structure, and, in places, to soil erosion.

Fire has always been an important factor in determining the nature of the vegetation of the region and it is likely that the alterations to the frequency of occurrence and intensity of fire brought about since settlement have caused further changes.

The impacts of both grazing and fire are discussed later in this chapter.

Vegetation Communities

Appendix VI provides a list of the plants of the study area. The individual species do not necessarily occur alone in discrete areas, but often occupy particular niches in the environment with other species with sufficient frequency for them to be recognized as forming communities (although each one may also occur with others in different combinations to form further recognizable communities). Almost 100 sub-communities have been identified in the Mallee area and these have been combined into 31 major communities, which are further amalgamated into 6 regional assemblages.

The regional assemblages and communities are indicated on Map 10 and described below. Appendix VII indicates the character species of these communities and their frequencies of occurrence. Introduced species are indicated by an asterisk before the scientific name.

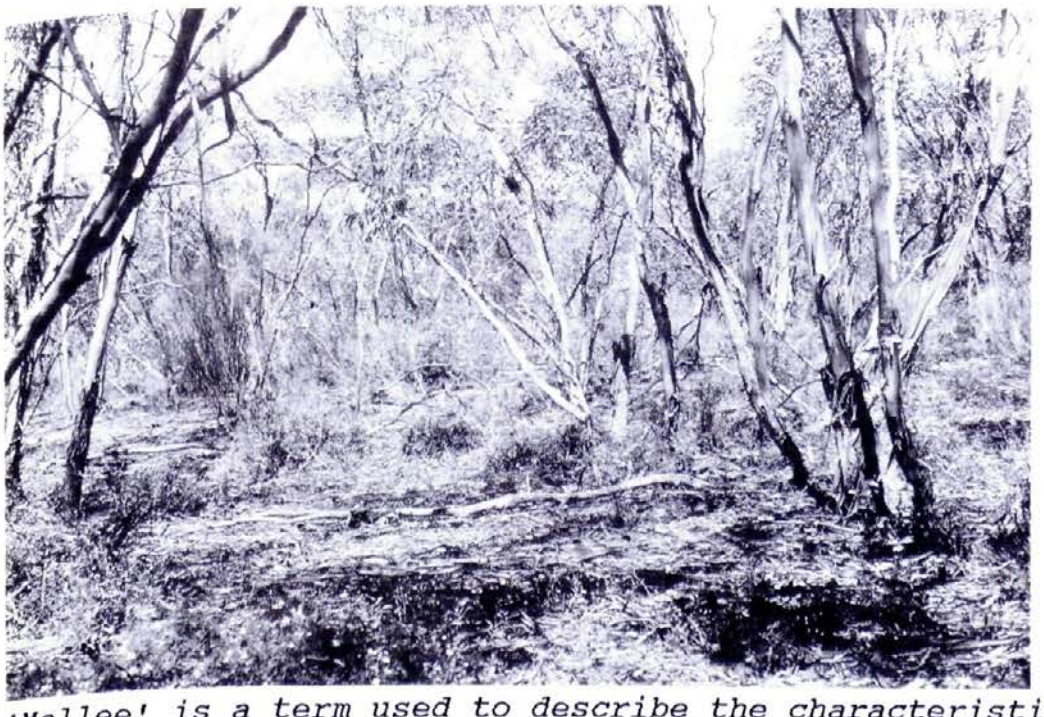
Dune-fields of the Sunset Country

Chenopod mallee

The most widespread of the aeolian landforms in the Mallee is the linear east--west dune-field of the Woorinen Formation. This landform is older than the parabolic dune-field of the Lowan Sand, and has more stable dune positioning and more weathered soils.

Chenopod mallee occurs in both the narrow east--west and broad irregular swales of the Woorinen Formation. In comparison with those on adjacent dunes, the red-brown soils of the swales are heavier, with more clay and/or loam. Limestone concretions (calcrete) often occur at or just below the surface, particularly on broad, lower-lying plains.

The overstorey of chenopod mallee is characterized by oil mallee (*Eucalyptus oleosa*), white mallee (*E. gracilis*), and, at times, red mallee (*E. calycogona*) or dumosa mallee (*E. dumosa*). The very open understorey is typified by scattered low shrubs and semi-shrubs (particularly from the families Chenopodiaceae and Zygophyllaceae), notably erect blue-bush (*Maireana pentatropis*), other *Maireana* spp., shrubby twin-leaf (*Zygophyllum aurantiacum*), pointed twin-leaf (*Z. apiculatum*), Mueller daisy-bush (*Olearia muelleri*), and stiff westringia (*Westringia rigida*). The open ground layer in-



'Mallee' is a term used to describe the characteristic growth habits of a group of eucalypt species.

cludes horned saltbush (*Sclerolaena diacantha*) and numerous annual herbs and perennials, notably burr stickseed (*Omphalolappula concava*), rabbit-tails (*Ptilotus seminudus*), and spear-grasses including the '*Stipa scabra* group' and feather spear-grass (*Stipa elegantissima*). In contrast with adjacent communities, porcupine grasses (*Triodia* spp.) are generally absent.

As the community name implies, a distinctive suite of low chenopod shrubs characterizes the ground layer. This group includes goosefoot (*Chenopodium curvispicatum*), frosted goosefoot (*C. desertorum*), ruby saltbush (*Enchylaena tomentosa*), rosy blue-bush (*Maireana erioclada*), radiant blue-bush (*M. radiata*), woolly-fruit bassia (*M. sclerolaenoides*), and oblique-spined saltbush (*Sclerolaena obliquicuspis*). Most of these species also occur in the woodlands of the heavier soils and grasslands, indicating the close affinities of chenopod mallee with these non-mallee communities.

Shallow-sand mallee

This community is intermediate between the chenopod mallee of the swales and the east--west dune mallee and deep-sand mallee of the dunes. It occurs in a range of situations where a relatively shallow layer of sand overlies the heavier soil of the Woorinen Formation - for example, where parts of the Woorinen Formation are partially exposed after being covered by deep Lowan Sand, on low east--west dunes adjacent to chenopod mallee, in sandy swales between east--west dune mallee, and in broad sand-filled depressions that are ancient remnants of groundwater-discharge activity.

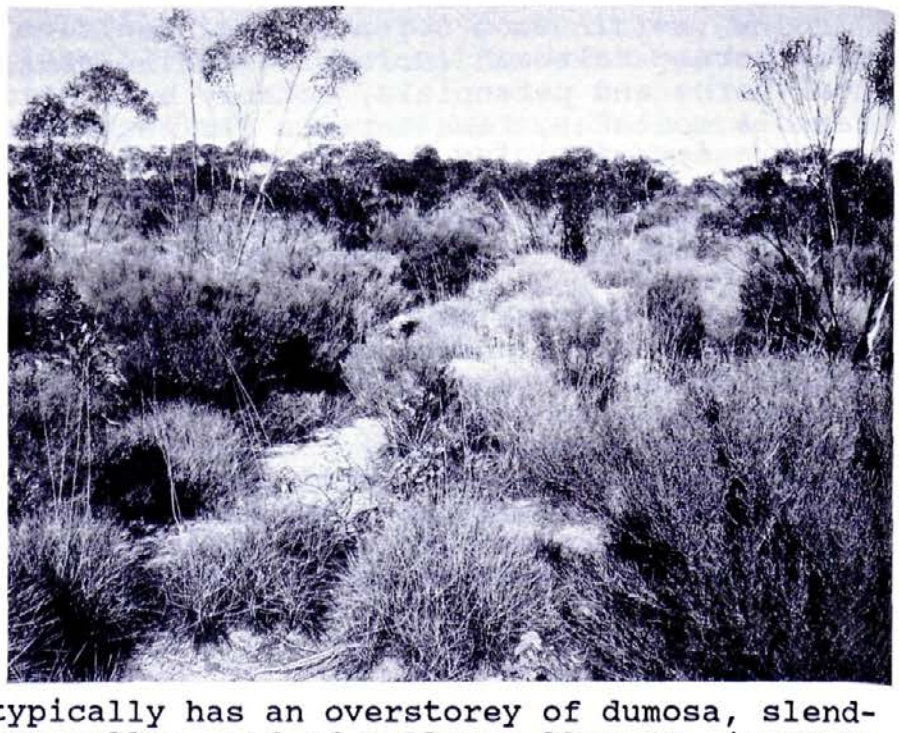
The overstorey is characterized by one or more of dumosa mallee, slender-leaf mallee (*E. foecunda*), grey mallee (*E. socialis*), and, at times, white mallee.

Dwarf nealie (*Acacia wilhelmiana*), moonah (*Melaleuca lanceolata*), and stiff westringia are often present in the shrub layer. Porcupine grasses typically dominate the ground layer, which otherwise supports an admixture of sandy-soil annual herbs and perennials such as erect blue-bush and horned saltbush, typical of heavier soils.

On low east--west dunes in the north-west of the Sunset Country, shallow-sand mallee is dominated by the distinctive silver mallee (*E. cyanophylla*), which is closely related to dumosa mallee and appears to replace it in this situation. Further south, on several broad depressions, low 'whipstick' forms of dumosa, white, and grey mallee typify the community, suggesting that these species, which are not usually found together, are growing in sub-optimal conditions. This is consistent with the transitional or intermediate nature of shallow-sand mallee.

East--west dune mallee

To the north of the Sunset Country, dunes with compact sandy-clay cores, overlain on their crests by pale orange sand, support east--west dune mallee.



East--west dune mallee.

The community typically has an overstorey of dumosa, slender-leaf, and grey mallee, and of yellow mallee (*E. incrassata*) that is at the northern limit of its distribution in the State. Depending on the sub-community, the open shrub layer may include nealie (*Acacia rigens*), dwarf nealie, scrub cypress-pine (*Callitris verrucosa*), desert phebalium (*Phebalium bullatum*), and/or small-leaf mint-bush (*Prostanthera microphylla*).

The ground layer characteristically comprises a more or less continuous sward of porcupine grasses with a suite of annual herbs seasonally prominent in the gaps. Composites are particularly notable among the herbs here and include a number of arid zone species like wirewort (*Asteridea athrixioides*) and wingwort (*Ceratogyne obionoides*).

Deep-sand mallee

Parabolic and irregular dunes of loose pale-yellow sand were created when the Lowan Sand spread from the west in a broad band across the southern Sunset Country. These deep dunes are younger, less weathered, and less stable than those of the Woorinen Formation and are still slowly encroaching on the Raak Plain at the eastern edge of the Sunset Country.

Deep-sand mallee occurs on both dune crests and swales of the Lowan Sand dune-field. Yellow mallee dominates the community, with small cooba (*Acacia bivenosa*) and green tea-tree (*Leptospermum coriaceum*) common in the open shrub layer. The ground layer typically supports scattered golden pennants (*Glischrocaryon behrii*) and common porcupine grass (*Triodia irritans*) and a diverse array of annual herbs including many composites, notably satin everlasting (*Helichrysum leucopsideum*).

Among the Sunset Country communities, this one most resembles the widespread mallee heath of the Lowan Sand dune-fields of the Big Desert. However, it lacks the diverse low shrub layer and varied perennial ground layer typical of the heaths.

Dune-fields of the Big Desert and Wyperfeld Park

Dune-crest tree-heath

This community is restricted to the crests of major parabolic and irregular dunes of Lowan Sand in the Big Desert. It has an overstorey characterized by stunted brown stringybark (*Eucalyptus baxteri*), often with yellow mallee. The tall, open shrub layer typically contains broom baeckea (*Baeckea behrii*), scrub cypress pine, and green tea-tree. The ground layer is very open, with a virtual absence of porcupine grass, which probably relates to the unstable surface of the exposed and slowly moving crests.

Several species are closely associated with, and indicative of, the dune-crest environment - wallowa (*Acacia calamifolia*), snow myrtle (*Calytrix alpestris*), slaty she-oak (*Casuarina muelleriana*), and heart-leaf beard-heath (*Leucopogon cordifolius*).

Dune-crest tree-heath resembles the deep-sand mallee on the taller dune crests towards the south of the Sunset Country, and the obvious affinities between the two communities mean that they are not always readily distinguishable. Nevertheless, snow myrtle and brown stringybark are not found north of the Big Desert.

Sand-plain heath

Although it has not been observed in the Sunset Country, sand-plain heath is widespread on the Lowan Sand of the Big Desert. It occurs in two situations: on minor dunes surrounded by mallee heath; and dominating vast open plains where the eastwardly-advancing Lowan Sand has pooled behind underlying sandstone ridges that have blocked its path.

The heath is typically treeless, although scattered slender-leaf mallee or yellow mallee may occur. The canopy consists of a more or less dense shrub layer, at heights of between 1 and 2 m, dominated by desert banksia (*Banksia ornata*), dwarf she-oak (*Casuarina pusilla*), and either green tea-tree or heath tea-tree (*Leptospermum myrsinoides*). Desert banksia is more prominent towards the crests of the dunes.

Many of the undershrubs, sedges, and other perennial monocotyledons of the diverse ground layer are common to this community and mallee heath. Heath-myrtle (*Micromyrtus ciliata*) is indicative and ubiquitous. The sub-community character species include gland flower (*Adenanthos terminalis*), common correa (*Correa reflexa*), prickly geebung (*Persoonia juniperina*), and heathy phyllota (*Phyllota pleurandroides*). Sclerophyllous perennial monocotyledons are also characteristic, notably tassel rope-rush (*Hypolaena fastigiata*), scale-shedder (*Lepidobolus drapetocoleus*), and the sedges - black rapier-sedge (*Lepidosperma carphoides*), sticky sword-sedge (*L. viscidum*), and matted bog-rush (*Schoenus breviculmis*). Grasses, although notably uncommon, include the distinctive long grey-beard grass (*Amphipogon caricinus*). Common porcupine grass is often present but never dominant. Annual species are notably absent, except for rare individuals of a very few widespread species, particularly sticky longheads (*Podotheca angustifolia*), small poranthera (*Poranthera microphylla*), and annual bluebell (*Wahlenbergia gracilenta*).

Tea-tree scrub

This community is closely associated with the Outlet Creek system. The encroaching Lowan Sands are over-running the creek and have already altered its course. Tea-tree scrub may represent the colonization of sand deposits that have either been derived from the riverine system or been recently blown across it. The natural firebreak that the riverine system provides may also be an important determinant of its composition.

Dense scrub, 2 to 3 m tall, of green tea-tree characterizes the community, but it usually includes a few other shrubs such as common aotus (*Aotus ericoides*), desert banksia, erect guinea-flower (*Hibbertia riparia*), or heath-myrtle. Fox-tail mulga grass (*Neurachne alopecuroidea*) is a faithful associate of green tea-tree. Sticky sword-sedge and common porcupine grass are characteristic of more open patches, where muntries (*Kunzea pomifera*) may also be prominent.

Mallee heath

While it is the dominant community of the Lowan Sand in the Big Desert, mallee heath has not been observed in the Sunset Country and is not prominent east of the Outlet Creek system. Slender-leaf and/or yellow mallee typically occur over a shrub layer dominated by scrub cypress pine, dwarf she-oak, desert hakea (*Hakea muelleriana*), and green tea-tree. The diverse shrubby understorey resembles that of the adjacent sand-plain heath, and includes common aotus, broom baeckea, desert baeckea (*Baeckea crassifolia*), common fringe

Mallee heath - swale mallee heath.

myrtle (*Calytrix tetragona*), white cryptandra (*Cryptandra leuco-phracta*), prickly cryptandra (*C. tomentosa*), erect guinea-flower, and ruddy beard-heath (*Leucopogon rufus*).

Porcupine grass is common in the ground layer, as are the sedges and other sclerophyllous monocotyledons of sand-plain heath - scale-shedder, black rapier-sedge, sticky sword-sedge, pale mat-rush (*Lomandra collina*), desert mat-rush (*L. juncea*), and woolly mat-rush (*L. leucocephala*). Mallee heath supports a greater variety of annuals than sand-plain heath, but they remain relatively uncommon when compared with other eucalypt-dominated communities.

Swale mallee-heath

This community occurs as small isolated patches throughout the Big Desert. It is intermediate between mallee heath, on the deeper Lowan Sands, and loamy sand mallee, which occurs on somewhat heavier and more fertile soils

Both slender-leaf and yellow mallees form an open canopy to a shrub layer including spiny wattle *(Acacia spinescens)*, brush heath (*Brachyloma ericoides*), scrub cypress pine, common fringe-myrtle, green tea-tree, and heath spyridium (*Spyridium eriocephalum*). The diverse shrub and ground layers include a mixture of species more typical of heathlands, such as white cryptandra, desert hakea, scale-shedder, and black rapier-sedge, as well as those more typical of loamier soils, such as nealie, Mitchell bertya (*Bertya mitchellii*), and rough halgania *(Halgania cyanea)*. Both groups of species appear to be at the limits of their (ecological) distributions.

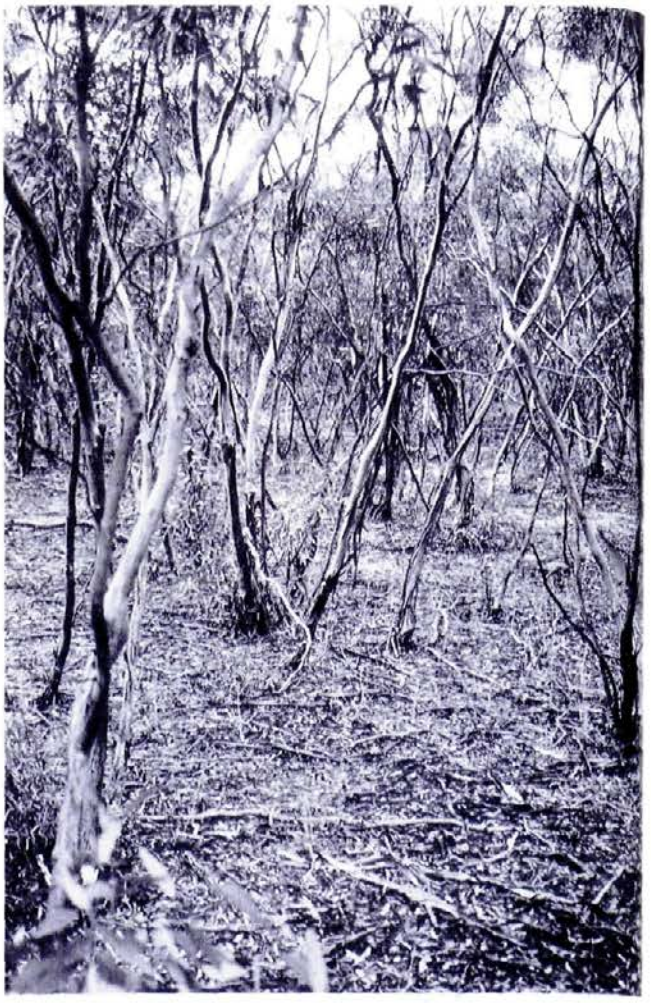
Loamy sand mallee

Wherever recent and plentiful Lowan Sand activity is absent, the dune-fields of the Big Desert and Wyperfeld areas are

Brown stringybark and, occasionally, yellow gum (E. *leucoxylon*) are scattered as an emergent tree layer over heathland containing many of the typical understorey species of mallee heath.

Red-swale mallee

This is the characteristic community of low, heavy-soil swales and plains with a strong underlying sandstone influence. Depending on the sub-community, the overstorey is dominated by one or more of red, dumosa, and grey mallees. The most distinctive sub-community, in which red and dumosa mallees adopt a 'whipstick' growth form, occurs over broad areas. Scattered shrubs of one or more of dark turpentine bush (*Beyeria opaca*), small hop-bush, moonah, and stiff westringia grow in the very open understorey. Several other distinctive shrubs may also occur, including hakea wattle (*Acacia hakeoides*), creamy honey-myrtle (*Melaleuca acuminata*), or scarlet mint-bush (*Prostanthera aspalathoides*).



'Whipstick' growth habit of red and dumosa mallee, which can be found on red swales.

The ground layer characteristically includes a few scattered specimens of wingless blue-bush (*Maireana enchylaenoides*) and horned saltbush, as well as a distinctive suite of annuals, notably blue heron's-bill (*Erodium crinitum*), *Hypoxis* species, dark plantain (*Plantago drummondii*), and swan greenhood (*Pterostylis cycnocephala*).

Big mallee

Occurring with major areas of red-swale mallee or on the margins of isolated grassy clearings, it is readily distinguishable by its large and tall mallee eucalypts, which have only one or a few thick trunks. Bull mallee (*Eucalyptus behriana*) and black mallee box (*E. porosa*) are the characteristic dominants of the community, but red mallee or dumosa mallee may also adopt such a growth form in these sites in the long-term absence of fire. The large size of the eucalypts is probably attributable to a combination of low fire frequencies, greater soil fertility, and favourable moisture status (such sites tend to be at the bases of low dunes).

The understorey is typically very open. A variety of chenopods are associated with the heavier soils, notably frosted goosefoot, nodding saltbush (*Einadia nutans*), ruby saltbush, wingless blue-bush, and horned saltbush. A limited array of opportunistic herbs characterize the ground layer. Inland pigface (*Carpobrotus modestus*) and variable groundsel are particularly prominent.

Yellow gum woodland

A number of small isolated soaks that are scattered throughout the Big Desert and Wyperfeld National Park carry this woodland. They are probably the result of superficial perched clay layers and are erratically fed by surface water.

Yellow gum typically occurs as a low stunted tree over an open understorey of variable composition. Occasionally opportunistic shrubs such as wallowa or sticky hop-bush (*Dodonaea viscosa*) are scattered across these flats. Otherwise, annual herbs, perennial grasses, or even the rhizome sticky sword-sedge may dominate the open ground layer.

Lunnettes and ridges

Pine--buloke woodland

Woodland dominated by slender cypress pine *(Callitris preissii)* and/or buloke *(Casuarina luehmannii)* occupies lunettes associated with lake-beds and creek systems. It also grows (or grew) as broader stands on solonized loams in low-lying, but non-saline, sites throughout the centre and south of the study area. Although the former is typical of deeper sands and buloke of heavier loams, the two species also occur together over broad areas.

The community has long been subject to heavy grazing pressures and very few stands can be found that are only lightly disturbed. Nevertheless, it appears that, originally, an open woody understorey of such species as umbrella wattle *(Acacia osswaldii)*, weeping pittosporum *(Pittosporum phillyreoides)*, and sweet quandong *(Santalum acuminatum)* characterized the community.

The ground cover was apparently once dominated by perennial tussock grasses and herbs and some of these still occur, notably wingless blue-bush and velvet tobacco (*Nicotiana velutina*) along with tussocks of *Stipa* species. However, the typical ground layer dominants are now mostly annuals with a substantial component of introduced species, many of them weeds such as Mediterranean turnip (**Brassica tournefortii*), smooth cat's ear, little medic (**Medicago minima*), catchflies (**Silene* spp.), clovers (**Trifolium* spp.), and squirrel-tail fescue (**Vulpia bromoides*).

An unusual form of this woodland occurs on a few sites in the far north-west of the study area, near the Murray River and west of Mildura. Here the dominant is white cypress-pine (*Callitris columellaris*) rather than slender cypress pine.

Belah woodland

This community occurs in association with major underlying sandstone ridges at Yarrara and Robinvale, and at isolated localities throughout the Sunset Country. Belah (*Casuarina cristata*) dominates a diverse and well-developed shrub layer that typically includes tall shrubs such as umbrella wattle, leafless ballart (*Exocarpos aphyllus*), cattle-bush (*Heterodendrum oleifolium*), weeping pittosporum, and usually twin-leaf emu-bush (*Eremophila oppositifolia*) and sweet quandong. The lower shrub layer, around 1 m tall, consists predominantly of desert cassia (*Cassia nemophila*), goosefoot, common emu-bush (*Eremophila glabra*), Mueller daisy-bush, pimelea daisy-bush (*Olearia pimeleoides*), and prickly fan-flower (*Scaevola spinescens*).

Such a variety of shrubs may support more lianes than is typical for the Mallee, and austral doubah (*Leichardtia australis*), purple pentatrope (*Rhyncharrhena linearis*), and climbing twin-leaf (*Zygophyllum eremaeum*) have all been recorded here.

The ground layer consists of a suite of predominantly native herbs, sub-shrubs, and perennial tussock grasses, many of which, such as delicate everlasting (*Helichrysum tepperi*), pygmy sunray (*Helipterum pygmaeum*), rabbit-tails, spear-grasses, and twin-leafs (*Zygophyllum* spp.), are indicative of heavier soils.

Savannah woodland and savannah mallee

Both communities are typically very disturbed, and the over-storey may be scattered or absent. There is considerable

Savannah mallee.

doubt that they are 'natural' plant communities - they possibly did not exist before the extensive disturbance associated with pastoral settlement.

Savannah woodland (scattered slender cypress pine and cattle bush) and savannah mallee (scattered white and grey mallees) occur in conjunction with the heavily grazed areas in boinkas and fringing the alluvial plain. Introduced species dominate the ground layer, particularly in the disturbed woodland areas. These include Mediterranean turnip, little medic, sow thistle (**Sonchus oleraceus*), and small nettle (**Urtica urens*), which is restricted to the shelter of shrubs and trees, and several grasses - red brome (**Bromus rubens*), barley-grass (**Hordeum glaucum*), Arabian grass (**Schismus barbatus*), and fescues (**Vulpia* spp.).

Grassland

A suite of introduced annual grasses, including species of *Bromus*, *Hordeum*, *Schismus*, and *Vulpia*, forms a grassland community. It is considered to be replacing the pine--buloke woodlands, the description for which applies here.

Evaporative basin (boinka)

Sand-plain grassland

Such grassland occurs in the Sunset Country on a series of open, sandy plains that lie to the south-east of the Danyo Fault (see Map 3). These slight depressions are considered to have once been active evaporative basins that were filled to various depths with sand after movement along the Fault resulted in their depression.

Cottony spear-grass (*Stipa drummondii*), desert spear-grass (*S. eremophila*), and sand wire-grass (*Aristida contorta*) dominate this community. The inter-tussock spaces contain a variety of native annuals, notably the composites orange sunray (*Helipterum jessenii*), pygmy sunray, flowery sunray (*Helipterum stuartianum*), button immortelle (*Leptorhynchos waitzia*), minnie daisy (*Minuria leptophylla*), and grey podolepis (*Podolepis canescens*). Other native herbs are also represented, including a variety of species largely restricted to this community, like lobed blue-bush (*Maireana lobiflora*), velleia (*Velleia arguta*), and notched twin-leaf (*Zygophyllum crenatum*).

Many plains areas have been subject to more or less heavy grazing by sheep, leading to the establishment and maintenance of several introduced herbs and grasses, the most prominent being little medic.

Gypseous plains grassland

In the far north-west of the Sunset Country lies an area of undulating plains associated with an evaporative basin where powdery gypsum or 'copi' is a distinctive component of the clay-loam and sandy-loam soils. The grassland occurring on the low rises and open flats of these plains is characterized by a suite of both native and introduced annuals, with

the low shrubs horned saltbush and oblique-spined saltbush, which are particularly unattractive to grazing mammals and thus are among the last shrubs to disappear from heavily grazed communities. Hoary blue-bush (*Maireana sedifolia*) and nitre-bush (*Nitraria billardieri*) may occasionally be found.

The plains are heavily grazed by sheep. All occurrences of the community in Victoria are grossly disturbed and their original composition can only be inferred. Scattered, veteran specimens of sugarwood (*Myoporum platycarpum*), together with other evidence, suggest that semi-arid woodlands still present in reserves in South Australia may approximate the original composition of gypseous plains grassland. Whatever its original composition, clearly the community is far less diverse than it was prior to the introduction of domestic stock and rabbits.

Saline shrubland

A number of evaporative basins or 'boinkas' occur throughout the Mallee. Saline shrubland is found in association with the various halite salinas that have developed within these groundwater-discharge landforms.

On saline clay pans the community is characterized by a low open shrub layer of succulent chenopods. The actual *Halosarcia* species dominant at a site depends on the frequency and depth of free water, its salinity, the gypsum content of the soil, and other physical parameters. The most common dominants, however, are grey glasswort (*H. halocnemoides*) and black-seeded glasswort (*H. pergranulata*).

These shrublands are very species-poor; the total number of plant species present varies between one and about twelve, with the introduced coast barb-grass (**Parapholis incurva*) and a crucifer - oval purse (*Hymenolobus procumbens*) - being particularly characteristic.

On the slightly higher and therefore less saline margins of the clay pans, and on broad plains where the topography does not dip quite so low, the saline shrubland is more diverse. Again, the floristic composition of the stands depends on the salinity of the site and its gypsum content. However, succulent chenopods - *Halosarcia* and *Sclerostegia* species - remain the dominant shrubs, although sea-heaths (*Frankenia* spp.) may co-dominate. Distinctive plants found here include a suite of associated herbs and sub-shrubs - notably saltbush (*Atriplex papillata*), rounded noon-flower (*Disphyma clavellatum*), and trefoil pennywort (*Hydrocotyle medicaginoides*) - and an array of tiny, ephemeral composites such as slender daisy (*Brachycome exilis*), elachanth (*Elachanthus glaber*), small nut-heads (*Epaltes tatei*), and tiny cudweed (*Gnaphalium indutum*).

Isolated gypseous rises throughout these saline shrublands usually support a different but still distinctive flora, even though they may be no more than 10 cm or so higher than the surrounding flats. Heathy blue-bush (*Maireana oppositifolia*), cottony spear-grass, and shrubby twin-leaf are par-

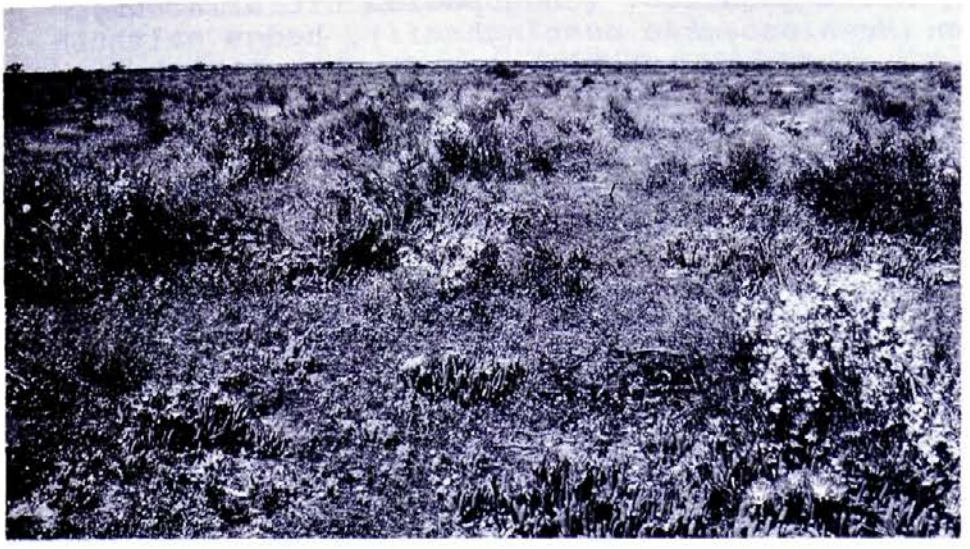
ticularly characteristic. Rare species of restricted distribution are also frequently found here, like fleshy minuria (*Kippistia suaedifolia*), swainson-pea (*Swainsona stipularis*), and rabbit-ears twin-leaf (*Zygophyllum compressum*).

Alluvial terraces and riverine plain

Alluvial-plain shrubland

Broad, flat alluvial terraces occur along the Murray River, west from Mildura to the border. Alluvial-plain shrubland dominates these virtually treeless plains.

The dominant low shrub layer, about 1 m tall, comprises chenopods, particularly bladder saltbush (*Atriplex vesicaria*), tangled bassia (*Sclerolaena divaricata*), and three-spined saltbush (*S. tricuspis*). The ground layer is characterized by rounded noon-flower and a suite of annual herbs, both native and introduced. Lower-lying areas, which are more affected by saline groundwater, usually carry black-seeded glasswort and coast barb-grass, two species typical of saline shrubland. The community contains a number of species rare or absent elsewhere in the State, although they may be locally common here. These include twining purslane (*Calandrinia volubilis*), twin-flower saltbush (*Dissocarpus biflorus*), leafless blue-bush (*Maireana aphylla*), and desert glasswort (*Pachycornia triandra*).



Alluvial saltbush shrubland.

Most, if not all, alluvial-plain shrubland is subject to sheep grazing, which, depending on its intensity, leads to the selective removal of the more palatable bladder saltbush in preference to desert glasswort and *Sclerolaena* spp. In some areas, grazing has resulted in the complete removal of perennial native vegetation, permitting severe scalding of the soil surface.

Alluvial-rise shrubland

Red-brown sandy-loam rises scattered along the alluvial plain, especially on the margins, have been built up during more arid periods by wind-blown material from the adjoining river terraces. They are also termed 'source-bordering dunes', as a reflection of this development. Such rises also

occur as one of the landforms in boinkas, so not all occurrences of the community they support are strictly alluvial.

In this community the shrub layer is usually dominated by shrubby blue-bush *(Maireana pyramidata)* to about a metre tall, but occasionally also includes either old-man saltbush (*Atriplex nummularia*) or hoary blue-bush (*Maireana sedifolia*). The ground layer includes scattered chenopods, notably baldoo (*Atriplex lindleyi*), goat head (*Malacocera tricornis*), hairy bassia (*Sclerochlamys brachyptera*), and three-spined saltbush. The inter-shrub spaces are occupied by a limited range of annuals, including a number of introduced species like Arabian grass.

Even more than with alluvial-plain shrubland, alluvial-rise shrubland is usually degraded by stock-grazing, and severely disturbed by rabbits and their warrens. The sandy rises of these shrublands provide the best burrowing areas on the alluvial plains.

Black box--chenopod woodland

The Murray River floodplain is characterized by black box--chenopod woodland, which is scattered from the south-east of the study area to Lindsay Island. The community is usually, although not always, dominated by an open canopy of black box (*Eucalyptus largiflorens*) and a shrubby understorey of ruby saltbush, nitre goosefoot (*Chenopodium nitrariaceum*), tangled lignum (*Muehlenbeckia cunninghamii*), hedge saltbush (*Rhagodia spinescens*), and, at times, old-man saltbush.

The ground layer also typically contains a number of chenopods, including slender-fruit saltbush (*Atriplex leptocarpa*), baldoo, nodding saltbush, hairy bassia, and occasionally three-spined saltbush. Native herbs are prominent in the

Black box with lignum understorey - black box--chenopod woodland.

spaces between the shrubs. One sub-community commonly contains the distinctive pale beauty-heads (*Calocephalus sonderi*), while paper sunray (*Helipterum corymbiflorum*) is characteristic in another.

Grazing by cattle and sheep has selectively affected the community. Old-man saltbush has a much reduced distribution, with its place seemingly taken by nitre goosefoot and tangled lignum.

Black box wetland

In the south-eastern corner of the study area, heavy clay soils that are subject to periodic flooding carry low woodland dominated by black box.

Shrubs are typically absent, but the dense mesic ground layer of rushes and sedges may include common spike-rush (*Eleocharis acuta*), small spike-rush (*E. pusilla*), and rush (*Juncus flavidus*) with, on slightly higher parts, grasses like brown-back wallaby-grass (*Danthonia duttoniana*), spider grass (*Enteropogon acicularis*), and purple love-grass (*Eragrostis lacunaria*). Free-standing water usually supports a number of semi-aquatics, including the ferns of the *Azolla* genus, as well as star-fruit (*Damasonium minus*) and buttercups (*Ranunculus* spp.).

Black box woodland

The courses of the major drainage systems of Chalka Creek in the Hattah--Kulkyne area and Outlet Creek have been strongly modified by the influx of sand from the adjacent dunefields. In the former, the sites are topographically higher and thus more sensitive to the altered flooding regime of the Murray River resulting from its regulation upstream.

The flooding regime of the Outlet Creek system has been so altered that little of the alluvial system has been flooded since the early 1920s, when water reached Wirrengren Plain. As a result, negligible regeneration of the flood-dependent trees has occurred and the ground layer is now characterized by native and introduced herbs and grasses that are otherwise associated with the sandy soils of mallee and pine--buloke communities. Most of the plants reliant on occasional flooding, such as the shrubs three-nerve wattle (*Acacia trineura*) and tangled lignum, have either become extinct there or dwindled to a few isolated individuals.

River red gum forest

This community, associated with Outlet Creek, has been so degraded that even the mature trees are dying (without regeneration) and the ground layer is very similar to that of the adjoining degraded black box woodland. However, along the Murray River, the distinctive river red gum forests remain.

River red gum (*Eucalyptus camaldulensis*) dominates an open forest, often with a subsidiary open understorey of eumong (*Acacia stenophylla*) and occasionally willow wattle (*A. sal-*

icina). Depending on the sub-community, the ground layer includes lesser joyweed (*Alternanthera denticulata*), common sneezeweed (*Centipeda cunninghamii*), flat spurge (*Chamaesyce drummondii*), spiny flat-sedge (*Cyperus gymnocaulos*), warrego summer-grass (*Paspalidium jubiflorum*), and river bluebell (*Wahlenbergia fluminalis*). However, the floristic composition depends heavily on both the frequency of flooding and the time since the most recent flood.

The community is most variable west of Mildura, where the diverse topographic features include well-developed bar deposits and up to four different levels of terracing.

Lake-bed herbfield

Lake-beds support a variable range of herbfields and grasslands depending on the soil type and the time since inundation. Communities change in rapid succession as the lake-beds dry up after being flooded. In the first few seasons after a flood the lake-beds are usually dominated by tall native herbs, notably common blown grass (*Agrostis avenacea*), southern liquorice (*Glycyrrhiza acanthocarpa*), and Australian hollyhock (*Lavatera plebeia*), although occasionally the shrub oondoroo (*Solanum simile*) may form a more or less dense open shrubland. In the periods between floods, kangaroos or domestic stock commonly impose a heavy grazing pressure. Consequently, introduced annuals usually come to dominance until the next inundation. These annuals include bromes (**Bromus* spp.), barley grass, smooth cat's ear, medics (**Medicago* spp.), and clovers (**Trifolium* spp.). Lake-beds that have escaped heavy grazing may form a low open shrubland dominated by spiny lignum (*Muehlenbeckia horrida*).

Major Impacts on Natural Vegetation

Grazing

Since the arrival and establishment of European pastoralists a little less than 150 years ago, dramatic changes have taken place in the grazing pressures on the natural vegetation of the Mallee. More than half of the region has been alienated and cleared for agriculture and a further large area (particularly in the south-east of the Sunset Country) was cleared but subsequently allowed to regenerate, with variable success. The remainder, being more or less in a natural condition, is not representative of the former variety, but consists predominantly of heath and mallee on soils (principally deep siliceous sands) that are very infertile, too saline, or otherwise unsuitable for agricultural development. However, even here, the impacts on the vegetation have substantially altered.

Grazing pressures have radically changed. The small to medium-sized native mammalian browsers and grazers are now extinct in the Mallee. Similarly, the original rodent fauna (that was substantially herbivorous) has been depleted, particularly from woodlands and grasslands (see Chapter 8 - Fauna).

More than half the Mallee has beeen cleared for agriculture.

Rabbits

From the late 1860s rabbits have become ubiquitous, often reaching plague proportions. The advent of myxomatosis, about 30 years ago, reduced rabbit numbers somewhat. They remain common to abundant, however, and it has been suggested that their numbers are increasing again as they develop greater resistance to the disease and less-virulent strains become predominant.

Even on public land subject to high-intensity grazing from domestic stock, rabbits undoubtedly exert the greatest impact on the vegetation. They are by no means uniformly distributed across the region. Grasses and other palatable herbs are uncommon in the main vegetation communities of the deep infertile sands of much of the Big Desert and the similarly infertile Lowan Sands of the southern half of the Sunset Country. These communities - deep-sand mallee, dune-crest tree-heath, sand-plain heath, mallee heath, and swale mallee-heath - support relatively few rabbits, and the vegetation is little altered.

On the more fertile loams and clay-loams that support woodlands and grasslands, however, a more herbaceous ground layer predominates. Rabbit numbers in these communities are frequently high and their grazing pressure can lead to substantial degradation of the vegetation.

The heavier clay-loams of alluvial sites do not permit the development of even rudimentary warren systems, although the plant communities here provide adequate to seasonally abundant feed. On these soils (alluvial-plain shrubland, black box--chenopod woodland, river red gum forest, and lake-bed herbfield) the rabbits either shelter above the ground (in logs and shrubs) or construct warrens in nearby deeper, more friable soils. Alluvial-rise shrubland grows on isolated rises in and near such areas and thus is often severely disturbed by rabbits constructing warrens.

Mallee communities on soils of intermediate fertility - such as chenopod mallee, shallow-sand mallee, east--west dune mallee, and loamy sand mallee - usually support moderate to low numbers. Rabbits here have a selective impact as they preferentially graze the more palatable species and ignore those less palatable.

Goats

Little investigation has taken place into the way that feral goats affect native vegetation in the Mallee, although they are widespread and relatively common throughout. They are predominantly browsers here and thus less dependent than rabbits on the herbaceous field layer. However, they do need access to water in summer, and the provision of troughs, tanks, and other drinking water for licensed stock-grazing has enabled them to persist and even increase in numbers in areas remote from agricultural land (where they also have access to water in summer).

Some anecdotal evidence suggests that goats are responsible for the decrease of a number of the less-common palatable shrubs such as broom milkwort (*Comesperma scoparium*) and sweet quandong. Locally they may exert a heavy browsing pressure.

Domestic stock

Early pastoral runs for the grazing of sheep and cattle were concentrated along the Murray River and Outlet Creek and in non-riverine woodlands and grasslands. Current licensed grazing is also concentrated in these communities, as they support the greatest amount of useful forage for stock. Licensees are responsible for rabbit control on their licensed areas, but this control has usually been insufficient to keep rabbit numbers low. As a result the woodlands and grasslands are usually subject to substantial grazing pressure from both rabbits and stock.

Licensed grazing also has indirect impacts in that troughs, tanks, and other forms of stock-water must be provided to enable sheep and cattle to use non-riverine areas. However, rabbits, goats, and kangaroos also have access to this water, resulting in the maintenance of (artificially) high populations of these grazing animals over summer, further stressing the vegetation. Apart from a few isolated blocks (notably Timberoo, Wemen, and Yarrara), woodlands and grasslands are now substantially degraded and continue to deteriorate.

Kangaroos

Not all the native herbivores have been eliminated from the Mallee. Red kangaroos (*Macropus rufus*) range from uncommon to locally common in the more open woodlands and grasslands north and west from the Raak plains, and western grey kangaroos (*M. fuliginosus*) are now very common. Kangaroo numbers in Hattah--Kulkyne and Wyperfeld National Parks are particularly high, and considerable evidence shows that they are contributing to further degradation of the woodlands.

Even where stock no longer graze and rabbits are virtually absent, grazing pressure from kangaroos alone is sufficient to prevent regeneration of vegetation and leads to the gradual elimination of species and communities. In the Hattah--Kulkyne park in particular, the kangaroos have access to water in summer, and this greatly assists in the maintenance of their very high densities there. In heathland and mallee remote from stock-watering points, kangaroos remain at a low density and have negligible grazing impact.

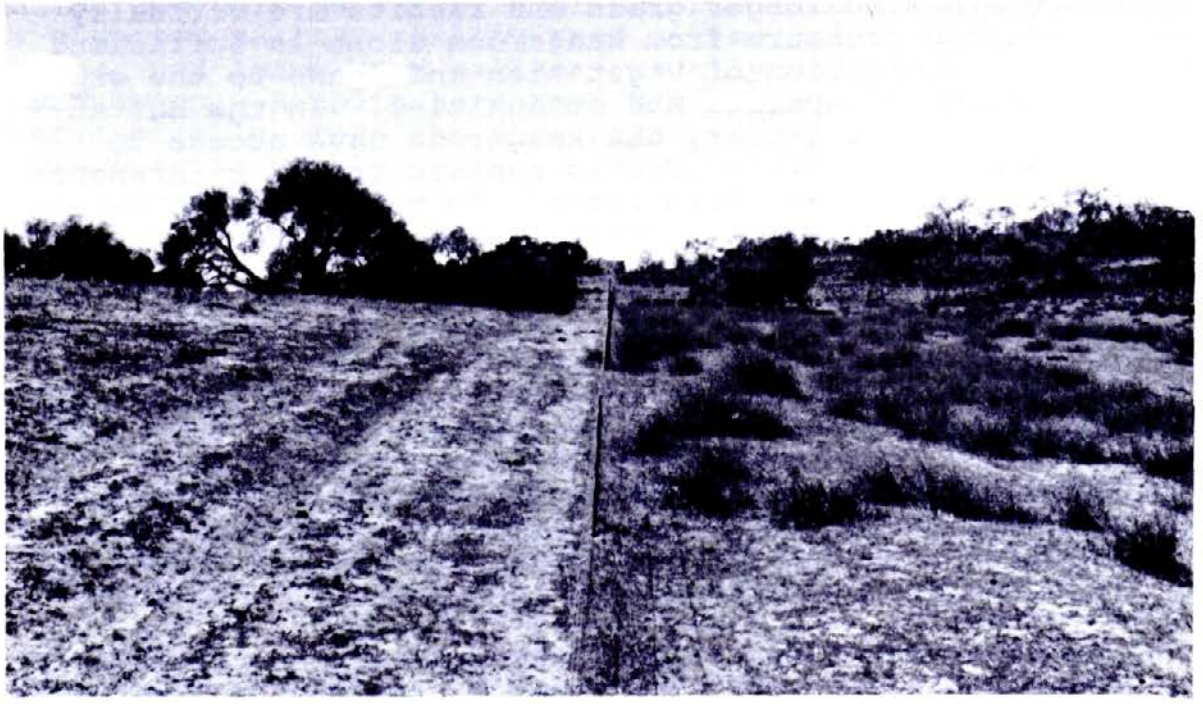
Total grazing impact

As indicated above, grazing pressure - whether from rabbits, domestic stock, or kangaroos - is concentrated in the grassland, woodland, and riverine communities. Although all these mammals have somewhat different dietary preferences and, in situations of abundant feed, select different species to differing degrees, some plant species are grazed by all the animals. Many others are ignored, unless necessity compels otherwise, and a relatively small number of the total plants present may support the bulk of the mammalian grazers. Whether the grazing mammal is introduced or native is irrelevant in terms of the loss of leaf biomass.

Despite their differing dietary preferences, in many situations the animals cannot exercise their preferences and take plant species that they would otherwise ignore. In droughts, little feed remains available and, once they have eliminated the preferred plants, grazers are forced to eat others. As the drought progresses, they may take progressively less-preferred species until they have eaten nearly all the accessible edible vegetation in a landscape. If the number of grazing animals in a habitat is high compared with the available forage, such feed crises occur relatively often.

In the Mallee, the vegetation is most under stress from grazing mammals in late summer to autumn. If that stress is prolonged, the perennial grasses and other palatable herbs disappear. Following winter rains the first species to regenerate are the cool-season annuals, including a number of introduced grasses. These tend to exclude the perennials. As the subsequent dry summer sets in, the annuals seed and die and the animals concentrate even more strongly on the depleted perennial grasses and palatable herbs. The original herbaceous ground layer, made up predominantly of perennial native plants, is thereby replaced by predominantly annual species, most of which are introduced weeds. The ground is bare in summer, and this contributes significantly to soil erosion problems.

Even seedling and sucker regeneration of the woody dominants are browsed under food-stress situations, and all vegetation within reach is removed. When that regeneration is removed, woodlands are rapidly converted to weedy annual herblands. Communities such as sand-plain grassland, pine--buloke woodland, belah woodland, gypseous plains grassland, and other non-riverine woodland do not regenerate successfully until grazing pressure is substantially reduced. Grazing at levels that prevent even minimal regeneration of the woody species and native perennial cover eventually destroys these



The effect of continuous grazing can be dramatic.

communities and fosters their replacement by annual herblands and grasslands.

Already, large areas have been degraded in this way and it is now almost impossible to determine the original floristic composition of savannah woodland, savannah mallee, and gypseous plains grassland. The last-named was probably a low woodland dominated by sugarwood with a shrubby chenopod understorey, but such a vegetation community no longer exists anywhere in Victoria.

Shrublands and woodlands on the alluvial terraces have been similarly grazed. In places, the grazing has been so severe as to contribute to the disappearance of some communities, as has occurred in the Wyperfeld National Park and at Pine Plains (although changed flooding regimes have also contributed to this degradation), but at other sites the grazing-induced changes have been less severe. Unpalatable plants - such as annual *Atriplex* and spiny *Sclerolaena* species and desert glasswort - have become more prominent at the expense of the more palatable shrubs, such as perennial *Atriplex* and *Maireana* species.

While interpreting the extent of plant communities from aerial photographs and satellite images, the botanists preparing Map 10 - Floristic Vegetation - have identified communities that are disturbed by grazing, timber-getting, and/or altered water regimes. The extent of this disturbance that is evident from the air is plotted on Map 12.

A number of isolated parcels of public land, scattered throughout the agricultural districts, are considered significant for the preservation of some vegetation communities or provide good examples of the communities. These are listed in Appendix IX.

Fire

Responses to fire by the Mallee vegetation communities vary widely. As the following discussion indicates, many species have adaptations that assist their survival during and after burning. Indeed, for a number, regeneration is negligible in the absence of fire, while others are killed by it and their subsequent regeneration is problematical. Some species occur in habitats and communities that are not susceptible to fire and are consequently rarely or never burnt.

Clearly, fires were a part of the Mallee landscape long before the arrival and establishment of the first European settlers. However, there is very little information on Aboriginal burning practices and, in any case, so many changes have occurred over the last 150 years (species extinctions, weed invasions, grazing pressure changes, and clearing for agriculture) that, even if these practices were known, it would probably be inappropriate to reinstate them.

The extents of wildfires and prescribed burns in recent years in the study area dune-fields are plotted on Map 11. Although large wildfires are still relatively common in the region, many areas are also subject to prescribed burns for fuel reduction. Consequently, manipulation by the land managers complicates the natural fire regime, particularly the frequency and season of burn. None the less, knowledge of the fire responses of plant species and communities is important to land management and, based on their fire responses, plant communities can be grouped into four sets.

Fire-free shrublands and woodlands

Saline shrubland, alluvial-plain shrubland, and alluvial-rise shrubland are communities that are not prone to fires. They have a discontinuous shrub layer dominated by species (usually chenopods) that are non-flammable and usually suc-

Vegetation communities associated with salt lakes and copi islands on the Raak Plain are usually not prone to fire.

culent. In better seasons, annual grasses may provide some fuel, but this is too scattered to carry a fire. These communities, therefore, are not subject to wildfire and cannot be burnt by prescribed fires. Their regeneration is neither dependent on nor facilitated by fire, and their component species show no adaptations to it.

The overstoreys of black box--chenopod woodlands and river red gum forests will readily burn under conditions of high wind and low relative humidity - common summer conditions in the Mallee. However, the tree canopies are too discontinuous to carry crown fires, and the understoreys are typically dominated by non-flammable chenopods and/or mesic herbs that stay green all year. Because the understoreys do not readily carry fires, these riverine communities rarely burn.

Lake-bed herbfields are surrounded by fire-resistant riverine woodlands or forests. They usually support dense herblands that, after a recent flood or when moisture is not limiting (in winter), are far too moist to burn. These communities are so palatable to grazing animals that, even in the long-term absence of flooding, they do not retain enough herbage to support any fires in the drier months.

Mallee

Four principal fuel types occur in the communities dominated by mallee eucalypts and the more of each of these fuel types present, the more flammable is the vegetation community.

- the eucalypts themselves
- flammable shrubby understorey
- seasonal growth of tussock grasses(principally species of *Stipa*
- more or less continuous hummocks of porcupine grasses

Eucalypts have little or no seed stored in the soil. Instead, they regenerate from dormant buds on the lignotubers and release seed from woody capsules held in the canopy - fire being the trigger for opening the capsules. A massive synchronized rain of seed after a hot fire produces more than sufficient for the many seed predators (mainly ants) so that some seedlings may establish. However, most of these perish over the next few years, as they cannot compete with the resprouting lignotuberous mallees or the dense and vigorous understorey. Only in gaps in the canopy can the seedlings continue to grow. In the absence of fire, very little regeneration from seed occurs, as predators harvest nearly all the seed as soon as it is released from the canopy and, in any case, the germinants cannot establish in the unbroken soil crust or because of the competition for soil moisture in the dry summers.

A flush of annuals and short-lived perennials arises immediately after fire. Many of these plants persist as the vegetation ages (particularly the annuals), but many others gradually disappear and remain solely as seed stored in the soil until the next fire breaks their dormancy. After fire,

Adaptation to fire is important for plants in the Mallee - as in lignotuber regeneration of black mallee box after fire.

the ground layer is often dominated by species that were apparently absent beforehand, such as woolly goodenia, wheel fruit, fairy fan-flower, and spear grass. In the communities on deep siliceous sands (mallee heath, broombush mallee, swale mallee-heath, and deep-sand mallee) many shrubs persist as the vegetation ages, but the fire ephemerals do not, resulting in a gradual decline in the species richness of the community. No species appear to be limited to long-unburnt vegetation, although it is only in the long-term absence of fire (for at least 60 years) that scrub cypress pine (a species that is killed by fire and regenerates solely from seed stored in fire-resistant cones) can come to co-dominance with the mallee eucalypts.

Mallee communities on the more loamy soils (shallow-sand mallee, east--west dune mallee, and loamy sand mallee) may show an even more dramatic increase in both species richness and diversity after burning. A vigorous field layer of annuals, including many fire ephemerals, dominates for the first few seasons, but after 3 to 4 years the previously insignificant shrubs emerge. For these communities, more than any other group, the species richness and diversity after a fire is due to (fire ephemeral) woody shrubs as well as herbs. Up to 15 to 25 years the understorey is dominated by a diverse assemblage of shrubs from many genera, notably *Acacia*, *Exocarpos*, *Halgania*, *Olearia*, and *Pimelea*. These shrubs gradually become less common, the eucalypts increase in height and cover, and the porcupine grass hummocks spread to form a more or less continuous sward. The inter-hummock spaces become stabilized by lichens and mosses and a few characteristic herbs. The rate of increase in plant biomass is greatest in young vegetation, due to a dramatic increase in the availability of many limiting nutrients. It greatly decreases as the vegetation ages.

Fires rarely occur in chenopod mallee, because the eucalypts are usually spaced too widely, the dominant understorey shrubs are the non-flammable chenopods and species of *Zygo-*

phyllum, and herbs are too few and scattered. However, they may occur after particularly favourable seasons have enabled the spread of a more or less continuous stand of tall spear grasses. Species richness increases after a fire due to the invasion, from nearby dunes, of a suite of ubiquitous annuals. The algal/lichen crust, so important in fixing nitrogen in long-unburnt vegetation, is frequently destroyed on burning, thus facilitating seedling establishment. When burnt, the understorey shrubs usually die and the species rely on seed, dropped from the remnant unburnt plants, for regeneration (fires are usually very patchy in chenopod mallee). Fires that occur too frequently (such as intervals of 10 to 15 years or less) may eliminate or greatly reduce both the shrubs and those herbs characteristic of, and largely restricted to, long-unburnt stands.

Heathlands

The pattern of post-fire regeneration in heathlands is similar to that in the more shrubby mallee communities. Species richness increases dramatically, with the regeneration of those species present before the fire along with a suite of post-fire colonizers and short-lived perennials. During the subsequent two decades, 30 to 40% of species are lost (although the loss is only apparent, as they mostly remain in the community as soil-stored seed). Subsequently, the number of species is maintained. This is largely due to the longevity of the woody shrubs and sclerophyllous herbs that resprout from protected buds (rather than germinate from seed) after fires - sedges, lilies, and similar plants.

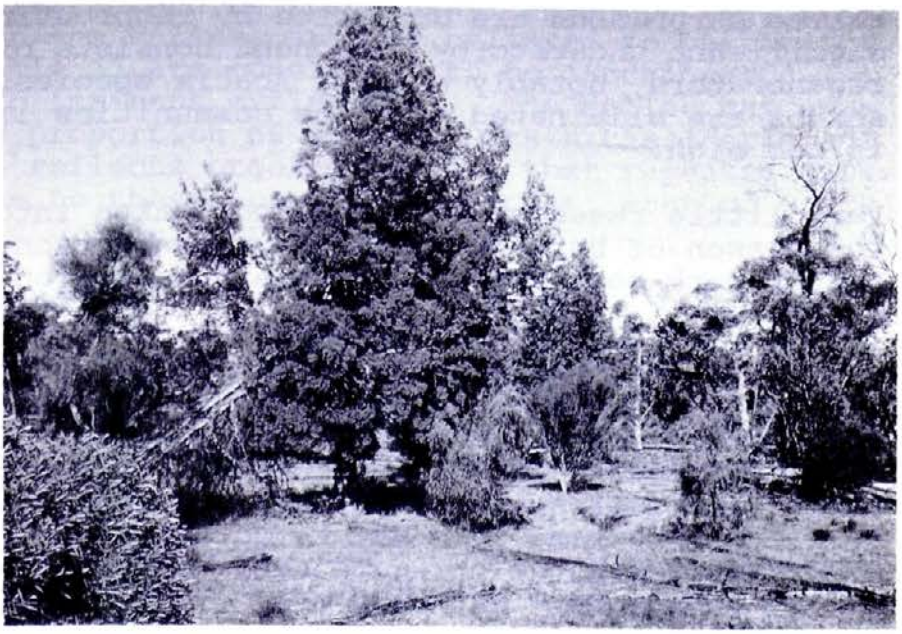
However, a major structural change does take place as the vegetation ages. The seed-regenerating species desert banksia - all individuals of which are killed by fire - emerges as a co-dominant approximately 10 years after the fire. By about 20 years, the shrubby *Casuarina* species senesce and the shrub canopy opens up. The resulting gaps are invaded by rhizomatous monocotyledons (like sedges and rope-rushes, but not grasses). As the vegetation ages further these monocotyledons come to increasing dominance and the shrub layer opens up even further. In the extreme long-term absence of fire (more than 60 years) *Callitris* species may invade, to produce a woodland dominated by slender cypress pine, or the suppressed understorey shrub scrub cypress pine may emerge to form a scrub--pine woodland.

Fire-susceptible woodlands and grasslands

The susceptibility of belah and pine--buloke woodlands to fire provides a dramatic and intriguing contrast to the fire-resistance or adaptation of the surrounding mallee. With the exception of moonah and weeping pittosporum, all woody plants in these woodlands, including the dominant *Callitris* and *Casuarina* species, are killed by fires, even low-intensity ones that do not reach the crowns. Subsequent regeneration occurs solely from seed.

These woodlands burn only rarely, however, because the shrub and tree layers consist of species that are not flammable and are too discontinuous to carry a fire under all but the

pine--buloke woodland.



most extreme conditions. The ground layer similarly comprises non-flammable species (notably chenopods, *Zygophyllum* species, and succulent members of the Aizoaceae), and the herbs are too few and small to add significantly to the fine fuels. Nevertheless, in the rare seasons that encourage the growth of tussock grasses, and under extreme weather conditions, fires may burn into the woodlands. Because the subsequent seedling regeneration is particularly susceptible to grazing, it is common for pine--buloke woodlands to be eliminated by a single fire, as this community is subject to high grazing pressures.

Fire management

A large proportion of the recent fires in the Mallee area (see Map 11) were due to lightning strike, although human-induced fires also covered substantial areas. Further information about wildfires in the Mallee, including data on their extent and causes and discussions about fire-control measures, is given in Chapter 16 - Hazards and Conflicts.

Fire frequency and the season of burn have dramatic impacts on post-fire regeneration.

In the heathlands, two of the most important plant community dominants (desert banksia and scrub cypress pine) are killed by fire and rely solely on seed released from protective fruiting cones for subsequent regeneration. Many of the understorey shrubs are similarly totally reliant on seed. Plants regenerating in this way usually do not flower and set seed for a number of years after establishment. If another fire were to occur before these susceptible species set seed, it would eliminate them from the vegetation community. Such closely spaced fires have occurred in the past and substantial areas of sand-plain heathland now lack these obligate seed regenerators. As an example, it is clear that intervals of 10 years or more are needed to prevent a decrease in seedling recruitment of desert banksia. In such heathlands the seed bank does not reach its pre-fire levels until approximately 15 years after burning.

Mallee shrublands are dominated by resprouting plants, but a significant understorey component consists of obligate seed regenerators, notably shrubby *Acacia* species. Again, these shrubs are eliminated from the communities if fire frequency is too high.

Very little research has been undertaken into the effect of the season of burn on post-fire regeneration, although some recent work confirms the long-held suspicion that it is crucial.

In heathlands, the seedling populations of both the obligate seed regenerators (such as broom baeckea, desert banksia, and scrub cypress pine) and those species that regenerate from resprouting as well as from seed (like the shrubby *Casuarina* and *Leptospermum* species) are significantly reduced by fires occurring from May to October. This is particularly critical for the obligate seed regenerators. Similarly, mallee eucalypts - although they display no diminution of resprouting ability under repeated spring burns - are rapidly eliminated by as few as two autumn burns in close succession. Such differential effects of season of burn have critical importance for management, as prescribed fires are usually applied in the cooler months when they are easiest to control. This is a time of year when 'natural' fires (those not due to human causes) are notably rare and the vegetation is poorly adapted to such a regime.

Occasionally, prescribed fires are required for vegetation management goals. For example, large areas of mature heathland were severely damaged by extraordinarily severe frosts in 1982. Most of the dominant desert banksia died. For this species, negligible regeneration occurs in the absence of fire. In such a situation, the heathlands could be burnt in the warm months immediately after the frosts to enable the plant to regenerate and retain its place in the community.

Map 11 indicates the extent of both prescribed and wildfires between 1968 and 1987. Because of these, very few long-unburnt vegetation patches remain, and it is significant that two of the most threatened vegetation types (pine--buloke woodland and scrub pine woodland) are both highly susceptible to fire.

Map 11A depicts the extent of a major wildfire in the Big Desert in 1959. Any tracts not burnt either then or in subsequent fires would contain the sole representations of old mallee vegetation in the area.

Conservation Status of Plant Communities

Two principal aspects are considered in relation to plant conservation: the conservation status of individual species and that of the recognized plant communities.

Appendix VIII gives the status and location in the Mallee area of individual species considered rare or threatened. Most of them occur mainly on public land, and for many the records are restricted to conservation reserves. However, a substantial number are not represented in reserves and a few

grow only on private land or roadsides. Five species, formerly recorded in the Mallee, are now believed to be extinct in Victoria, while 33 are considered to be 'endangered' (threatened with imminent extinction). The Mallee has an unusually large proportion of species within the 'depleted' category. This reflects ongoing threats that repeated fires and grazing pose to these long-lived species, most of which are woody shrubs or small trees.

A number of the conservation reserves recommended by the Council and approved by government have not yet been gazetted, nor are all the reference areas scheduled under the *Reference Areas Act* 1978. However, for the purposes of this report it is assumed that, as reservation will eventually take place, the plant communities in the reserves are protected.

The locations of the various conservation reserves and the land-use categories are indicated on Map 8.

Chenopod mallee

Pink Lakes State Park and Hattah--Kulkyne National Park both contain examples of this community. In the former, most of them are interspersed among saline shrubland and grasslands and remnant woodlands and have consequently been heavily grazed in the past. Although licensed stock-grazing continues here, it will cease in 1989. Stands in Hattah--Kulkyne National Park are not subject to such grazing pressures, and remain in relatively good condition.

Large parts of the north-west of the Sunset Country support chenopod mallee. Some is represented in the Millewa Reference Area (C1 on Map 8), but grazing continues on this site. Flora and fauna reserves G5 and G34 also contain examples of the community; grazing continues in the latter.

Shallow-sand mallee

Both Pink Lakes State Park and the Hattah--Kulkyne National Park contain good representations in a relatively undisturbed condition.

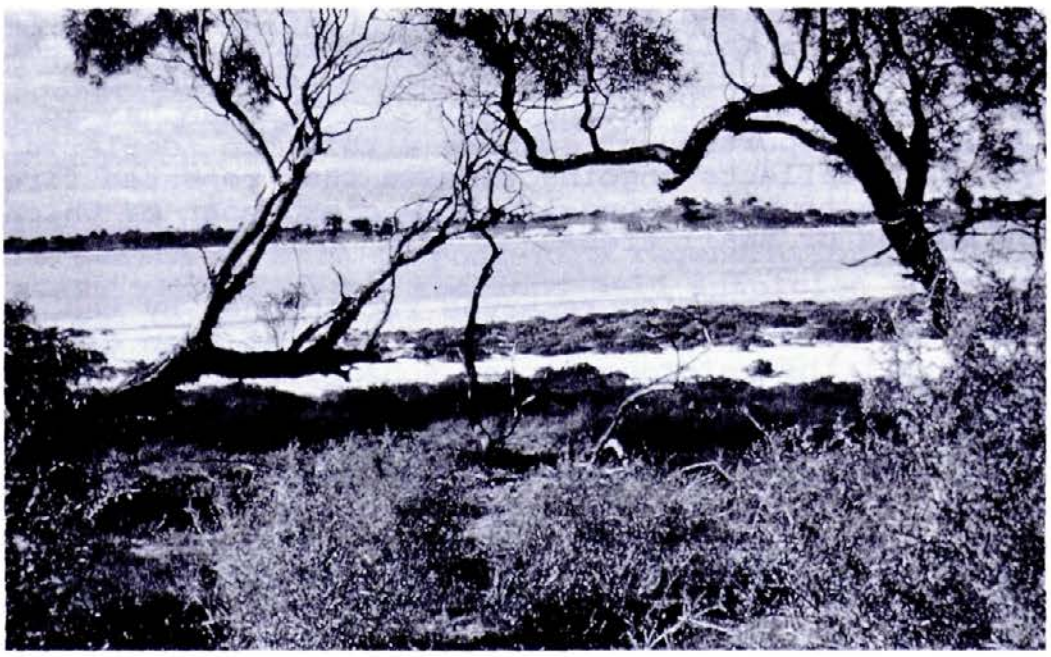
Shallow-sand mallee also occurs as large discrete stands in the far north-west of the Sunset Country in a set of unique limestone depressions. Further north, another distinctive variant (co-dominated by blue mallee) is found on low east--west dunes. Neither of these sub-communities is reserved.

East--west dune mallee

As indicated on Map 10, this is the dominant vegetation community on the huge tract of low, parallel, east-west dunes throughout the northern half of the Sunset Country and it is represented in the Sunset Reference Area (C3 on Map 8).

Deep-sand mallee

The deep, infertile, siliceous sands that determine and characterize deep-sand mallee are particularly unattractive



Pink Lakes State Park contains examples of a range of vegetation communities.

for agriculture or stock-grazing and thus large areas remain uncleared and in relatively good condition. The vegetation community is well-represented in both the Pink Lakes State Park and the Hattah--Kulkyne National Park and is dominant over the least-disturbed part of the Sunset Country (the south-west).

Dune-crest tree-heath

The community is scattered throughout the western half of the Big Desert and is well represented in both the Big Desert Wilderness and Red Bluff Wildlife Reserve, but not in the Wyperfeld National Park. The wilderness area is primarily a recreation reserve and Red Bluff was reserved mainly for the local fauna. Nevertheless management goals of both reserves are consistent with preservation of their botanical values.

Sand-plain heath

Huge areas of the Big Desert are dominated by sand-plain heath. It is extensively reserved in both the Wyperfeld National Park and the Big Desert Wilderness, and also occurs in the Red Bluff Wildlife Reserve.

Tea-tree scrub

Tea-tree scrub is closely associated with the Outlet Creek system and is found adjacent to Lake Albacutya. It is represented in both Wyperfeld National Park and Lake Albacutya Park.

Mallee heath

Interspersed with sand-plain heath, mallee heath occurs throughout the Big Desert. It is represented in the western

half of Wyperfeld National Park, the Big Desert Wilderness, in the Red Bluff Wildlife Reserve, and Lake Albacutya Park.

Swale mallee-heath

Although not common or widespread, swale mallee-heath occurs scattered throughout the western half of Wyperfeld National Park and in the Big Desert Wilderness. It is secure in these reserves.

Loamy sand mallee

The six preceding vegetation communities occupy infertile soils largely unsuitable for agriculture. Loamy sand mallee, however, is found on heavier soils that are somewhat more fertile and less prone to wind erosion and, as a result, extensive stands of it appear to have been alienated and cleared. Nevertheless, a large area of the community is reserved, principally in the eastern half of the Wyperfeld National Park and in the Wathe Wildlife Reserve. Most of this reserved area was burnt recently in a wildfire. A public land corridor exists between the two, but this is not reserved and a portion is used for agriculture.

A further large parcel of loamy sand mallee occurs in the approved Bronzewing Wildlife Reserve, but that has not yet been declared and remains unreserved Crown land.

Scrub-pine woodland

It is difficult to determine the former extent of such woodland (the present study is the first comprehensive one covering the vegetation communities of the Mallee region). Nevertheless it appears, from the scanty historical records, that dense scrub pine once characterized large areas of the Big Desert and was far more common in the Sunset Country than it is today. Early survey maps and plans giving accounts of the vegetation are frequently annotated with 'dense pine' or similar descriptions, and these include many places where scrub cypress pine is now virtually absent.

The community depends on the long-term absence of fire and is now restricted to isolated small patches. Some of these are reserved in the Hattah--Kulkyne National Park, Wyperfeld National Park, and the Big Desert Wilderness. Their long-term security there is uncertain, however, as wildfires (whether natural or otherwise) still occur and are progressively eliminating these small patches. The largest remaining area of scrub-pine woodland occurs in the Big Desert, west of Wirrengren Plain, and several smaller ones lie north of the wilderness area. These are not reserved.

Sandstone-rise broombush

Isolated patches of sandstone-rise broombush occur throughout the Big Desert and the Sunset Country. It is reserved in the far south-west of the Wyperfeld National Park, and in the Red Bluff Wildlife Reserve. It is also scattered through the Big Desert Wilderness and in the south-eastern portion of the Big Desert.

The community is far less common in the Sunset Country and is unreserved there. The largest area containing it lies west of Rocket Lake, but this differs distinctively from the main communities farther south in the Big Desert because of the associated species - different mallees, for example. Here it forms scattered stands, too small to map within broombush mallee.

Broombush mallee

Substantial stretches of the Big Desert Wilderness are dominated by broombush mallee, which also occurs in a number of places in the Wyperfeld National Park. It is more scattered in the Wathe Wildlife Reserve and only a small area is found in the Pink Lakes State Park. As Map 10 indicates, those stands in reserves comprise only a small proportion of its total extent in the Mallee area. Broombush-cutters seek it out.

Broombush mallee also occurs in the Sunset Country and at Annuello, although, surprisingly, it is absent from the Hattah--Kulkyne National Park. It is largely unreserved in these more northern areas.

Heath woodland

Represented in the Big Desert Wilderness and Red Bluff Wildlife Reserve, and in a few isolated patches in the far west of Wyperfeld National Park, heath woodland is very rare in the study area. It occurs as very isolated, small patches around the sandstone outcrops of the Big Desert. This community was probably never common, and it is unlikely that it has been reduced from its former extent.

Red-swale mallee

Small stands of red-swale mallee are scattered throughout the eastern half of the Wyperfeld National Park, Wathe Wildlife Reserve, and the Big Desert Wilderness. However, its principal occurrence is outside reserves, in the western Big Desert and south-west from Lake Albacutya. The community could have been far more extensive in the past, as it grows on sites highly suitable for agriculture and would have been preferentially selected and cleared.

A variant of it occupies a large tract in the north-central portion of the Sunset Country. This has close affinities with chenopod mallee except that red mallee is present. Portion of it lies within the Sunset Reference Area C3.

Big mallee

Two of the characteristic dominants of this community - bull mallee and black mallee box - are very uncommon trees in reserves but are far more frequent roadside trees throughout much of the study area. As with scrub-pine woodland, it is difficult to determine the former extent of big mallee because it was preferentially selected and cleared for agriculture. Very small remnants have been noted in both the Pink Lakes State Park and Wyperfeld National Park, but the

Big mallee near Timberoo.

Community is effectively unreserved; the most significant areas outside reserves are located at Milmed Swamp and Chinaman Flat.

Yellow gum woodland

While far more common in the Wimmera, south of the Mallee, yellow gum woodland is scattered through the Big Desert as isolated patches and has been recorded in the Wyperfeld National Park, Big Desert Wilderness, and Red Bluff Wildlife Reserve. A relatively large isolated stand in the far north-west of the Big Desert is not reserved.

Pine--buloke woodland

Because of the relatively fertile loamy sands that support pine--buloke woodlands, most stands have been cleared for agriculture. However, examples of the community are found in the Hattah--Kulkyne and Wyperfeld National Parks, Pink Lakes State Park, and the Timberoo Flora and Fauna Reserve.

Although represented in these parks, its future nevertheless continues to be threatened, as discussed previously. Little of it can be found in the Hattah--Kulkyne National Park, and it is similarly degraded in the Pink Lakes State Park. Stands in the Wyperfeld National Park are also degraded, but these, although a wildfire has further reduced their area, remain among the best examples of pine--buloke woodland in the State.

Although somewhat disturbed and mapped as savannah woodland, the substantial stand in the Timberoo Flora and Fauna Reserve (G15 on Map 8) is in many ways in better condition than some of those in the Wyperfeld National Park because the woody species here are regenerating. This reserve is yet to be gazetted.

Pine--buloke woodland is probably the most threatened vegetation community of the Mallee.

Belah woodland

The small pockets of belah woodland in the Mallee are isolated outliers of more extensive stands found farther north in New South Wales and South Australia. It was never very common in Victoria, but the soils on which it grows are more suitable for agriculture than those of the surrounding mallee and as a result it was preferentially selected and cleared.

Yarrara (G1 on Map 8) carries the largest stand of this community left in Victoria. It is little damaged by grazing or former timber-cutting and, unlike the pine--buloke woodlands, shows ample evidence of regeneration. This area has not yet been gazetted as a flora and fauna reserve. Small patches of belah woodland towards the northern boundary of the Sunset Country have been severely degraded by overgrazing. They all lie within lands held under grazing licence. Another flora and fauna reserve containing belah woodland at Bambill South (G2 on the Map) has been gazetted. Other small pockets of the community are located near Weman (G6 and G7 on Map 8) and south of Carwarp (I9 on the map). Belah woodland remains substantially threatened due to the small size of the remnant stands.

Savannah woodland and savannah mallee

These communities are severely disturbed remnants, possibly of other communities. As such, it is very difficult to determine their original composition. They occur in the Hattah--Kulkyne National Park, Pink Lakes State Park, and a number of smaller reserves throughout the region. Extensive stands west of the Millewa and in the Raak Plains west of Hattah and Nowingi are unreserved.

Sand-plain grassland

The centre of the Sunset Country is characterized by broad stands of sand-plain grassland, such as at Birthday Plains and Sunset Plains. These are among the largest and least-disturbed native grasslands left in Victoria and are remarkably weed-free. Until the 1982 drought, they were subject to licensed stock-grazing, but since that time no licences have been issued there.

Those stands in the north of the Pink Lakes State Park have been disturbed by relatively heavy grazing and are not representative. Sand-plain grassland is otherwise unreserved. Its history of disturbance and suitability for licensed stock-grazing, as well as the lack of reservation, makes this community one of the most threatened.

Gypseous plains grassland

As previously discussed, the original composition and structure of these grasslands can only be inferred. They, and the landforms on which they typically occur, are unreserved.

It is likely that vegetation similar to the original would gradually re-establish with the reduction of grazing, as remnant native species occur as scattered components of the existing pasture. The original vegetation community is now extinct in the State.

Saline shrubland

A substantial sample showing the variety of this community is represented in the Pink Lakes State Park, and further small stands occur in the Hattah--Kulkyne National Park. As grazing seldom poses a significant threat to it, saline shrubland is secure in these reserves. Two further significant areas are not reserved, however.

Large tracts of saline shrubland are interspersed with gypseous plains grassland in the far north-west of the Sunset Country. Here the community is heavily grazed and its survival is threatened.

The most significant stands outside reserves, and perhaps the most significant in the State, are in the Raak Plains between Nowingi and Rocket Lake. A number of individual rare or threatened species are restricted to this site as well as sub-communities of similar status. The Raak Reserve (G34) contains an example, but grazing continues here and further threats are imposed by adjacent gypsum-mining.

Alluvial-plain shrubland

This community is not represented in any reserves apart from the Lake Walla Walla Reference Area (C2 on Map 8). The extent of alteration to it depends on the grazing intensity, but all of it is affected to some degree. Nevertheless, substantial areas of relatively undisturbed alluvial-plain shrubland still exist immediately south of Lindsay Island, north of Lake Cullulleraine, and south-east of Wallpolla Island.

Alluvial-rise shrubland

This shrubland is everywhere greatly degraded by overgrazing and the activities of rabbits. It occurs as discrete stands, interspersed among the alluvial-plain shrubland, immediately south of Lindsay Island, north of Lake Cullulleraine, and south-east of Wallpolla Island. It can also be found scattered in the far north-west of the Sunset Country. None of these sites falls within a conservation reserve.

Black box--chenopod woodland

The Hattah--Kulkyne National Park and Murray--Kulkyne Park contain substantial stands of this woodland. Grazing intensity determines its condition, including the periodically heavy grazing pressure applied by kangaroos. A lack of regeneration of some important components of the community, such as tangled lignum, is causing some concern.

Lindsay Island, Wallpolla Island, and the adjacent river terraces support extensive tracts of relatively undisturbed

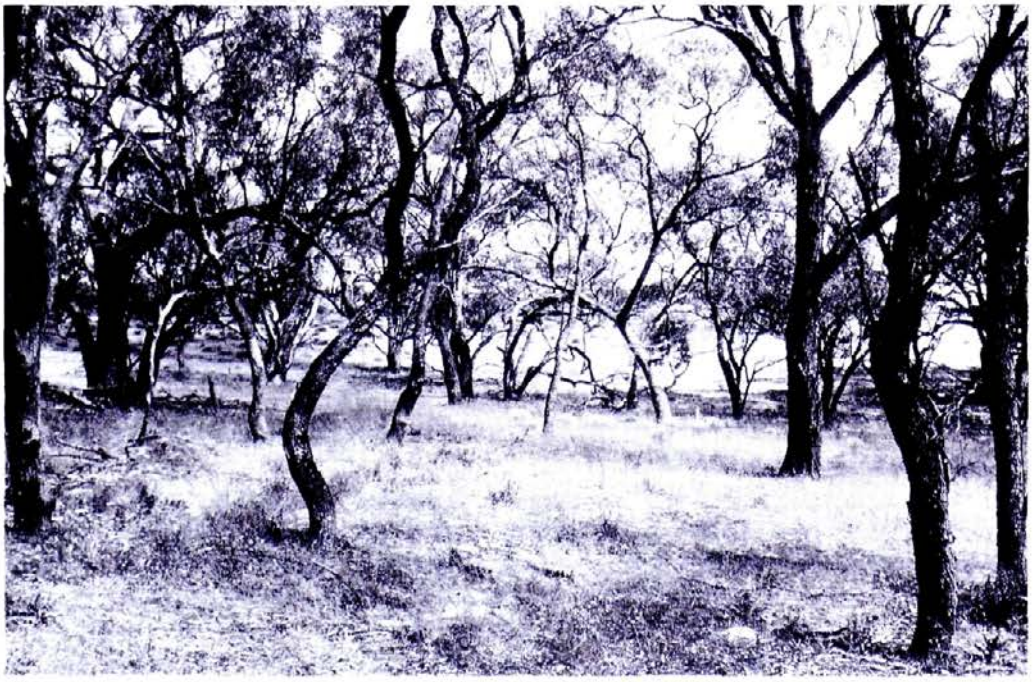
black box--chenopod woodland as well as large areas that were harvested for timber. These are not reserved.

Black box wetland

This wetland only occurs in the far south-east of the study area as isolated patches in Leaghur Forest (E6 on Map 8) and in a few smaller blocks of public land. Some of the stands are included in wildlife reserves, where the conservation of the black box wetland is a goal of management. The remainder occur in areas utilized for timber-harvesting and licensed stock-grazing.

Black box woodland

As with savannah mallee, black box woodland is an 'unnatural' community - altered by human intervention. Although it occurs in the Hattah--Kulkyne National Park, it is subject to further change there because of altered flooding regimes from the Murray River and the effects of heavy grazing from rabbits and kangaroos. It is also found in the Wyperfeld National Park as the moribund remnant of riverine woodland. In Wyperfeld, the woodland shows negligible regeneration of any woody species and it continues to degrade.

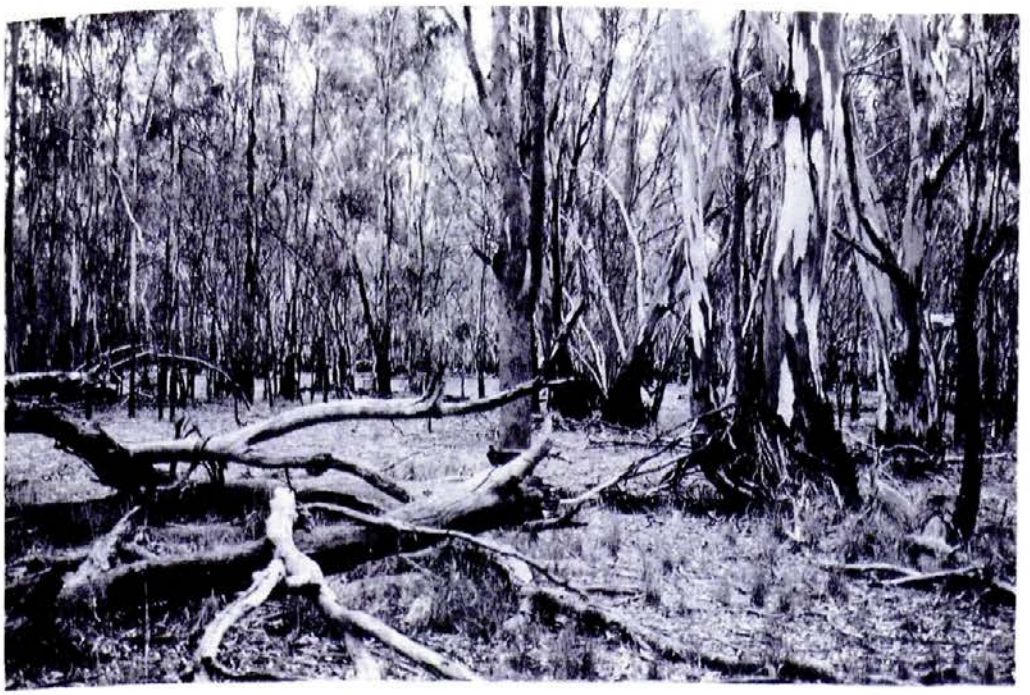


Altered flood regimes can affect black box woodlands.

River red gum forest

The original community of river red gum forest no longer grows in Wyperfeld National Park or elsewhere along the Outlet Creek system because of changes to the flooding regime of the lower Wimmera River.

Although flows in the Murray are controlled, it still floods occasionally, and substantial stands of this community are maintained in the Hattah--Kulkyne National Park and Murray-Kulkyne Park. The major threat here is grazing. Elsewhere



Along the Murray, distinctive river red gum forests remain.

along the Murray (in the Mallee), Lindsay Island and Wallpolla Island carry the largest unreserved stands of river red gum forest.

Lake-bed herbfield

The floristic composition of lake-bed herbfield depends on flooding and grazing regimes. This community occurs in the Wyperfeld National Park (where it comprises chiefly annual weeds - principally because of lack of flooding) and in many of the lake-beds in the Hattah--Kulkyne National Park (where it is subject to very heavy grazing from kangaroos). Lake Walla Walla is the largest unreserved lake-bed still occasionally subject to flooding. This community in Wirrengren plain is extensively modified.

References

Costermans, L.F. (1981). 'Native Trees and Shrubs of South-eastern Australia.' (Rigby Publishers Ltd: Melbourne.)

Cunningham, G.M., Mulham, W.E., Milthorpe, P.L., and Leigh, J.H. (1981) 'Plants of Western New South Wales.' (Government Printer: Sydney.)

Groves, R.H. (ed.) (1981). 'Australian Vegetation.' (Cambridge University Press: Melbourne.)

Hall, N. *et al*. (1972). 'The Use of Trees and Shrubs in the Dry Country of Australia.' (Australian Government Publishing Service: Canberra.)

Specht, R.L. (1972). 'The Vegetation of South Australia.' (Government Printer: Adelaide.)

8. FAUNA

The fauna species of the Mallee are diverse, numerous, and to a large degree unique in Victoria. The big areas of public land in the Big Desert and the Sunset Country suppor a number of species not found elsewhere in the State and, because of widespread clearing of mallee vegetation in this and other States, these remaining large tracts of mallee ar of national importance.

Certain components of the fauna (notably the mammals) have changed markedly in composition and status since European settlement. Some of these changes are discussed in this chapter, as are various activities that continue to have an impact on faunal populations today.

The Mallee has great importance for the conservation of a number of species, and these are discussed in the section o 'significant and notable' vertebrates. However, we still have far from complete knowledge of the local fauna - espec ially the invertebrates, which are not yet fully described. Further research is required so that effective management for the conservation of the fauna can be undertaken.

Faunal information provided in the Council's report in 1974 was based on the limited data available at that time. Sinc then our knowledge of the area's vertebrates and invertebrates has increased substantially, and this chapter update the earlier work. Most of the new information was obtained during surveys conducted over the past 2 years by the National Parks and Wildlife Division of the Department of Conservation, Forests and Lands and the Museum of Victoria, in conjunction with the botanists who prepared the information for Chapter 7 - Vegetation.

These surveys concentrated mainly on the large tracts of public land in the western half of the Mallee; consequently less information is available for the agricultural land and for the many small areas of remnant native vegetation in th eastern half. Similarly, within the area surveyed, some plant communities might have been under-represented in the sampling. To help overcome this problem, information from scientific literature and museum records has been incorpora ted where possible.

A number of permanent survey sites have been established in the Mallee to monitor the long-term dynamics of faunal populations. This is the first time that such a program ha been undertaken in Victoria.

The appendices include a complete list of all vertebrate species currently known in the Mallee, with an indication of their occurrence in major habitat categories and plant communities, their dependence on mallee vegetation, and

their distribution and abundance in the study area (Appendix X). This list gives both scientific and common names for all vertebrate species and, unless a species has no recognized common name, the latter have been used throughout the text.

Significant and notable vertebrates are listed in Appendix XI. Appendix XII indicates areas of importance for selected species, and distribution maps for some are incorporated in the text. Appendix XIII lists a number of mammals that are now extinct in the study area. Appendix XIV presents the distribution of some ground-dwelling invertebrates, in major habitat categories, while Appendix XV lists the fish species found in the area.

This chapter is derived from an unpublished report to the Land Conservation Council titled 'Fauna of the Mallee Study Area North-western Victoria', August 1987. The large number of references used in its preparation are listed in Appendix XVI.

Historical Changes to the Vertebrate Fauna

Historical sources of information are limited, but it is clear that marked changes have occurred to the fauna of the Mallee region (particularly the mammals) since European settlement in the mid 19th century.

The earliest explorers in the Mallee usually made only passing reference to wildlife and in many cases we cannot be sure about the species to which they referred. However, there is some fascinating anecdotal information, such as a description of a death adder, and reference to sightings of 'kangaroos, wallabies, paddymelons, and kangaroo-rats'.

In 1857, a scientific expedition, led by William Blandowski, was sent by the Victorian government to the junction of the Murray and Darling Rivers to investigate the local natural history and to collect specimens. To this expedition, and particularly to the work of one member, Gerard Krefft, we owe our knowledge of the mammalian fauna extant in this area at the time of settlement. Limited observations were also made on the reptiles and amphibians there. In the late 19th century and the first decades of the 20th, a number of ornithologists visited the Mallee and their reports now provide useful information on historical aspects of the avifauna.

In 1966, reviews of the mammals, amphibians, and reptiles of the Mallee summarized the fragmentary information available from museum specimens, personal field notes, and the scientific literature. In subsequent years, studies of some species and limited surveys have added further to our knowledge, but it was not until 1985 - in preparation for this report - that the first comprehensive survey of the vertebrate and invertebrate fauna of this region was undertaken.

Mammals

From their base camp at the junction of the rivers, members of the Blandowski expedition recorded 29 species of mammals

(excluding bats), 18 of which no longer occur in the region. Good supporting evidence indicates that at least 12 of these formerly occurred on the Victorian side of the State border (see Appendix XIII).

Five of the mammal species recorded during that expedition - pig-footed bandicoot, eastern hare-wallaby, crescent nail-tail wallaby, lesser stick-nest rat, and Gould's mouse - are now totally extinct. For one of these, the pig-footed bandicoot, the type locality is in the Mallee area - near the junction of the Murrumbidgee and Murray Rivers. Other species formerly present and apparently common in the Mallee area in the 1850s - such as the western barred bandicoot, bridled nail-tail wallaby, and desert mouse - have greatly declined in range elsewhere in Australia.

The cause of the decline and local extinction of mammals in the Mallee is not clear, but similar changes in the native mammal fauna have been recorded elsewhere in the semi-arid and arid zone of Australia. Characteristically, the medium-sized mammals with body weights ranging from 0.2 to 5 kg have been the ones most affected. Three main hypotheses for the decline of these species have been advanced.

- Native mammals could not survive the increased level of predation resulting from the arrival of the introduced carnivores - the red fox and cat.

- The huge numbers of introduced grazing herbivores - sheep, cattle, and later European rabbits - destroyed the habitats of native mammals.

- Those native mammals that declined, or became extinct, could not cope with alterations to the patchwork of environments, which resulted from changes to the pattern of fires following European occupation.

Probably the actual cause of decline is a combination of all of these factors. In addition, the decline of at least one species, the dingo, may be attributed to relentless hunting and poisoning by settlers. Formerly common in the Mallee area, pure-bred dingoes are now unlikely to be still there.

Not all species of mammal have lower abundance. The western grey kangaroo and red kangaroo have probably increased in number because of a reduced level of predation and an increased availability of water at stock watering points.

Recent discoveries of three species of small mammal have added to the list of those known to occur here in historical time. The little pygmy-possum was first recognized in the Mallee in 1977 (in South Australia) and 1978 (in Victoria). Formerly, individuals of this species had been confused with the western pygmy-possum. The Mallee ningaui (a small marsupial mouse) was first recorded in Victoria in 1977 and was described as a species in 1983. In 1985, the paucident planigale was first captured in Victoria, adjacent to the Murray River in the north-west of the study area. These captures extended the known range of this small marsupial some 200 km further south.

The paucident planigale was first trapped in the Mallee during 1985.

At least eight introduced mammal species (dog, red fox, cat, European rabbit, brown hare, house mouse, goat, and pig) now have feral populations present in the Mallee. Of these, the European rabbit has caused the greatest impact on the natural environment.

Rabbits were first introduced into the region in 1866, when two settlers brought four pairs to their Morton Plains property, some 24 km north of Donald. By 1880, the rabbits in the Mallee had undergone a population explosion and were causing enormous devastation. At this time, the then Minister for Lands inspected the country to see the ravages they caused. and noted '... I never saw, and could not have conceived a greater picture of desolation... We went over miles of the country without seeing a solitary sheep or a sign of life, except thousands of rabbits, and so thoroughly had these devastated the district that there was not a blade of grass to be seen, and the trees were stripped of their bark as high as the rabbits could reach.' (Kenyon, 1982.)

Birds

Several bird species in the Mallee area have declined in abundance during the past 150 years, but evidence suggests the extinction of only a limited number of those formerly resident. Neither the magpie goose nor the superb parrot, for instance, lives here now, but neither species has become extinct.

A number of birds were directly affected by human activity. The settlers hunted common bronzewing, kori bustard, malleefowl, and a range of waterfowl for food and, in season, collected large numbers of malleefowl eggs for the table. Wedge-tailed eagles and other birds of prey were poisoned or shot because of their perceived threat to stock. For example, in about 1909, a station hand at Pine Plains claimed to have poisoned more than 200 eagles in a year.

Spotted bower-birds, formerly common along the Murray River valley, were destroyed as pests in the orchards near Mil-

dura. Prior to 1940 as many as 30 birds were destroyed each week in the vicinity of the Chaffey homestead there. This species was still present on the Victorian side of the Murray in 1940, but now has no known breeding pairs in Victoria and is rare in adjacent areas of New South Wales.

Many of the early ornithologists were keen egg-collectors. This practice became less popular and is now illegal, but covert collecting continues. Birds of prey - particularly the rarer species such as the black falcon and grey falcon - are among those birds most vulnerable to the reduced breeding success that results.

Despite direct human impacts on the avifauna, the most notable changes to the status of many birds may be related to habitat alteration or to the total clearing of habitats. Grazing by both domestic stock and rabbits, fragmentation of mallee vegetation into scattered isolates, timber-harvesting, and altered fire regimes have all contributed to changes in avifaunal habitat. Based upon historical information, species more abundant in the study area formerly than they are at present include the bush thick-knee, western whipbird, black-eared miner, kori bustard, malleefowl, and brolga.

Agricultural settlement has proved advantageous to some birds, notably those that inhabit open country. Species such as Richard's pipit, willie wagtail, crested pigeon, little raven, yellow-throated miner, and galah have probably expanded their range in the study area. The provision of artificial watering sites at bores and stock dams may also have contributed to an expansion of a range of species such as the brush bronzewing and white-plumed honeyeater.

Reptiles and amphibians

In 1857, Krefft collected and described reptiles and amphibians during the Blandowski expedition, but pointed out that this collection was far from complete. Other historical data are limited primarily to museum records or to general accounts. Assessment of historical changes is further confused by the numerous taxonomic and nomenclatorial changes that have occurred in these classes.

Two elapid snakes - the death adder and fierce snake - formerly recorded in the study area are no longer believed to be present. The junction of the Murray and Darling Rivers is the type locality for the latter. Waite (1918), in a revision of the blind snakes (family Typhlopidae) in Australia, recognized eight species as occurring in the Mallee region; now only two of these are known there.

Clearing for agriculture has greatly reduced the available habitat for many reptiles. Changes to the vegetation from grazing, altered burning regimes, and timber-cutting could also have contributed to changes in the abundance of certain species. Many snakes are killed by humans, and for some species (such as the carpet python) killing and collecting activities might have contributed to local and regional population declines.

Vertebrate Fauna

More than 450 vertebrate species are currently known in the study area, comprising 39 mammals, more than 300 birds, 77 reptiles, 10 amphibians, and 27 fish.

Based on their distributional patterns, the vertebrate fauna may be divided into three broad categories, and the following sections include examples of species from each.

- Some species are typical of the Bassian biogeographic region of south-eastern Australia. Their distribution extends into the south-east of the study area and into the more mesic environments along the Murray River.

- Others typify the hot, dry Eyrean biogeographic region. These occur throughout the semi-arid parts of the Mallee area, and many reach the south-eastern limit of their Australian distribution here.

- Species in the third category are widespread in Australia and occur in both of the above biogeographic regions.

Mammals

The 39 mammals, comprising 31 native and 8 introduced species, currently known to occur in the Mallee area include 2 monotremes, 14 marsupials, and 15 placental mammals.

Recent surveys have clarified the distribution and identity of several bat species. The western broad-nosed bat (*Scotorepens balstoni*) has been recorded here, but not the little broad-nosed bat (previously named *Nycticeius greyi*, now *S. greyi*). The taxonomy of the little bat (*Eptesicus pumilus*) has recently been revised, and it has been found to include a number of species, at least two of which (*E. regulus* and *E. vulturnus*) are present in the Mallee. The northern sheathtail-bat (*Taphozous australis*) is not known in the region, although the yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*) occurs here.

In addition, three small terrestrial mammals have been recorded since 1974 as a result of increased survey work and the use of new trapping techniques. The Mallee ningaui was first captured in Victoria in 1977, and the paucident planigale in 1985 during the recent survey. The little pygmy-possum was identified as occurring in the Mallee in 1977; previously this animal was confused with the western pygmy-possum.

Unconfirmed records suggest several other species that may occur periodically in the study area. The euro (*Macropus robustus*) occurs north of the Murray River, and is likely to cross into Victoria at times. The red-necked wallaby (*M. rufogriseus*) is present in the Little Desert and there are reports of this species in the southernmost reaches of the Big Desert. The pied wattled bat (*Chalinolobus picatus*) has been recorded in New South Wales just north of the Murray, but has not as yet been found in Victoria. In 1856 the yellow-footed antechinus was common along the river; in the

past 80 years, however, only one record has come from the study area - a specimen from Mildura presented to the Museum of Victoria in 1963. The cause of decline of this species is not known and its current status here is uncertain.

Koalas, although not known historically, were introduced to Loch Island at Mildura in 1957. Over the following years, the colony of six animals slowly declined and died out. Koalas have also been released at Swan Hill.

The mammalian fauna of the Mallee area is distinctive in at least the following three respects.

- Many species known here either do not occur elsewhere in the State (red kangaroo, Mallee ningaui, paucident planigale, and Mitchell's hopping-mouse) or are limited to this and closely related areas (silky mouse, western pygmy-possum, and greater long-eared bat).

- More species have disappeared from the study area since European settlement than from any other part of Victoria.

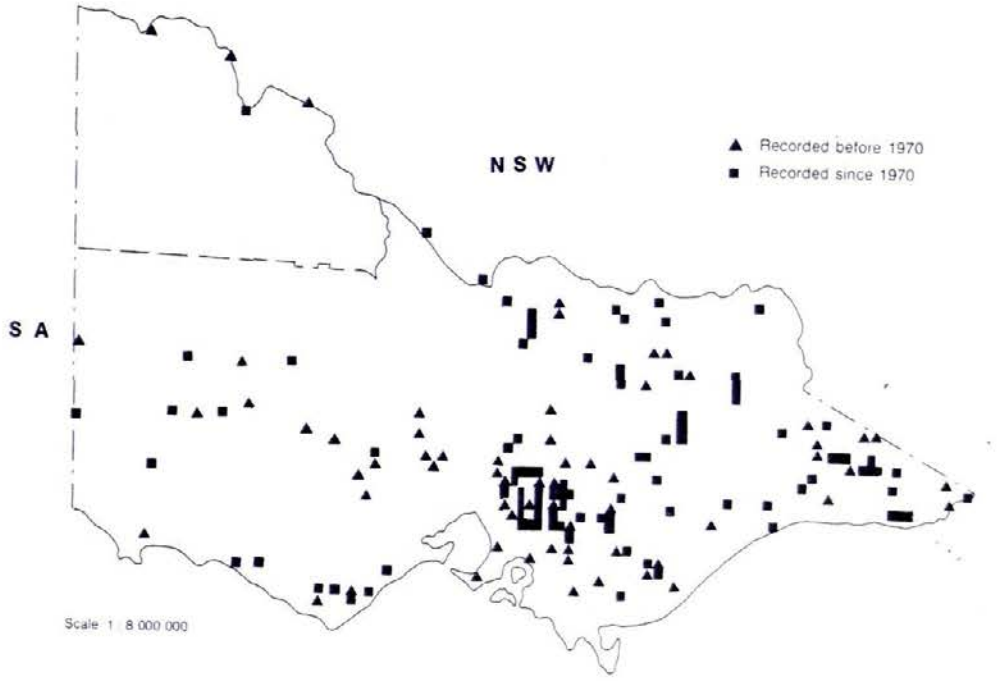
- The composition of the fauna within historical times differs distinctively from that in the rest of the State. Families well represented include the Dasyuridae (carnivorous marsupials comprising 8 species), the Macropodidae (kangaroos, wallabies, and rat-kangaroos - 6 species), and the Muridae (rodents - 7 species). The Phalangeridae and Petauridae (possums and gliders - 2 species), however, are poorly represented in comparison with southern Victoria. The diversity of bats (families Emballonuridae, Molossidae, and Vespertilionidae - 12 species) is similar to that in other parts of Victoria, but the species composition differs.

The distributional patterns of the mammalian fauna can be discussed in relation to the two main biogeographic regions. Fauna typical of the Bassian region include species inhabiting the more mesic environments along the Murray River, such as the feathertail glider and the little forest eptesicus, and species such as the swamp wallaby that have entered the study area via creeks from the south.

Within Victoria, the red kangaroo is only known in the Mallee.

Figure 14

DISTRIBUTION OF THE FEATHERTAIL GLIDER



Species whose distribution is largely associated with the Eyrean region include the paucident planigale, red kangaroo, and greater long-eared bat. Another group is adapted to the semi-arid mallee vegetation - for example, the Mallee ningaui, silky mouse, and Mitchell's hopping-mouse.

Widespread mammals that occur in both broad biogeographic regions include the short-beaked echidna, white-striped mastiff-bat, and Gould's wattled bat.

Birds

The study area, a relatively hot and dry environment, supports a distinctive element of the Victorian avifauna that comprises primarily the mallee-dependent birds - such as the malleefowl, red-lored whistler, mallee emu-wren, and black-eared miner - and the typically inland ones - such as the inland dotterel, grey falcon, white-winged fairy-wren, and crimson chat. Some Bassian species also extend into this area and these include the crested shrike-tit, superb fairy-wren, and New Holland honeyeater. Altogether, some 300 avian species have been recorded in the Mallee (see Appendix X). More than 75% of these currently breed here or have done so in the past, including several irruptive species (such as the black honeyeater, orange chat, and little crow) that generally appear in larger numbers during unfavourable conditions inland.

Particularly prominent groups, in both numbers and diversity, are the raptors, parrots, and cockatoos throughout the Mallee and, in the Big Desert, the honeyeaters. In the south-east, the extensive Kerang wetlands and surrounding flats provide refuge areas for the freckled duck and habitat for many other water-birds and waders. Along the Murray

River many hollow-dependent species, including the regent parrot, live and breed in the large old river red gums.

Widespread clearing of mallee and *Callitris--Casuarina* woodland has resulted in the severe decline and near extinction of some avian species, including the black-eared miner, and fragmentation of their preferred habitat. The well-known malleefowl, once a common sight throughout mallee scrub from central Victoria to the Little Desert and north to the Murray River, has now been reduced to a total Victorian population of less than a thousand pairs, the majority of which live in the large continuous Big Desert--Wyperfeld tract of public land. Other formerly more-common species now close to extinction in the Mallee area include the magpie goose, kori bustard, western whipbird, and spotted bower-bird. The superb parrot no longer occurs here.

The conservation status of birds in the Mallee area is currently threatened by:

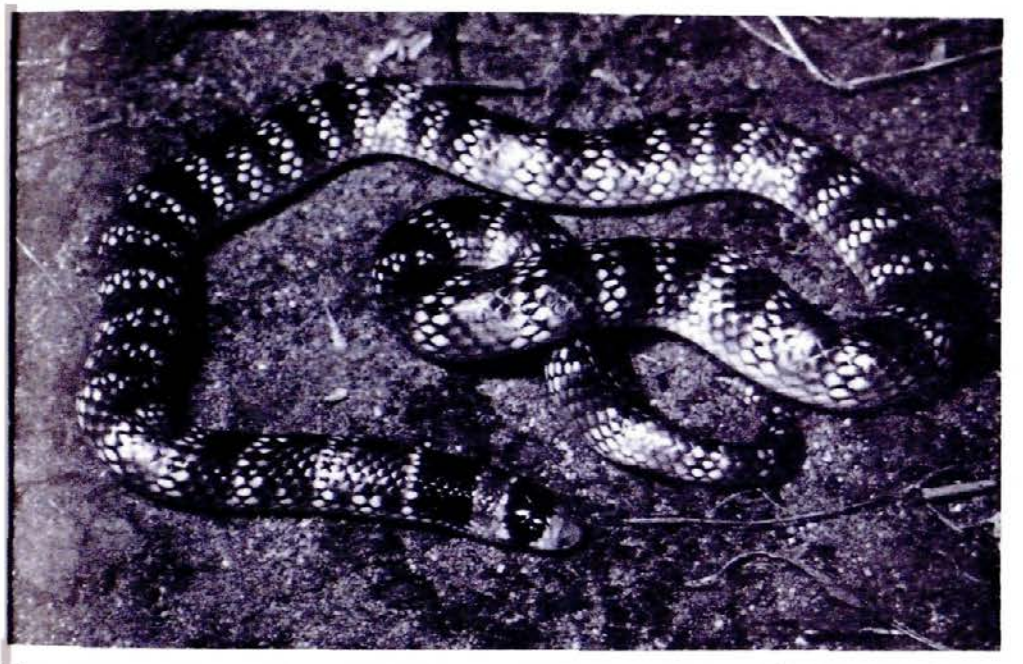
- existing and increasing isolation and fragmentation of populations, leading to potentially disastrous genetic consequences for some species (for example, malleefowl and white-browed treecreeper)
- degradation of remaining natural habitat by introduced grazing mammals, and repeated burning
- pesticide accumulation in the food chain
- egg-collectors, wild-bird fanciers, and dead-bird traders
- introduced carnivores

Three-quarters of Australia's mallee vegetation has already been cleared, increasing the importance of the remaining mallee in Victoria.

Reptiles and amphibians

The 77 species of reptiles currently recognized here represent nine families. These comprise 3 fresh-water tortoises (family Chelidae), 9 geckos (Gekkonidae), 9 legless lizards (Pygopodidae), 7 dragon lizards (Agamidae), 3 goannas (Varanidae), 22 skinks (Scincidae), 8 blind snakes (Typhlopidae), 1 python (Boidae), and 15 venomous snakes (Elapidae). This far exceeds the number found in any other Victorian region, and several factors contribute to its remarkable diversity.

Species associated with two zoogeographic regions are present: those (such as desert skink and beaded gecko) adapted to the semi-arid environments of the Eyrean region, which incorporates the bulk of the study area; and those associated with the Bassian region of the south-east and the Murray River corridor. Many inland or northern species reach the southern edge (beaked gecko and coral snake) or western edge (*Hemiergis millewae*) of their distributions in the area, while many species normally found in the more mesic environments of south-eastern Australia can also exist here, either



The southern edge of the coral snake's distribution occurs within the mallee.

along the watercourses (eastern tiger snake and spotted grass frog, for instance) or in the south (the brown toadlet).

Habitats in the study area vary widely and the diverse mallee communities associated with the two large blocks of public land are unique in Victoria. Within these communities, porcupine grass (*Triodia* spp.) is extremely important for reptiles. This plant provides sheltered micro-environments that are utilized by many species and that support an abundant invertebrate food resource.

Two species of snakes previously recorded in the study area probably no longer exist there. Neither the death adder nor the fierce snake has been seen in the area this century. The eastern tiger snake and the red-bellied black snake, strictly confined to riverine habitats, seem to have declined markedly here in recent years; the cause of this decline is not clear.

Our knowledge of the local reptiles is still far from complete. Some species only have single records and there are perhaps two as-yet-undescribed species.

Most of the 10 amphibian species (frogs) known here are restricted to the vicinity of the watercourses. Three species, however, are widespread in more arid environments, burrowing below the ground during adverse climatic conditions and emerging to feed and breed only after heavy rains.

The list of reptiles and amphibians provided in Appendix X includes all taxa presently recognized as occurring (or having occurred) in the Mallee area, with their currently perceived taxonomic placements. Other lists have been published, but recent taxonomic changes would make comparison very difficult.

Fish

Within the study area, 27 species of fish have been recorded in the principal water bodies: Avoca River, including the Kerang Lakes; the anabranches of the Murray River; the north Loddon River; and Lake Albacutya, which is currently dry (see Appendix XV). Earlier reports of the presence of crucian carp (*Carassius carassius*) in the area were in error. Of the 27 species, six (carp, tench, redfin, goldfish, brown trout, and mosquitofish) are not native to Australia; two (long-finned eel and short-finned eel) have probably been translocated to the area from their normal coastal range; and two species (trout cod and Macquarie perch), although listed in the appendix, may no longer occur in the Mallee.

Fish of major recreational and/or culinary value include the introduced carp, redfin, and brown trout and the native golden perch, Murray cod, silver perch, freshwater catfish, and river blackfish. Recreational and commercial fishing are discussed respectively in Chapters 11 and 12. The remaining species may be classified as forage fish, being small, generally native to Australia, and providing food for larger fish. Forage fish are important from a conservation standpoint in that they maintain ecological processes that keep the aquatic environment in balance.

It is believed that native fish species have declined in both range and abundance, principally because of water abstraction and regulation, poor land-use practices, increased salination, and general degradation of the aquatic environment. They appear to be less tolerant of degraded aquatic environments than introduced species, as evidenced by the relatively large populations of carp, tench, redfin, and mosquitofish in the region. The Fisheries Division of the Department of Conservation, Forests and Lands is currently breeding native fish species, mainly Murray cod and golden perch, to restock areas where populations have experienced severe decline or have disappeared altogether.

Habitat Use by Vertebrate Fauna in the Mallee

The use of habitats by the Mallee fauna is discussed below in relation to the floristically defined plant communities described in Chapter 7 - Vegetation. Patterns of use are diverse: some species occur throughout a wide range of floristic communities, while others occupy only a limited range. Appendix X provides a list of the vertebrate fauna recorded in each community. The following brief accounts seek to describe the characteristic features of the fauna recorded in the seven major groups of plant communities identified in the appendix. As fauna also respond to structural characteristics of the vegetation, particularly the maturity of the stands, these major groups of communities may include several markedly different faunal assemblages.

Dune-fields of the Sunset Country

The dune-field plant communities in the Sunset Country form one of the major tracts of natural habitat for native fauna in the Mallee area, and are of great importance for those

species that depend on mallee vegetation. Fauna are not distributed evenly throughout, but respond to the changes in vegetation that follow the dune--swale pattern of the landscape.

Numerous species appear to be widespread throughout the dune-field communities, including western grey kangaroo, lesser long-eared bat, Gould's wattled bat, King River eptesicus, grey shrike-thrush, weebill, spiny-cheeked honeyeater, grey butcherbird, white-eared honeyeater, malleefowl, shingle-back, nobbi dragon, *Pogona vitticeps*, *Menetia greyii*, and beaded gecko.

Another group is associated with mallee vegetation where the understorey includes (and is usually dominated by) *Triodia*. As the hummocks of *Triodia* grow, expand, and then senesce, they provide a variety of micro-habitats for the fauna. The Mallee ningaui, striated grasswren, and mallee emu-wren forage around and shelter within hummocks of *Triodia*. Many species of reptiles are also found here, and those typically associated with this habitat include *Delma nasuta*, *Hemiergis millewae*, Mallee dragon, western blue-tongue, and *Ctenotus brachyonyx*.

In the swale areas between dunes, mallee with a chenopod understorey (chenopod mallee) provides favoured habitat for a number of birds, particularly those that nest in tree hollows (for example mulga parrot, Mallee ringneck, and striated pardalote) and those that prefer to forage in more open spaces (jacky winter, red-capped robin, hooded robin). Reptiles recorded here include the wood gecko, coral snake, *Ctenotus uber*, *Lerista punctatovitta*, and *Ramphotyphlops bituberculatus*, but no species clearly appear to favour this habitat.

Western blue-tongued lizard; it prowls the porcupine grass hummocks of the Sunset Country.

Several 'significant' species - the black-eared miner, red-lored whistler, malleefowl, *Ctenotus brachyonyx*, and *Hemiergis millewae* - depend on the dune-field communities of the Sunset Country for their conservation.

Dune-fields of the Big Desert

As indicated in Appendix X, the heathland plant communities of the Big Desert dune-fields support many species that also occur in the dune-fields of the Sunset Country. However, a number are restricted to the Big Desert, where the varying floristic and structural composition of the plant communities has contributed to differences in faunal composition.

Small native terrestrial mammals are more numerous in these habitats. The little pygmy-possum, western pygmy-possum, and silky mouse are widespread in the heathlands, and the Mallee ningaui, common dunnart, and Mitchell's hopping-mouse are also present. The relative abundance of bats here is low and most captures are of common and widespread species like the lesser long-eared bat, Gould's wattled bat, and King River eptesicus.

The diversity of birds in these habitats varies with the structural complexity of the vegetation. Heathland, for instance, comprising a single stratum of low heathy shrubs, supports fewer species than mallee-heath where an overstorey of mallee is also present.

A distinctive feature of the avifauna of the Big Desert is the abundance and diversity of honeyeaters, particularly in spring. At least 11 species have been recorded there, and commonly occurring ones include the yellow-plumed, white-eared, spiny-cheeked, tawny-crowned, white-fronted, and brown-headed honeyeaters and the red wattlebird.

For three 'significant' birds, the Big Desert dune-fields are particularly important. The slender-billed thornbill favours heathland vegetation where an overstorey is absent, while the red-lored whistler occurs in mallee-heath communities. The malleefowl, which requires large tracts of mallee

The numbers of malleefowl in the Mallee have been reduced through human activities.

vegetation for a viable population to persist, is most numerous in parts of the Big Desert dune system.

Many of the reptiles found here are also present in the Sunset Country, but some five species - *Amphibolurus norrisi*, *Ctenotus robustus*, *Aprasia aurita*, *Unechis spectabilis*, and master's snake - were recorded only in the Big Desert. *Aprasia aurita* is an extremely rare endemic species, known only in a small area of dune-field in the eastern Big Desert. The detailed habitat requirements of this species are not known.

Dune-field with underlying sandstone ridge

The fauna of the broombush and heath woodland communities in this group is very similar to that present in the Big Desert dune-field communities. However, the red swale mallee, big mallee, and yellow gum woodlands are more open vegetation types with a distinctive overstorey. They support fewer reptiles and small mammals than the heath communities do, but accommodate birds that favour the more open understorey. These include the chestnut-rumped thornbill, restless flycatcher, and white-winged triller, as well as hollow-dependent birds like the Australian owlet-nightjar, brown treecreeper, and mulga parrot. The taller canopy also provides roosting sites for raptors and those birds, such as the white-browed woodswallow and rainbow bee-eater, that hawk insects above the canopy.

Lunettes and ridges

Most of the land formerly occupied by the plant communities of the lunettes and ridges has been cleared for agriculture, and much of what remains - such as that north of the Sturt Highway - is badly degraded through the removal of the cypress pine trees and intensive grazing by stock and rabbits.

Other than the bat fauna, native mammals are poorly represented. At least seven species of bats have been captured in these communities and the increased availability of water at stock dams and tanks may benefit them. One of them - the greater long-eared bat - is rare in Victoria and a single individual captured in woodland in the Hattah--Kulkyne National Park is the third record of this species for the State. The common brushtail possum and western grey kangaroo are present in woodlands, while the red kangaroo, western grey kangaroo, and fat-tailed dunnart occupy the open savannah habitats.

Two distinct avifaunal assemblages occur here - one in woodlands and the other in the more open savannah habitat. The woodland assemblage of birds typically includes the singing honeyeater, striped honeyeater, yellow thornbill, Gilbert's whistler, and the threatened white-browed treecreeper, which occurs nowhere else in Victoria. The other assemblage typically comprises the Australian magpie, willie wagtail, yellow-throated miner, black-faced woodswallow, and Richard's pipit. It is periodically supplemented by other species such as the ground cuckoo-shrike, banded lapwing, and many different birds of prey.

The seven species of geckos found here form a notable component of the reptilian fauna of these habitats. One of these, the beaked gecko, is currently known in Victoria only in belah woodland in the north-west of the study area. Other reptiles present include the skinks (*Ctenotus regius*, *C. uber*, *Lerista punctatovittata*, and *Morethia boulengeri*) and at least four snakes (the eastern and western brown snakes, coral snake, and *Unechis nigriceps*).

Evaporative basin (boinka)

Saline shrublands in the shallow depressions and natural grasslands on sandplains and gypseous plains offer markedly different habitats for fauna.

Saline shrublands, with low plant diversity and limited structural complexity, provide few opportunities for wildlife. Mammals rarely occur here, other than individuals straying from nearby mallee vegetation. Birds that forage in these low shrublands include the white-fronted chat, orange chat, white-winged fairy-wren, red-capped robin, and rufous calamanthus; when the shallow saline depressions are flooded, the Australian shelduck, red-capped plover, red-necked avocet, black-winged stilt, masked lapwing, and other waders may be present. A number of reptiles, most of which are widely distributed, also occur in the saline shrublands. These include *Pogona vitticeps*, *Menetia greyii*, and shingleback, but one species - the skink *Morethia adelaidensis* - is specialized for the saline shrublands fringing saline lakes and does not occur in other habitats.

Most areas of grassland (gypseous-plains grassland and sandplain grassland) have been grazed by stock and infested with rabbits, and in most places this has caused degradation of the habitat. Loss of the scattered trees and shrubs is also apparent. The western grey kangaroo and red kangaroo occur here, but other than these, and the introduced house mouse, terrestrial mammals are rarely encountered.

The southern whiteface, Richard's pipit, yellow-rumped thornbill, and white-fronted chat feed in the grasslands. And, where scattered trees are present, many other birds - such as the singing honeyeater, yellow-throated miner, blue bonnet, pink cockatoo, hooded robin, and chestnut-crowned babbler - are found. Birds of prey, including the wedge-tailed eagle, little eagle, Australian kestrel, brown falcon, and barn owl, also hunt here.

Geckos, including the tree dtella, Bynoe's gecko, and thick-tailed gecko, form a notable component of the reptile fauna in these grassland habitats. Other common species include *Ctenotus regius*, *Lerista bougainvillii*, *L. punctato vittata*, and *Morethia boulengeri*. The rare *Tympanocryptis lineata*, a notable species of dragon lizard in the Mallee, occurs mainly in the grassland.

Alluvial terraces and riverine plain

The plant communities of the riverine areas and adjacent alluvial terraces offer a range of habitats, which differ in

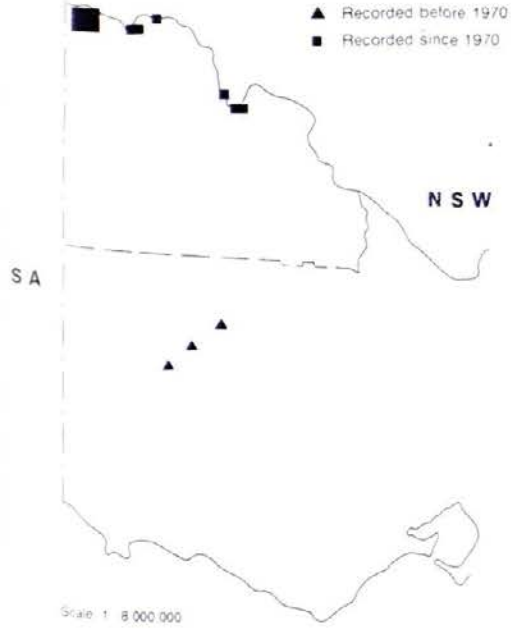
both floristic and structural composition and support a number of distinctive assemblages of fauna.

Rivers, lakes, billabongs, and wetlands provide a variety of aquatic habitats that are used by many species, particularly by waterfowl and wading birds such as grey teal, Australian pelican, great cormorant, black-fronted dotterel, sharp-tailed sandpiper, curlew sandpiper, and greenshank, as well as such amphibians as spotted grass frog, Peron's tree frog, eastern banjo frog, and long-thumbed frog. Three species of tortoise - eastern long-necked tortoise, broad-shelled river turtle, and Murray turtle - live in the Murray River and the water-rat forages in rivers, billabongs, and swamps.

Forests of river red gum that usually fringe the rivers and water bodies, particularly along the Murray, provide important habitat for many hollow-dependent species such as parrots, cockatoos, kingfishers, treecreepers, and bats. A number of threatened species including white-bellied sea-eagle, regent parrot, bush thick-knee, barking owl, and carpet python are also resident here. The mesic environment of these forests has provided a corridor that permits a number of species characteristic of southern Victoria to penetrate this semi-arid region. These species include the feather-tail glider, large-footed myotis, crested shrike-tit, brown quail, superb fairy-wren, striated thornbill, tree goanna, eastern tiger snake, and common eastern froglet.

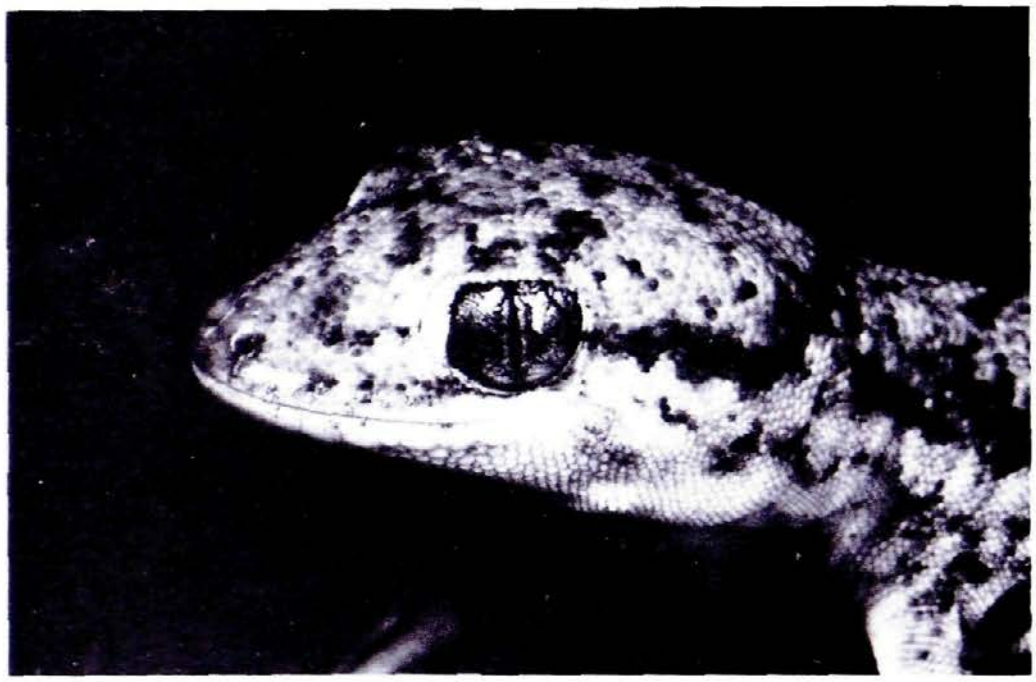
Figure 15

DISTRIBUTION OF THE TESSELLATED GECKO



Many of the species occurring in river red gum forests also use the adjacent black box woodlands. However, several species characteristic of the latter community, notably the paucident planigale and tessellated gecko, do not occur in river red gum. These small animals shelter in the deep cracks that form in the alluvial clay soils.

The chenopod shrublands of bluebush and saltbush on the alluvial terraces support a markedly different and less diverse fauna - the fat-tailed dunnart and red kangaroo are characteristic, and the avifauna typically comprises the white-winged fairy-wren, southern whiteface, Richard's pipit, and black-faced woodswallow, with seasonal or nomadic visitors such as the white-fronted, crimson, and orange chats, brown songlark, banded lap-wing, and inland dotterel. Many different birds of prey hunt over this habitat - in particular, the very rare grey falcon. The diversity of reptiles in the chenopod shrublands is also low, but those that do occur include Bynoe's gecko, tessel-lated gecko, *Ctenotus uber*, *Menetia greyii*, and curl snake.



The tessellated gecko is characteristic of the black box woodlands found adjacent to the river red gum forests.

Agricultural and urban

This category encompasses a wide range of habitats, in various states of disturbance. These include small towns and built-up urban areas, farm buildings and farm dams, sewage works, railway sidings and silos, rubbish tips, vineyards, citrus orchards, vegetable gardens, wheat paddocks, grazing lands, small scattered stands of trees in agricultural land, and vegetated road and rail reserves.

The fauna of these habitats usually comprises a remnant of the original complement together with, and often dominated by, introduced species. The fat-tailed dunnart, red kangaroo, western grey kangaroo, and several species of bats (the lesser long-eared bat, Gould's wattled bat, little mastiff-bat, and white-striped mastiff-bat) may occur in cleared farmland, together with the introduced house mouse, rabbit, hare, cat, and fox. The common brushtail possum persists around farm buildings and urban gardens, and the little red flying-fox occasionally visits orchards.

A variety of birds are found in these habitats. Native birds that favour open country, such as Richard's pipit, galah, Australian magpie, white-fronted chat, welcome swallow, and willie wagtail are widespread in farmland, while many other native species occur where patches of remnant vegetation are present along roadsides and amid cleared land. These include weebill, yellow-plumed honeyeater, singing honeyeater, spiny-cheeked honeyeater, red-capped robin, white-browed woodswallow, and white-winged chough.

Patches and strips of native vegetation have high conservation value here. Many species of raptors hunt over cleared farmland and nest in remnant vegetation along roadsides. For several - spotted harrier, black-shouldered kite, and

Australian kestrel - this is the primary habitat in which they are usually observed. Farm dams and particularly sewage works provide additional wetland habitat for such wading birds and waterfowl as white-faced heron, masked lap-wing, grey teal, little pied cormorant, and yellow-billed spoonbill.

The introduced house sparrow, feral pigeon, and common starling are most numerous around farm buildings, silos, and towns, while the European goldfinch and skylark favour open farmland.

Few species of reptile live in cleared agricultural or urban habitats, but these include shingle-back and eastern brown snake. Patches or strips of native vegetation, particularly where the understorey and litter layers are retained, may provide habitat for some species such as *Pogona vitticeps*, *Lerista bougainvilli*, *Morethia boulengeri*, and sand goanna. Artificial wetlands, like farm dams and sewage works, have provided additional habitat for a number of amphibians, including spotted grass frog, eastern banjo frog, and common eastern froglet.

Significant and Notable Vertebrates

A number of vertebrate taxa have been selected as having 'significant' or 'notable' status in the Mallee area. The criteria used for their selection are discussed below. The large number of taxa placed in these categories reflects the uniqueness of the Mallee compared with the rest of the State and its importance for the conservation of fauna in Victoria.

Criteria used for assessment

Taxa are listed as 'significant' if they conform to either of the following criteria:

- the Mallee area is important for the general conservation of the taxon
- the taxon is thought to be threatened when considered nationally, and Victorian populations are endangered or vulnerable

Taxa are listed as 'notable' if they conform to any of the following :

- the taxon is considered rare nationally, or in Victoria, or in the study area
- it is restricted to the study area in Victoria and/or it has a limited distribution outside that State
- it is of scientific interest
- it is threatened either regionally or in Victoria

The following brief account describes all of the significant species and some of the notable ones in the Mallee area.

Appendix XI provides a full list of them, together with assessments of their distribution, abundance, conservation status, and population trend.

Significant species

Little pygmy-possum (*Cercartetus lepidus*)

Averaging only 8 grams in weight, this is the smallest Australian possum. Prior to the 1960s, it was known only in Tasmania, where it occurs in a range of wet and dry sclerophyll forest habitats. It was subsequently recorded on Kangaroo Island, in parts of the south-east of South Australia, and in 1978 in the Mallee region of north-western Victoria. In these mainland areas it occupies quite different habitats from those used in Tasmania. The little pygmy-possum is widespread in the mallee and heathlands of the Big Desert and has been recorded in mallee vegetation at several localities in the Sunset Country. The area now forms a significant proportion of the known distribution of this species.

The animal forages in the shrub and ground layers, where it feeds on invertebrates, small reptiles, and probably pollen and nectar. In winter, when food is scarce and temperatures are low, it often enters periods of torpor, curling into a tight ball and reducing its body temperature to conserve energy.

Large-footed myotis (*Myotis adversus*)

This bat is never found far from water, and its distribution in Australia is limited to areas of the northern and eastern coasts where permanent water is available. In Victoria it occurs throughout the coastal zone and along the major river systems north of the Divide. The lack of permanent water in the Mallee restricts the large-footed myotis to a corridor along the Murray River. It feeds primarily on aquatic invertebrates that it takes from the surface of the water with its large feet. Small fish have also been recorded in its diet.

In southern Victoria, it uses caves or mines as roosts during the day, but females use only a small number as maternity sites, where they congregate to give birth. Because of the limited number of maternity sites, this species is extremely susceptible to disturbance and has been classified as 'vulnerable'. In northern Victoria, the large-footed myotis may roost in tree hollows, but it is not known whether these are used as maternity sites.

Silky mouse (*Pseudomys apodemoides*)

The silky mouse has a very restricted distribution, occurring only in the Big Desert and Little Desert of Victoria and in adjacent areas of similar habitat in South Australia. In the Big Desert it is relatively common in heathland vegetation, particularly in areas that support a diversity of plants to provide seeds (a major food item) all year round. This often results when the heathland vegetation regenerates

following a fire. The mouse's other food items include insects and banksia nectar.

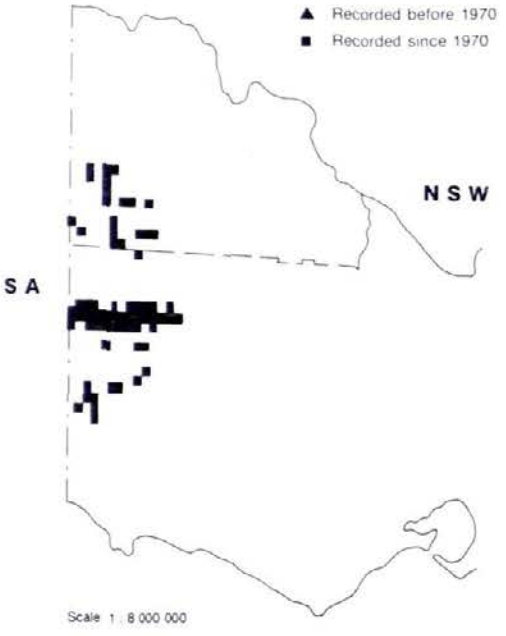
The frequency and intensity of fires appear to have an important influence on the local distribution, abundance, and ecology of the species. The silky mouse shelters during the day in a burrow system, thus avoiding the extremes of temperature experienced here.

Malleefowl (*Leipoa ocellata*)

This sedentary and territorial bird builds a nesting mound, in which it lays and incubates its eggs. It is known to feed on shoots and flowers of shrubs, seeds of *Acacia* species and other shrubs, and invertebrates.

Figure 16

SILKY MOUSE DISTRIBUTION



The malleefowl is famous for the mound it builds to incubate its eggs.

Both the malleefowl and its habitat are threatened throughout Australia. The species has already disappeared from the forests of south-western Australia and the whipstick mallee of central Victoria, and has almost gone from the arid inland, where it provided sustenance for the early explorers. Victorian populations are now isolated and scattered as a result of land clearing for cereal crops and pasture. The greatest densities of birds are found at Wathe Wildlife Reserve, in Bronzewing Wildlife Reserve, and in parts of the Big Desert--Wyperfeld park region. Other populations persist in the Sunset Country, in the Hattah--Annuello area, in

Wandown Wildlife Reserve, and outside the study area at Wychitella and the Little Desert. The Victorian population has been reduced to less than a thousand pairs and is still declining.

The species will very rarely breed in an area that has been recently burnt, requiring 20 or more years before conditions are favourable. The fact that more than 60% of the remaining mallee vegetation in Victoria has been burnt in the last decade (see Map 11) warrants concern about the current breeding status of the malleefowl. When it does breed, eggs are known to be taken by foxes, and newly hatched chicks fall prey to raptors, foxes, cats, and probably feral dogs. Further, research has shown that mallee grazed by domestic stock sustains only 10--20% of the numbers of malleefowl found in ungrazed mallee.

Regent parrot (*Polytelis anthopeplus*)

The regent parrot feeds on seeds, fruits, and buds of plants occurring in mallee, cereal crops, vineyards, and orchards. Its two major breeding areas in Victoria are the Wyperfeld National Park and land along the Murray River, from the Murrumbidgee junction to Robinvale.

Proximity to mallee vegetation is a key factor in sustaining breeding colonies along the Murray, and all colonies are within 20 km of mallee, particularly Christmas mallee (*Eucalyptus socialis*) and yellow mallee (*E. incrassata*). Breeding does not occur along the river where adjacent mallee has been extensively cleared. Favoured nesting sites are in large, old, and dying river red gums near permanent water, and often on river bends. Historically, hollows in black box and large mallees were also utilized for nesting.

A fall in the number of nesting hollows - resulting from clearing, forestry practices, severe fire in mallee, and competition from the introduced common starlings - poses a threat to this species. Other threats come from illegal trapping, egg-collecting, and, to a minor extent, the accidental death of birds feeding on spilt grain on roadsides.

Freckled duck (*Stictonetta naevosa*)

The freckled duck is known to feed on hornworts, algae, and aquatic invertebrates, especially crustaceans. It breeds in sheltered wetlands surrounded by thick vegetation such as reeds, cumbungi, and lignum. During inland drought it seeks refuge at a limited number of permanent fresh-water wetlands - predominantly in the south-east of the continent. Unfortunately, this makes it very vulnerable during the duck-shooting season and many have been shot, even though the species is protected by law. Important wetlands for the freckled duck occur in the south-east of the Mallee area.

Plains-wanderer (*Pedionomus torquatus*)

This ground-dwelling species feeds on insects and seeds of introduced and native grasses. Recent research has shown that it requires a mosaic of vegetation types, consisting of

sparse grassland for foraging and roosting and small patches of dense grass for refuges.

It has declined in Victoria, where it was relatively numerous and widespread in natural grasslands. Improved pasture, competition from grazing, and introduced predators are the suspected causes of its decline.

Although the plains-wanderer was until recently thought to be endangered, research conducted in the New South Wales Riverina has shown it to be locally common there, and limited surveys elsewhere have located small numbers in south-western Queensland, western New South Wales, western Victoria, eastern South Australia, and the Willandra National Park in New South Wales.

Kori bustard (*Ardeotis kori*)

Formerly known as the Australian bustard, the kori bustard is a large turkey-like bird that feeds on small vertebrates, insects, seeds, and fruits. It is infrequently recorded in the Big Desert and elsewhere in open country throughout the Mallee area. It was more common in the past, occurring in suitable grassland throughout Victoria. However, conversion of grasslands into farmland, shooting, and predation of eggs and young by foxes has led to a widespread decline. A small resident population persists just south of the Mallee area at Telopea Downs and possibly another exists in the Big Desert.

Red-lored whistler (*Pachycephala rufogularis*)

The bird feeds on invertebrates obtained from the ground, branches, and leaves, generally in open mallee with a dense low shrubby layer.

It has an extremely restricted range and a very small population. Victoria is the stronghold of the species, but contains less than a few hundred birds, almost all of which occur in the Big Desert--Wyperfeld park area and the southern Sunset Country. Even within this locality it has a patchy distribution, avoiding large areas of unsuitable vegetation.

Western whipbird (*Psophodes nigrogularis*)

A cryptic ground-dweller, the western whipbird has historically been difficult to locate throughout Australia. Formerly, the best-known Victorian population existed in the Manya area where, from 1919 onwards, it was recorded as reasonably common. However, persistent egg-collecting and wholesale clearing of mallee resulted in its local extinction by 1932. Other observations have since been made in a few localities within the Big Desert, the most recent of these being at Red Bluff in 1984, where one bird was heard calling from heathland.

A recent study investigating how broombush-harvesting affected fauna has concluded that the western whipbird is not restricted to broombush as formerly thought, but also that

its status in Victoria should be considered as in serious risk of extinction.

Mallee emu-wren (*Stipiturus mallee*)

The mallee emu-wren is a tiny, secretive, insectivorous bird found in pairs and small groups. It is confined to mallee scrub containing *Triodia*, in which it shelters, roosts, and nests, and thus it has a very restricted range encompassing suitable habitat in the Victorian and South Australian 'Murray Mallee' region. Victoria - where it is most frequently, although patchily, recorded in the Hattah--Kulkyne National Park and the Big Desert - contains most of the bird's population.

Slender-billed thornbill (*Acanthiza iredalei*)

This small, insectivorous bird feeds in small flocks on the ground and in low shrubs. In Victoria, it is restricted to low dense heathland of dwarf casuarina, banksia, and hakea, both in the Big Desert and, outside the study area, in the Little Desert. The latter south-eastern population and that in the adjacent 90-Mile Desert in South Australia form the geographically isolated race '*hedleyi*' that, unlike the other races, occurs in and is restricted to heath.

Black-eared miner (*Manorina flavigula melanotis*)

The black-eared miner - a shy, retiring bird - forms small flocks in dense mallee. It feeds on nectar and invertebrates obtained from the ground, on trees, and sometimes in the air.

The closely related yellow-throated miner frequents roadside verges in farmland, woodland, and margins of mallee and cleared land. Clearing and fragmentation of the Victorian mallee have together resulted in the creation of habitat more favourable to the yellow-throated species, which has subsequently invaded this new habitat and hybridized with the black-eared miner, resulting in the near extinction of the latter.

The survey in 1986/87 indicated that, at present, only eight black-eared miners are known in Victoria. These birds are scattered through the mallee, occurring near Berrook, Wymlet, and in the Annuello block, where they all occur in colonies with black-eared--yellow-throated hybrids.

White-browed treecreeper (*Climacteris affinis*)

A quiet, unobtrusive bird, the white-browed treecreeper occurs in pairs or small groups, feeding on invertebrates on tree-trunks and sometimes on the ground. It has suffered a massive decline in numbers through the extensive clearing of its preferred Victorian habitat of *Callitris* and *Casuarina* woodlands. As Figure 18 indicates, it presently occurs in isolated populations at Wyperfeld, Timberoo, Yarrara, Meringur, and a few other scattered stands of suitable woodland. The Victorian population is now likely to be less than a thousand individuals.

The black-eared miner (left) depends on Mallee vegetation for food and shelter, while the invertebrates found on tree-trunks provide food for white-browed treecreepers (right).

Figure 17

DISTRIBUTION OF THE BLACK-EARED MINER

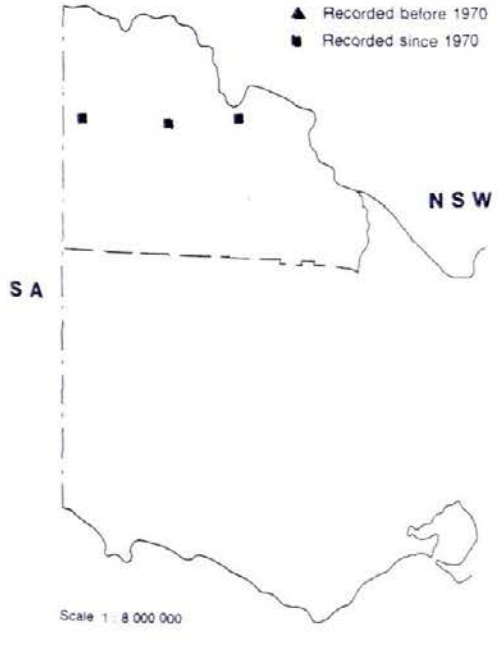
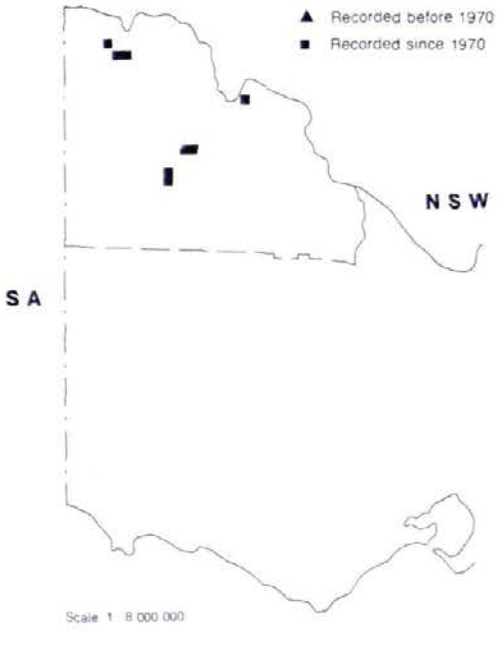


Figure 18

DISTRIBUTION OF THE WHITE-BROWED TREECREEPER



Aprasia aurita

This legless lizard (pygopodid) was described from a small number of specimens collected early this century in the Ouyen--Woomelang area east of the Wyperfeld National Park. Most of the land there has now been alienated and cleared for agricultural purposes. As no specimens of this lizard had been found since the early collections were made, it was

Figure 19

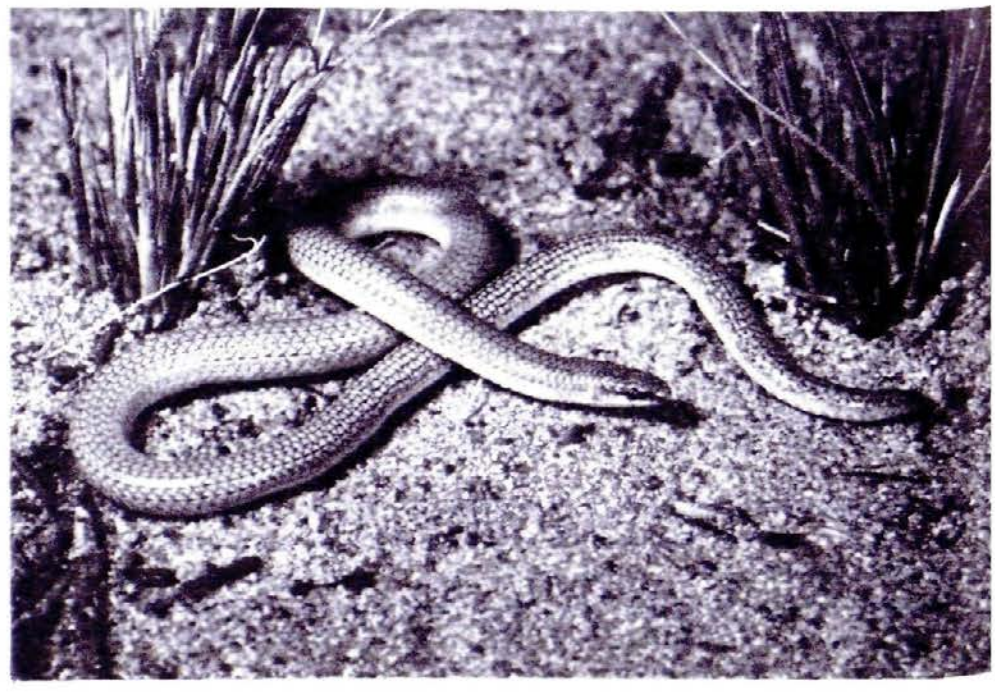
DISTRIBUTION OF APRASIA AURITA

feared the species might have become extinct. However, the recent studies have located a remnant population in the Wathe Wildlife Reserve (D4 on Map 8), which now appears to contain the only remaining population of the species.

The reserve was originally set aside because of its value for malleefowl, which are present in relatively large numbers in the long-unburnt vegetation found here. It contains vegetation communities similar to those found in the nearby Big Desert, the major difference being in their respective fire histories; most of the Big Desert has been burnt far more frequently. The Wathe Reserve is connected to the eastern edge of the Big Desert by a thin strip of public land.

Very little is known of the biology of *Aprasia aurita*. It is a small burrowing pygopodid, probably active by day, but rarely on the surface, and appears to be restricted to sandy soils in long-unburnt mallee and heathy vegetation. It coexists with the closely related *A. inaurita*. The latter occupies similar vegetation communities in the Big Desert and Sunset Country as well, but, in contrast to its much rarer cousin, is also found in areas subjected to fires or in early post-fire seral stages.

Fire history, therefore, in combination with diet may be the key to understanding why *Aprasia aurita* has such a restrict-



Aprasia aurita.

ed distribution. *A. inaurita* is a specialist feeder on the eggs of particular species of small ants and *A. aurita* probably has similarly specialized food requirements. As the two species coexist, they may be adapted to feeding on different species of ants. Species composition within ant communities has been found to depend on fire regimes, so *Aprasia aurita* may depend on ants that are only present in late post-fire seral stages. This could explain its absence from the neighbouring parts of the eastern Big Desert, most of which have been burnt recently and frequently.

Delma impar

Another legless lizard, this is a terrestrial species adapted to life in open native grasslands. It occurs sparsely throughout the drier areas of such country in southern New South Wales and Victoria, with apparent concentration on the basalt plains to the west of Melbourne. It is also known to occur in grasslands in the east of the Mallee area, but is rare and appears to be declining throughout its range.

Native grasslands generally have been subjected to severe and widespread modifications, through agricultural land use that involves both structural and floristic changes to the vegetation. While *Delma impar* has managed to survive in some agricultural areas, it has only done so in those areas where the impact has been relatively slight - as under light grazing. Populations appear to have seriously declined or disappeared in the more intensively utilized areas, such as those under continual heavy grazing or cultivation. Remnant native grasslands on both public and private land are therefore important for the conservation of the species.

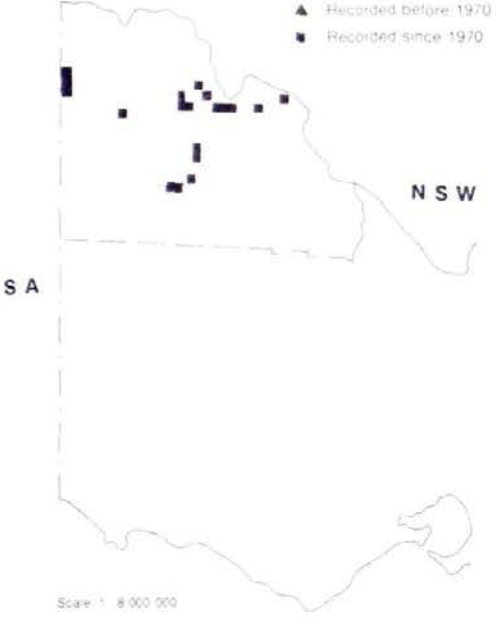
Ctenotus brachyonyx

Because it has limited distribution, centred on the 'Murray Mallee' region of Victoria, South Australia, and New South Wales, this medium-sized skink is listed as significant. In Victoria, it is found only in the northern mallee areas - of Sunset Country, Hattah, and Annuello - where it is relatively widespread but uncommon, usually occurring in communities containing *Triodia* spp.

It is a diurnally active insectivore, moving within and between *Triodia* hummocks when basking and foraging, and burrowing beneath the *Triodia* for shelter when inactive. Knowledge about its fire ecology - and its interaction with the various seral stages of the plant communities that support *Triodia* - is uncertain.

Figure 20

DISTRIBUTION OF CTENOTUS BRACHYONYX



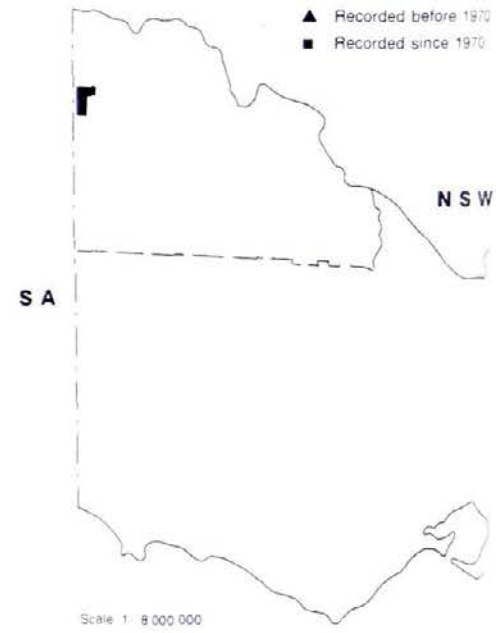
Hemiergis millewae

This small skink was discovered and described only relatively recently from collections made in the south-west of the Sunset Country. Further work there has revealed that it has a restricted distribution in Victoria, although it occurs patchily outside the study area - in South Australia and Western Australia.

It is an elongate thigmothermic skink with reduced limbs, specialized for life within *Triodia* hummocks. The sheltered micro-environments and food supplies that *Triodia* provide are essential for it, as only the microclimate-moderating effect of large hummocks allows it to survive in the harsh Mallee environment.

Figure 21

DISTRIBUTION OF HEMIERGIS MILLEWAE



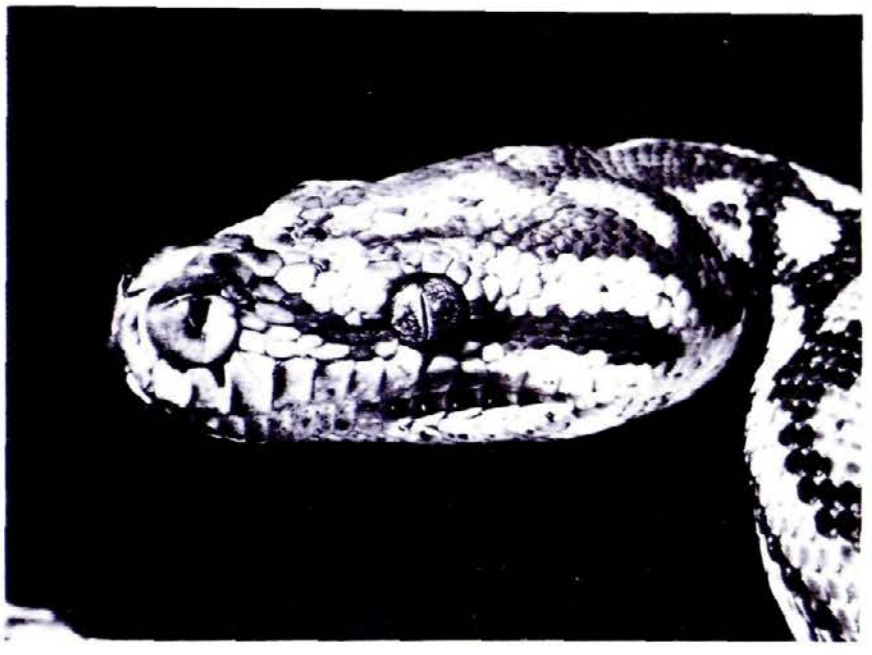
The species is usually active only within the porcupine grass hummocks, rarely venturing between them and found only in very large plants that usually have significant accumulations of litter and other dead vegetation. Such conditions are found where fire has been excluded for many years; indeed, *H. millewae* does not occur in early post-fire seral stages, which has implications for the management of res-erves for its survival. Furthermore, given its limited mobility, one would expect it to colonize areas, as they reach the later seral stages, only very slowly.

Carpet python (*Morelia spilota variegata*)

The carpet python was once widespread in woodlands along major watercourses and in the rock outcrops of northern Victoria. It is a slow-moving nocturnal species, specialized for hunting small mammals and birds in trees and on the ground. It shelters during the day in hollows in trees or rock crevices, and females incubate their eggs under cover of large accumulations of litter.

These attributes have made it particularly vulnerable to human interference, both by direct collecting for the pet trade (now illegal in Victoria) and by destruction of its habitat through agricultural and forestry activities.

The reduction in the number of mature or dead trees and the reduction of litter accumulations - resulting from silvicultural practices and firewood-collecting - have probably been important factors in its decline. Foxes might also have contributed to this decline, as they have the potential to prey upon eggs, hatchlings, and the incubating females.



Collection and killing of the carpet python could have contributed to local population declines.

The carpet python is now rare in Victoria, with the Mallee possibly being its major stronghold in the State. It seems to be associated largely with the river red gum community in the study area, and probably now exists only as a number of essentially isolated populations in the less-disturbed, more-extensive tracts of that community.

Notable species

Mallee ningaui (*Ningaui yvonneae*)

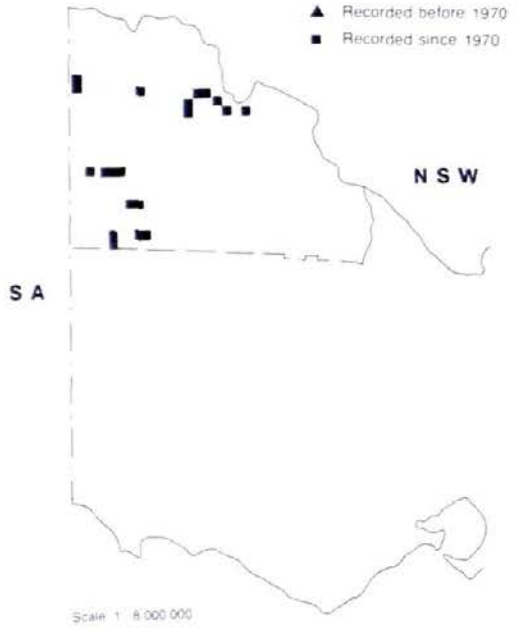
The name 'ningaui' is derived from an Aboriginal name given to 'tiny mythological beings that are hairy, have short feet, and only come out at night to hunt for food, all of which is eaten raw' (Archer, 1975). This describes some features of the small marsupial mouse, which is nocturnal and a voracious eater of large insects.

Although the genus *Ningaui* was not recognized until 1975 - with the first animals from Victoria recorded in 1977 - it is now known to be relatively widespread through mallee vegetation in Victoria, South Australia, and the south-west of Western Australia.

In Victoria it occurs in the Big Desert and Sunset Country, almost always where hummocks of *Triodia* dominate the understorey. The effect of different fire regimes on the species' specific habitat requirements is yet to be determined.

Figure 22

DISTRIBUTION OF THE MALLEE NINGAUI



Paucident planigale (*Planigale gilesi*)

The paucident planigale is a tiny marsupial carnivore of the arid and semi-arid regions of Australia. In 1985 it was recorded for the first time in Victoria at several localities along the Murray River, west of Mildura. This recent discovery, which extended the known range of the species some 200 km south, resulted from the use of new trapping techniques, rather than a recent influx.

Figure 23

DISTRIBUTION OF THE PAUCIDENT PLANIGALE

All Victorian records come from the riverine plains, where a grey cracking clay soil carries vegetation usually consisting of black box, with a clumped understorey of lignum or saltbush.

This voracious carnivore attacks insects and lizards, often larger than itself. Being very small (approximately 10 g) and extremely active, it has a high metabolic rate, and needs a very high food intake. For protection from predators, and as a buffer against temperature extremes, it shelters down cracks in the clay soils; its flattened head and body enable it to use quite small openings.

Common dunnart (*Sminthopsis murina*)

Despite its wide distribution throughout most of Victoria - excluding the broad coastal region, where it is replaced by the closely related white-footed dunnart (*Sminthopsis leucopus*) - nowhere does the common dunnart appear to be numerous. In the Mallee area, it occupies a range of mallee and heathland habitats in both the Big Desert and the Sunset Country, but in very low numbers. For example, it comprised only 3% of the native small terrestrial mammals captured in the recent survey. It is not clear what factors limit the abundance of this small insectivorous marsupial.

Western pygmy-possum (*Cercartetus concinnus*)

While it is associated with the woodlands and dry sclerophyll forests of the south-west of Western Australia, in eastern Australia the western pygmy-possum inhabits mallee vegetation in both Victoria and South Australia. In the Mallee it is known only in the Big Desert, where it commonly occupies mallee-heath and broombush habitats.

The ecology of the species is similar to that of the little pygmy-possum, with which it co-exists in many parts of the Big Desert. It is not yet clear how these very similar species partition the habitat and other resources, such as food and nesting sites.

The western pygmy possum. It is widespread in the heathlands of the Big Desert.

Yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*)

Although distributed throughout much of Australia, the yellow-bellied sheathtail-bat is rarely encountered. This is at least partly due to its fast flight, usually well above the canopy.

Victoria has only 13 confirmed records of this species, two of which come from the Mallee area - the most recent being an individual collected at Mildura in 1956. The species may possibly migrate into southern Australia during autumn, as records have come from Victoria and southern South Australia at this season. Some of these animals have been found exhausted and in unusual locations, such as resting on an exposed wall in broad daylight.

Greater long-eared bat (*Nyctophilus timoriensis*)

This bat is patchily distributed throughout areas of semi-arid and arid southern Australia, although nowhere is it common. Only three records place the species in Victoria, two of them in the Mallee area and the third just to the south. One individual was caught in 1962 in an area of open mallee in the east of the Sunset Country. A second specimen was trapped during the recent survey in an open woodland of *Casuarina* in the Hattah--Kulkyne National Park. During the survey more than 2000 bats were captured throughout the study area, but these included only one greater long-eared bat, which must therefore be considered a rare species here. Little is known of its ecology.

Mitchell's hopping-mouse (*Notomys mitchelli*)

As its name suggests, Mitchell's hopping-mouse is a native rodent, with elongated hind feet and a long tufted tail, that moves by a series of rapid hops. It occurs in areas of

mallee in north-western Victoria as well as the south of South Australia and Western Australia. In Victoria the species is restricted to the Mallee area, where it is widely distributed in mallee habitats in the Big Desert and Sunset Country.

Colonies of the mouse appear to be locally concentrated in areas with deep sands (such as the tops of dunes) where a shrubby understorey is present. Seeds from these shrubs form the major component of the animal's diet, and it builds extensive burrow systems to provide nesting sites.

Mitchell's hopping mouse is nocturnal and lives on a diet of seeds, insects, and green plants.

Peregrine falcon *(Falco peregrinus)*
Grey falcon *(F. hypoleucos)*
Black falcon *(F. subniger)*
Australian hobby *(F. longipennis)*

These falcons occur throughout the Mallee area and are generally rare resident species. Individuals dispersing from unfavourable conditions inland periodically supplement some populations. All four species are threatened by the following processes:

- theft of eggs and young for collections and falconry
- capture of adults for falconry and private zoos
- collections of specimens for the dead-bird trade
- pesticide accumulation, which causes egg-shell thinning, and ultimately reproductive failure through breakage of eggs, and increased mortality of embryos in the unbroken eggs

White-bellied sea-eagle *(Haliaeetus leucogaster)*

This is a large bird of prey whose diet varies throughout its range. Along inland rivers and wetlands, fish form a substantial part of that diet. As fish are known to rapidly accumulate such pollutants as pesticides from water, concern is held for the very small resident population of the white-bellied sea-eagle in the study area.

Invertebrate Fauna

Ecological importance

Invertebrates include all animals without backbones, and the major groups in the Mallee relevant to this study are insects, arachnids (such as spiders and scorpions), molluscs, myriapods (centipedes and millipedes), crustaceans, and worms.

As elsewhere, invertebrates here dominate both the terrestrial and aquatic faunas, in terms of numbers of individuals, numbers of species, and biomass. They play essential roles in the structure and function of ecosystems: they are involved in feeding on plants, in nutrient recycling (decomposition), in parasitism, predation, and scavenging, and in pollination. Moreover, although occupying the lower levels of the food chain, they comprise the main food of many species of amphibians, reptiles, birds, and mammals.

Significance of the Mallee invertebrate fauna

Despite their vital roles in the ecosystem, no systematic inventory or ecological study of the invertebrates has been conducted in the Mallee until the survey for this review was undertaken. In many parts of Victoria, fragmented and selective collections by early naturalists are all that are available to document the fauna present before clearing. However, even though published information on the Victorian Mallee invertebrate fauna is scarce, large areas remain relatively undisturbed and so an inventory/ecological study will still provide some very important baseline information.

The following section is compiled from a survey of the invertebrate fauna conducted by the Museum of Victoria during 1985--87 and from published references and available unpublished studies.

The region is one of the most interesting biogeographical zones in Victoria and, except for those of the northern tropics, has elements of faunas from all parts of Australia. The semi-arid Mallee has elements related to those of Western Australia and South Australia, as well as to the central Australian fauna of South Australia, western New South Wales, and south-western Queensland. The wetter riverine forests have elements of the moister south-eastern Australian fauna.

Many invertebrate species have a disjunct distribution between the Victorian Mallee and west of the Eyre Peninsula as a result of the incursion of the sea into the Murray Basin.

The fauna

It is difficult to estimate the total number of invertebrate species in the Mallee, and even the most thorough survey will result in only a rough inventory. Recent arrivals in the area (by either natural or Man-mediated means) continue to add to the numbers. The beetles (Coleoptera) are among the better-known groups, and the recent survey collected a total of 301 ground-dwelling species. Of these, 132 are known and, while some of the rest will also be known, many are undescribed and there is at least one new genus of weevils. Except for the butterflies, most invertebrate groups will contain a large proportion of undescribed species.

The invertebrate fauna does not have uniform composition in either time or place. It varies according to abiotic (climate and soil) and biotic (vegetation type and other animals) factors, seasonality, and events such as fire.

It has often been assumed that invertebrate communities reflect the plant communities in which they are found. At present, we have inadequate information to either prove or disprove this assumption, and must exercise care when considering management plans that affect invertebrates but are based on plant or vertebrate information.

In general, the invertebrate fauna can be divided into terrestrial and aquatic, and the terrestrial fauna further subdivided into arboreal and ground-dwelling or subterranean. However, these divisions are often nominal because many species use more than one habitat - for example, some have subterranean immature stages and arboreal adults.

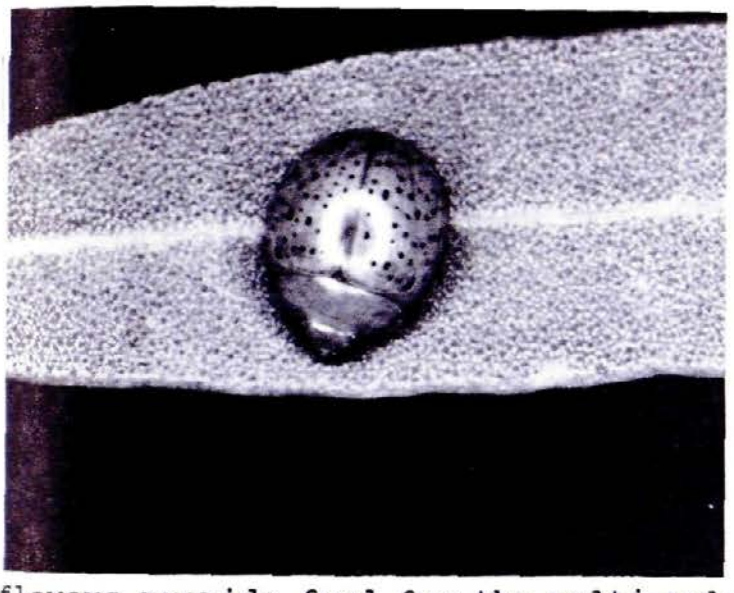
Arboreal fauna

For arboreal invertebrates, distribution depends on the vegetation community, host plant species, host plant architecture and age, and fire history. The species include herbivores, parasitoids, predators, and scavengers.

Herbivores feed on their host plant by chewing leaves, sucking plant juices, making galls, or mining leaves and stems, or may feed on wood in the trunk. Many are species-specific and would not survive without their host plant. Many cryptic species depend on microhabitats such as bark or tree holes.

Mallee eucalypts have a large suite of insects that are restricted to them. These include bugs (Hemiptera) such as psyllids, cicadellids, and eurymelids, many of which are protected by ants that feed on the honeydew the bugs excrete. Foliage-chewers include chrysomelid, scarab, and curculionid beetles, and moth and sawfly larvae. A recent study of the mallee arboreal invertebrates found representatives from at least 75 families, dominated by ants (mainly ground-dwelling species), spiders, beetles, and bugs. Other groups of plants, especially wattles and tea-trees, also support host-specific fauna.

Flowering of the host plants is an important factor in determining faunal abundance, and eucalypt and tea-tree



Invertebrate fauna, such as this chrysomelid beetle, have an essential role to play in the structure and functioning of ecosystems.

flowers provide food for the multi-coloured jewel beetles (Buprestidae) - such as *Stigmodera* species and the large orange-yellow *Julodimorpha bakewelli* - beetles such as the Lathridiidae and Anthicidae, and the native bees (Colletidae and Halictidae).

Butterflies are a well-recognized group. However, although nearly all Victorian species are well known, their distribution and ecology are not. In the study area, 20 native species have been found and they rely on mat-rushes, sedges, quandong, and mistletoe plants for food for their larvae. Some are attended by ants, which care for the larvae in their nests during the day and bring them out at night for feeding. A number of rare butterfly species occur here, and further studies are required on their distributions and habitat requirements. These include the skipper (*Motasingha atralba*) on sedges, the blue (*Candalides hyacinthinus simplex*) on dodder-laurel, and *Ogyris otanes* on sour bushes. The introduced cabbage white butterfly (*Pieris rapae rapae*) is also found in the Mallee.

The many arboreal spiders found here include active hunters such as jumping spiders (Salticidae) and crab spiders (Thomisidae), web-building species such as the orb-weavers (Argiopidae), and the colonial spider (*Badumna* sp.) that builds messy silken nests. Under the bark of plants are found huntsman spiders, including some very large species in river red gum, and the small pseudoscorpions.

Ground-dwelling and subterranean invertebrates

Many species dwell on the ground and hide in litter, in rotting logs, under rocks, or in plants such as porcupine grass, or utilize the more stable subterranean environment by burrowing into the soil.

The ground-dwelling fauna comprises representatives of 11 classes of invertebrates. Some groups - such as Araneae (spiders), Coleoptera (beetles), and Formicidae (ants) - are widespread throughout the Mallee, although others - like Oligochaeta (earthworms) and Isopoda (woodlice) - are fairly localized, as indicated by Appendix XIV.

Ants, beetles, spiders, and cockroaches dominate the ground-dwelling fauna. Ants are the most abundant group of invertebrates in the Mallee and a study of an area 50 m x 50 m in the Big Desert identified more than 150 species of ants active over a 1-year period. These different species can coexist because they have different feeding habits - ranging from predation, scavenging, seed-harvesting, and collecting honeydew from plant-feeding bugs, to combinations of all these activities - and different seasonal and daily foraging times. Ants' seed-harvesting activities are important, because they either destroy seeds (especially eucalypt seeds) or disperse them (acacia seeds, for example).

While ants are the most abundant group, the beetles have more diverse trophic functions. More than 300 species of ground-dwelling beetles live in the Mallee, belonging mainly to four families: the carabs (Carabidae, such as species of *Carenum*, *Neocarenum*, *Euryscaphus*, *Parroa*, and *Scaraphites*), pie-dish beetles (Tenebrionidae), cockchafers (Scarabaeidae), and weevils (Curculionidae)). Many of the carabs and tenebrionids live in burrows or in porcupine grass. This grass also provides important habitat for amycterine weevils and cockroaches. Some 25 species of cockroaches occur in the Mallee, including at least two undescribed ones. Two species of carab beetles - *Cicindela scatigera* and *Megacephala australis* - are found in association with salt pans.

Small and soft-bodied spring-tails (Collembola) rely on litter, logs, or rocks for protection, and are usually found in cool weather after rain. Isopods (Crustacea) and earthworms (Oligochaeta) are common after heavy rains in some areas. Termites are rarely seen openly, but they occur in rotting wood.

Several species of ground-dwelling spiders are well known, and these include wolf spiders (Lycosidae), the red-and-black spider (*Nicodamus* sp.), and the Mallee mouse spider (*Missulena* sp.). The recent Mallee survey resulted in the rediscovery of the barking spider (*Selenocosmia stirlingi*),

Carab beetles dwell in the ground.

which was considered extinct in Victoria. These large burrowing spiders are very long-lived (8--10 years to reach maturity). Other interesting finds include: two undescribed species of Gallieniellidae, a family of spiders previously known only in Madagascar; undescribed species of *Zelotes* and *Echemus* (Gnaphosidae); and a new genus of Clubionidae. The Mallee supports approximately 30--40 species of the larger ground-dwelling spiders.

A barking spider - it is considered rare in the Mallee.

Three species of harvestmen (Opiliones) are found here, including an undescribed genus and a species from the family Assamiidae, which is the most southerly record of this family in Australia.

The five species of scorpions include *Isometroides vescus* - its first record in Victoria. This is a specialized predator of burrowing spiders, found previously in south-western Western Australia, South Australia, the Northern Territory, and New South Wales.

Myriapods include the carnivorous centipedes (chilopods) and the detritivorous millipedes, both of which occur in plant litter and beneath logs and rocks. The nine species of centipedes include an undescribed species of *Otostigmus*.

Mantids and phasmatids are often found on the ground, although both groups use the arboreal habitat. The survey identified seven phasmatid and 14 mantid species, the latter occurring in Victoria only in the Mallee area.

Several central Australian native land molluscs are also confined in Victoria to the Mallee: *Thermapupa adelaide*, *Sinumelon fondinalis*, and *Australbinula bannertonensis*.

Aquatic habitat

In aquatic habitats, the number of species (and individuals) of invertebrates depends on the permanence and rate of flow

of the water and on the amount of vegetation and detritus in it. The species also change with increasing salinity - from fresh to saline. True fresh-water habitats are becoming increasingly rare in the study area because of the increasing salinity of the surface water and dryland salinity. The fauna of the temporary streams and lakes that rely on the flow of the Wimmera River, for instance, is severely threatened by the decreasing frequency and amplitude of filling.

More than 69 species of invertebrates were found in a survey of six lakes in the Outlet Creek system, including 25 common to all lakes, and 25 found in only one. The insect fauna included dragonflies (Odonata), aquatic bugs (Corixidae and Notonectidae), beetles (Dytiscidae), midges (Chironomidae), and mayflies (Ephemeroptera). Caddis-flies (Trichoptera) are limited to fresh water and are vulnerable to the rising salinity levels. Adult dragonflies and may flies can be found flying well away from water. Other groups found here include water mites (Hydracarina), ostracods, cladocera, copepods, decapods and amphipods (Crustacea), oligochaeta (worms), and molluscs. The fresh-water molluscs include the gastropods *Notopala hanleyi* and *Plotiopsis balonnensis*, the mussel *Velesunio ambiguus*, and the snail *Bulinus* sp.

Species considered rare

It is difficult at this stage to recommend listing many of the invertebrates as rare or endangered because the sparseness of information prevents differentiation between a rare species that is simply limited in its distribution and one whose range or abundance has been reduced. However, it is possible to nominate five that may be considered rare, but that require further study. These are:

Arachnida:	Theraphosidae:	*Selenocosmia stirlingi* (barking spider)
Insecta:	Coleoptera:	*Epilectus mastersi*
Insecta:	Lepidoptera:	*Motasingha atralba*
Insecta:	Lepidoptera:	*Candalides hyacinthus simplex*
Insecta:	Lepidoptera:	*Ogyris otanes*

The effects of land use on the invertebrate fauna

Despite the lack of information regarding the invertebrate fauna of the Mallee area, it is still possible to identify the factors that are potentially damaging to them. The major ones include:

- clearing of native vegetation for farming - the survival of native invertebrates in altered habitats and the role of remnant pockets of vegetation is uncertain
- grazing of domestic (and feral) animals
- fuel-reduction burning - both timing and frequency are important, as most activity of invertebrates is seasonal

- introduction of exotic animals, including the honey bee (*Apis mellifera*)
- increasing salinity and altered stream-flow regimes (few stands of river red gums remaining in the Wyperfeld park, for instance, receive the required intermittent floods)
- over-collecting
- tracking and disturbance caused by broombush-cutting, apiculture, recreation, and Army manoeuvres

Factors Affecting the Distribution and Status of Vertebrate Fauna

The following are some of the more important factors that influence the distribution, abundance, and conservation status of fauna in the Mallee area.

Clearing of native vegetation

The impact of agricultural activities on wildlife primarily depends upon the extent and nature of changes that occur to the habitats used by animals. Total clearing of native vegetation to establish pasture or croplands has a devastating effect on resident wildlife populations. Few species can survive the loss of their habitat, and individuals are either displaced or die unless remnants of native vegetation are retained.

Clearing raises two issues of concern to wildlife conservation. First, it reduces the total extent of natural habitat and fragments it into disjunct patches. The large blocks of mallee vegetation in Victoria - the Sunset Country and Big Desert - have great importance because extensive tracts adjoining them in both Victoria and South Australia have been largely cleared and fragmented. Second, clearing of native vegetation has been selective, with those areas of greatest soil fertility and suitability for agriculture being more extensively cleared. In particular, woodlands of *Callitris* and *Casuarina* have been largely removed and faunal species typically associated with these habitats, such as white-browed treecreeper and beaked gecko, have greatly reduced distributions in the study area.

However, for some species - notably birds like the crested pigeon, little raven, Richard's pipit, and yellow-rumped thornbill, which favour open-country habitats - the increased area of farmland has been of benefit by providing a bigger area of suitable habitat. Some species have utilized new food sources such as grain crops and other introduced plants, while tanks and dams for watering stock have increased the availability of water for many.

Wildlife conservation in farmland

Within the grazing and cropping areas, remnant patches and strips of native vegetation are of crucial importance for the persistence of many native animals. Clearly, larger

remnants and those with less-disturbed vegetation have the greatest conservation value, but even small ones can benefit wildlife. For example, roadside strips of vegetation may serve at least four functions, listed here with examples of species that benefit:

- as a complete habitat (*Lerista bougainvillii*, *Menetia greyii*, splendid fairy-wren, red-capped robin, weebill, and yellow-plumed honeyeater)
- as a habitat for foraging (blue bonnet, white-winged chough, Mallee ringneck, grey butcherbird, short-beaked echidna, eastern brown snake, and shingle-back)
- as a refuge or roosting site for species that forage in adjacent habitats (Australian kestrel, spotted harrier, white-browed woodswallow, and yellow-rumped thornbill)
- as a refuge during migration or as a corridor for dispersal movements (white-winged triller, brown-headed honeyeater, and rainbow bee-eater)

Grazing in natural vegetation

Agricultural activities taking place in natural vegetation mainly comprise the grazing of sheep and cattle in native plant com-munities. Grazing by stock affects the natural environment and wildlife habitats through the changes that take place in the vegetation and soils. Its impact causes greatest concern in those plant communities that are not adequately represented in conservation reserves, such as the chenopod shrublands of the upper terraces and of the gypseous plains grasslands.

Grazing results in changes to both the floristic composition and structure of the natural vegetation. Palatable plants are eaten preferentially and may disappear from the community, leaving mainly unpalatable and non-nutritious species. Heavy browsing of grasses, herbs, and shrubs, particularly in times of drought, denudes the lower strata, thus removing cover and reducing the structural complexity of the habitat for fauna. Native species likely to be most affected by such vegetational change include shy hylacola, southern scrub-robin, chestnut quail-thrush, and malleefowl, which live or forage in shrubs and ground vegetation.

During his interpretation of the aerial photographs and Landsat images of the Mallee area for Map 10 (Floristic Vegetation), I. Roberts identified the extent of disturbed native vegetation caused by grazing stock. This is plotted on Map 12.

The impact due to stock trampling on soils has been studied mainly in chenopod shrublands, where the primary effects are soil compaction, soil erosion, and destruction of the surface lichen crust. These changes are greatest close to the soil surface (within 10 cm), which is also the zone where essential plant nutrients are most concentrated. Soil disturbance from trampling varies inversely with the distance from watering points.

The impacts that changes in soil micro-habitats have on fauna have not been described, but those species most likely to be affected include the coral snake and *Ramphotyphlops* spp., which live underground in cracks or burrows, and fossorial species that forage in the subsoil and litter like *Lerista punctatovittata* and *L. bougainvillii*.

Fire

The fauna of the Mallee area has been subject to periodic fires for thousands of years. The relationship that has developed during this period is complex and important, but it is also indirect: faunal species adapt not to fire *per se* but to the floristic composition and structure of the plant communities resulting from a particular fire regime. Of the three components of a fire regime (frequency, intensity, and the season of burn), frequency - the interval between fires - is likely to have the most important long-term influence on fauna.

It is important to recognize that different plant communities are adapted to differing fire regimes. Heathlands and mallee vegetation with *Triodia*-dominated understorey, for example, are relatively flammable due to the rate of accumulation of litter and the continuity of fuel. In contrast, chenopod shrublands or woodlands of *Casuarina* and *Callitris* have lower fuel loads and experience naturally occurring fires less frequently. Accordingly, it may be expected that the responses to fire of the fauna inhabiting these communities will differ fundamentally. The key to understanding the response of each species is to understand how fire affects the availability of that species' essential resources, such as food and shelter.

Heathland and mallee-heath vegetation reach their greatest plant species diversity in the first 5 years after a fire. Animal species that rely on seeds and flowers occur in their greatest density in such floristically rich vegetation. The silky mouse, for example, which depends on seeds for a major part of its diet, favours the early stages of post-fire succession in heathlands. In later years, as the vegetation matures and the species diversity gradually declines, the quality of the habitat for the mouse also declines. However, while frequent burning may initially seem advantageous for this native rodent, other research has shown that desert banksia (*Banksia ornata*), a prominent heathland plant and important food source for the silky mouse, would be eliminated with a fire frequency of less than 15 years.

As the vegetation ages, its greater structural complexity provides opportunities for other species.

There is no evidence that any faunal species are restricted to the early stages of post-fire regeneration in mallee communities. The limited data available for birds indicate a greater species richness in older mallee vegetation and this may correspond to an increasing structural diversity of the habitat with age. Birds such as the mulga parrot, Mallee ringneck, Australian owlet-nightjar, and striated pardalote use hollows for nesting, and require older mallee, which has

had time to develop hollows and spouts. Litter, which accumulates with time, provides cover for many reptiles and a foraging zone for ground-feeding insectivorous birds such as the chestnut quail-thrush, shy hylacola, and white-winged chough.

A study of the reptile fauna, in mallee vegetation of differing ages resulting from fire, recorded a similar number of species in each area, but found that their relative abundance differed markedly. Some species, such as desert skink, beaded gecko, and painted dragon, were most common in the most recent burn (4 years after a fire), while others (eastern spiny-tailed gecko and coral snake) were more numerous in older regeneration. The composition of the reptile fauna changed according to the age of habitat regeneration.

The occurrence of a number of species, such as the Mallee ningaui, striated grasswren, Mallee emu-wren, *Delma nasuta*, and *Hemiergis millewae* is closely linked with the occurrence of *Triodia* hummocks. With increasing time since burning, these hummocks form a diversity of micro-habitats as they grow and later collapse in the middle. Large living hummocks are used by the Mallee ningaui and *Hemiergis millewae*, for example, while the collapsed debris provides shelter for pygopodids such as *Delma nasuta*, Burton's snake-lizard, and many skinks.

Because of the lower fuel quantities present, chenopod shrublands support only infrequent fires. Little is known of the response to fire of the fauna in this vegetation.

Woodlands of *Casuarina*, *Callitris*, and black box and forests of river red gum all burn infrequently under a natural fire regime. Tree-hollows, a resource that is only present in mature trees, are required by species such as the white-browed treecreeper, cockatiel, and pink cockatoo in dryland woodlands, and by the regent parrot, sulphur-crested cockatoo, brown treecreeper, yellow rosella, common brush-tail

The loss of large river red gum trees - through fire or timber-harvesting - can reduce the numbers of hollows available for shelter.

possum, and feathertail glider in riverine forests. Large hollow logs create refuges for the carpet python, and abundant logs and litter provide habitat for skinks such as *Egernia striolata*, *Morethia boulengeri*, and *Cryptoblepharus carnabyi*. The effects of fire in woodlands of *Callitris* and *Casuarina* are exacerbated by grazing rabbits, which inhibit regeneration of these trees.

Fire may be used as a management tool to manipulate faunal habitats, but this use requires carefully planned strategies based on a sound understanding of the biology of the plant and animal communities. In the past 10 years, fires have burnt vast areas of public land and so long-unburnt stands of mallee are now scarce (see Maps 11 and 11A), endowing the remnant old mallee with great conservation significance. Based on our present understanding of the habitat requirements of wildlife, management of mallee vegetation requires the retention of a mosaic comprising patches of varying age since burning, with a bias towards older ages.

Harvesting of timber resources

Since European settlement, the forests and woodlands of river red gum and black box along the Murray River have been utilized extensively for timber production (see Chapter 13 - Forest Produce). Timber-harvesting reduces the number of available tree-hollows, which are extremely important for hollow-nesting fauna. The regent parrot, for example, a significant species in the Mallee, nests only in large hollows found in mature, senescent, or dead river red gums within 60 m of a waterway or lagoon. Harvesting of trees is also likely to alter flowering patterns and nectar supply, affecting those species, like invertebrates and honeyeaters, that rely on this food source.

Firewood-collection reduces the amount of fallen timber that provides essential cover for ground-dwelling species like *Morethia boulengeri*, marbled gecko, tessellated gecko, and paucident planigale. The grassy understorey in these forests is often grazed (in some cases to provide protection from fire) and, in addition to reducing eucalypt regeneration, this modifies the habitat of species requiring a dense understorey.

The *Callitris--Casuarina* woodlands have been selectively and heavily harvested in the past for their durable timber. A number of the medium-sized mammals that are now extinct probably occurred in these areas before European settlement. These would include red-tailed phascogale and brush-tailed bettong. The bulk of these woodlands has been cleared for agriculture, but, ironically, it was due to the requirement for timber that several areas like the Timberoo and Yarrara Flora and Fauna Reserves were originally excluded from alienation, and these now provide remnant examples of this formerly more extensive habitat.

In the past, firewood-cutters on the grazing blocks on public land removed the dead timber or large old mallees that often contain hollows and, due to the frequency of fires, very few mature mallee stands remain. Many species such as

bats and hollow-nesting birds depend on this resource, and this gives the remaining mature mallee great habitat importance.

Broombush-harvesting increases the disturbance to the natural vegetation directly through harvesting, and indirectly through the increase in tracks, camp-sites, and brush dumps. Mechanical harvesting causes greater disturbance than the usual manual cutting, and this is viewed with concern.

Broombush-harvesting may affect elements of this community's diverse vertebrate fauna.

A recent study showed that broombush areas have a diverse vertebrate fauna and that this vegetation, while no species are entirely restricted to it, may be important for several like the little pygmy-possum and red-lored whistler. Different-aged stands of broombush have correspondingly different associated suites of species. It is those characteristic of older and taller broombush (like malleefowl) that are thought to be most likely affected by harvesting.

Apiculture

Nectar is an important energy source for some native vertebrates. For several species of honeyeater, for example, it is a major food source - augmented by protein provided by invertebrates.

Exploitation of nectar by the apicultural industry has been described as a benign form of agriculture that only requires access to flora and space for apiaries. There is growing concern, however, that apiculture may be incompatible with maintenance of nature conservation values, particularly in nature reserves. We have little firm evidence to clearly

demonstrate the effect of honey bees on natural ecosystems, but the likely effects include the four listed below.

Firstly, the efficient foraging behaviour of the introduced honey bees means a reduction of the nectar supply to native fauna. This reduced nectar supply may lead to a decline of native pollinators. Several factors are relevant here.

- Honey bees tolerate low temperatures better than many native pollinators, and this allows them better access to nectar sources earlier in the day, when nectar is more abundant; and foraging is continued throughout most of the day.

- The highly developed communication system of honey bees facilitates rapid exploitation of nectar sources by a large number of individuals.

- The introduced bees are aggressive.

- Honey bees possess a long tongue that allows them access to flowers with deep corollas that are usually pollinated by birds or mammals.

- Hives are introduced to optimum locations and provide shelter for the bees from predators and adverse weather.

Secondly, bees increase hybridization of native flora. The plants and their native pollinators have evolved together - the plants relying on transport of their pollen, and the pollinators on a food source. The lower fidelity of honey bees to particular species has the potential for increased hybridization of plants.

Thirdly, however, they lead to inefficient pollination of native plants. Damage to native flowers when extracting nectar, avoidance of contact with anthers, and concentration of foraging on individual plants rather than spreading it across several plants may all contribute to inefficient pollination.

Fourthly, the bees compete for tree hollows. The displacement of hollow-nesting birds by feral honey bees has been observed, and this displacement may extend to hollow-dependent mammals.

Other Introduced Species and their Control

Eight species of introduced mammal (dog, red fox, cat, European rabbit, brown hare, goat, pig, and house mouse) and at least eight introduced birds (common starling, European goldfinch, house sparrow, skylark, common blackbird, spotted turtle-dove, feral pigeon, and mallard) have been recorded in the Mallee area.

Most of these species have a widespread distribution in the region. For example, the red fox, house mouse, cat, and rabbit occur throughout most public and private land, while others such as the common starling, house sparrow, feral pigeon, and common blackbird are widespread in cleared

farmland areas, where they are commonly associated with farm buildings, silos, or towns. Several introduced species have a restricted distribution: pigs occur mainly in the riverine forests and the skylark mainly in the south-eastern part of the study area, while the mallard and spotted turtle-dove are each known to inhabit only a few areas.

The impact of introduced animals is discussed in Chapter 16 - Hazards and Conflicts. The following summarizes the major perceived effects of introduced species and their control on native wildlife of the region.

Introduced species may interact with native wildlife chiefly through predation, competition, and alteration of habitat.

Predation

The red fox, dog, and cat prey on a wide range of native fauna. Rabbits (where they are common) are usually the major target, but in large blocks of public land these have lower densities and native fauna comprise most of the predators' diet. Some evidence suggests that predation by foxes on nests of the Murray turtle has influenced the age structure of this species' population. However, for most other species, concern about the detrimental impact of introduced predators is based only on circumstantial evidence or inference.

Competition

Introduced species may reduce availability of the resources that native fauna require. The common starling, for example, nests in tree hollows in mallee, woodlands, or forests; this reduces their availability for native birds. House mice are widespread throughout native vegetation, where they feed on invertebrates and seeds. Particularly in times of plagues, house mice are likely to compete for food with native small mammals and reptiles.

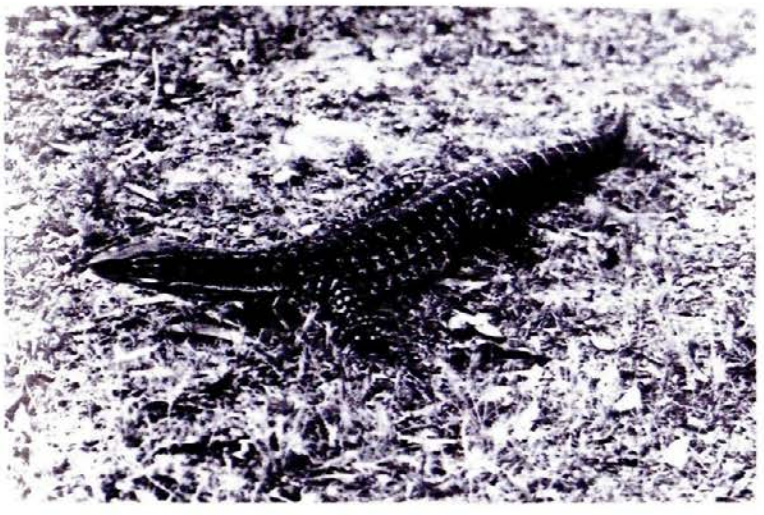
Habitat alteration

The European rabbit has had an enormous impact on the vegetation (and faunal habitat) in the Mallee since its introduction in the 1860s. Goats are widespread and browse native vegetation throughout public land, while pigs cause soil disturbance where they forage in riverine forests and woodlands.

Control programs to reduce those introduced species regarded as vermin may also have a detrimental effect on native fauna. Wildlife may be directly killed, as occurred when the sand goanna was found to be taking the strychnine baits laid for dogs in the Big Desert. In rabbit-control programs, hollow logs are often removed because of the harbour these provide for rabbits, but unfortunately this also removes cover for native species such as the carpet python.

Numerous other factors also impinge, to varying degrees, on fauna conservation values in the study area. These include salinity changes, water-supply and flooding regimes, hunt-

ing, recreation (including off-road vehicles), weeds and their control, and military training. They are variously addressed in the appropriate sections of other chapters of this report.



The sand goanna has been known to take strychnine baits intended for wild dogs.

References

References used in the preparation of this chapter are listed in Appendix XVI.

9. LAND SYSTEMS

The preceding chapters have discussed the various environmental factors - climate, geology, physiography, soils, and vegetation. However, no one factor determines productivity and management; it is their combined effect that controls the uses to which the land may be put. An inventory of land systems combines the various environmental factors.

Land systems are geomorphic entities delineated with the aid of aerial photographs and mapped at scales suitable for regional planning, usually 1:250 000. In the Mallee, for example, plains with dunes are mapped separately from dune-free plains. Further subdivisions are made on climatic criteria, using rainfall isohyets. Each land system contains a pattern of components, such as east--west sand dunes and loamy plains, which have different potentials and management requirements.

For mapping at State or continental scales, still broader mapping units are required, and again geomorphic units are the most relevant. The Murray Basin Plains north of the Victoria Highlands, for instance, contain the riverine plain, Mallee dune-field, and Wimmera plain. Each is further subdivided; the Mallee dune-field in the study area, for instance, is subdivided into areas with calcareous dunes (mainly used for agriculture) and the siliceous dunes of the Big Desert.

Information on land systems for the Council's initial investigation of the Mallee area was based largely on the 1963 report 'A Study of the Land in North-western Victoria' by J.N. Rowan and R.G. Downes.

By using more detailed aerial photography than was previously available, topographic maps, and recent geomorphic data, verified by some field checking, Mr J.N. Rowan of the Land Protection Division (Department of Conservation, Forests and Lands) has been able to achieve a greater degree of resolution of the land systems for the area. Map 7 (Land Systems) indicates these at a scale of 1:250 000 and Table 12 describes the characteristics of each. The table includes the land systems described in the Council's 1974 report, to indicate how these correlate with the more refined data.

Explanation of map symbols

The use of symbols instead of local names for the land systems is in conformity with recent work by the Council to map land systems across the State. They permit ready comparison between systems and between elements of the systems.

The land forms, lithology, and climate found in the Mallee area are indicated by the symbols shown in Table 11. Else-

where in the State, these symbols, additional ones, or a completely different suite could apply, depending upon the respective natural environments.

Table 11

KEY TO LAND SYSTEM SYMBOLS

Land form

E East--west dune
F Present floodplain
I Irregular dune
L Lunette
P Plain above flood level
R Stranded beach ridge, usually trending NNW--SSE (described as north--south elsewhere in the text)
W Weakly elongated (or weakly oriented) dune
Y Gypseous dune

Lithology

c Coarsely textured unconsolidated deposits
f Finely textured unconsolidated deposits
l Limestone
z Saline finely textured deposits

Climate (mean annual rainfall)

2 200--300 mm
3 300--400 mm
4 400--500 mm

For any system, the order in which the symbols are written indicates the relative proportions of each element. The land form symbols EPR, for instance, indicate that the land surface is dominated by closely spaced east--west dunes (E), which are located on a basement of a level plain (P), alternating with ridges (R). The order of the symbols PRE, on the other hand indicates that the east--west dunes are scattered over the area.

Similarly, the lithology symbols indicate the dominant texture of the soils - cf being predominantly a coarser-grained (sandy) soil and fc indicating that clays dominate.

Geomorphological units and soils

Elevation has influenced the nature and distribution of land forms, largely through control of depth to the regional water table, which lies at approximately 40--50 m above sea level in the northern and central areas. General surface elevations are about 100 m above sea level in the south, although there is higher land in the south-west (see the figure on page 57). Except for a raised belt known as the Sunset Strip, surface levels fall to about 40 m towards the north-west. This belt is flanked by the Noora depression in the west and the Raak depression in the east.

continued on page 196

Table 12

LAND SYSTEMS OF THE MALLEE

Geomorphic unit		Land system symbol (see key, Table 11)	Area			Correlation with land systems in 1974 LCC report
			Total (ha)	Percentage		
				of study area	in public land	
MALLEE DUNE-FIELD						
Very closely spaced, reddish-yellow, east--west dunes with soft cores	on plains and ridges	EPRcf2	186 500	4.4	72	Central Mallee
		EPRcf3	48 000	1.1	26	
	on plains in Raak depression	EPcf2	53 000	1.2	90	
Sand-plains with scattered reddish-yellow east--west dunes in Noora depression		PEcf2	8 000	<1	100	
Closely spaced east--west dunes with compact cores	on plains and ridges in north	EPRfc2	143 000	3.3	12	
		EPRfc3	513 000	12.1	2	Central Mallee, Tempy
	on plains in Raak depression	EPfc2	41 000	1.0	33	Central Mallee
	on plains in Noora depression	EPfcl2	36 000	1.0	100	
Scattered east--west dunes	on plains and ridges in south	PREfc3	463 000	10.9	1	Hopetoun
	on ridges and plains in north	RPEfc2	224 000	5.3	19	Millewa
		RPEfc3	9 000	<1	15	Central Mallee
	on plains and ridges fringing the Noora depression	PREfcl2	58 000	1.4	80	
	on plains in Raak and Tyrell depressions	PEfc2	154 000	3.6	12	Hopetoun
		PEfc3	10 000	<1	5	
Weakly oriented dunes on plains and ridges in the south		WPRf3	185 000	4.3	0.3	Boigbeat

Dominant dependent features			Public land use (as indicated on Map 8)
Indigenous vegetation	Soils (in order of occurrence)	Soil deterioration processes	
Low mallee scrub	Reddish-yellow sands Sandy red duplex soils Calcareous earths	Wind erosion Leaching	A2,A3,C3,D3,F2,H3, S1-Sunset
			A2,C5,G various, S1-Sunset
Low mallee scrub	Sandy red duplex soils Reddish-yellow sands Calcareous earths	Wind erosion Leaching	S1-Sunset
Mallee scrub	Calcareous earths Sandy red duplex soils	Wind erosion Salting Leaching Compaction	D3,D5,E3,E5,F2,F3,G var.,H2,N3,P6,S1-Sunset
			S1-Sunset
Mallee scrub	Shallow loams on limestone Sandy red duplex soils	Wind erosion Leaching	S1-Sunset
Mallee scrub	Calcareous clays Calcareous earths Sandy red duplex soils	Wind erosion Salting Leaching Compaction	A1,A4,E7,E9,F2, G various
Pine--belar woodlands, tall mallee scrub	Calcareous earths Sandy calcareous earths	Wind erosion Salting Compaction	C1,C3,D1,D2,E4,F3, F5--7,G various, S1-Sunset and Neds Corner
Grassy pine--belar woodland, mallee scrub	Shallow loams on limestone Calcareous earths Sandy calcareous earths	Wind erosion Salting	F2,S1-Millewa
Tall mallee scrub, grassland	Grey gypseous clays Sandy red duplex soils	Salting Wind erosion Leaching	G various,H4,S1-Sunset
Mallee scrub	Calcareous earths Calcareous clays	Wind erosion Compaction	I various,S1

Table 12 (continued...)

Geomorphic unit		Land system symbol (see key, Table 11)	Area: Total (ha)	Area: Percentage of study area	Area: Percentage in public land	Correlation with land systems in 1974 LCC report
MALLEE DUNE-FIELD (continued...)						
Plains, ridges and areas of weakly oriented dunes in south		PWRf3	348 000	8.2	0.4	Culgoa
Locally high ridges without linear dunes	Yarrara, Robinvale Walpeup	Rf2 Rf3	9 000 2 000	<1 <1	47 49	) Boigbeat
Evaporative basin plains	plains with gypseous dunes in depressions	PYfz2 PYfz3	27 000 84 000	<1 1.9	77 35	) Raak
		PYcf2	5 000	<1	100	Berrook
	salt pans in Raak depression	Pz2	11 000	<1	100	) Raak
	sand-plains and saltpans in Raak depression	Pcz2	41 000	1.0	80	)
	lunettes (also in riverine plain)	Lf2 Lf3	2 000 28 000	<1 <1	75 11	) Raak,) Lindsay island
Clay plains and sand-plains in Raak depression		Pfc2	37 000	1.0	99	) Berrook
Irregular pale dunes, closely to widely spaced	on plains and ridges	IPRc2	10 000	<1	100	Berrook
		IPRc3 IPRc4	310 000 49 000	7.3 1.2	99 83	) Big Desert 2
	on plains in Raak and Noora depressions	IPc2	53 000	1.3	100	Berrook

Dominant dependent features			Public land use (as indicated on Map 8)
Indigenous vegetation	Soils (in order of occurrence)	Soil deterioration processes	
Tall mallee scrub, mallee scrub	Calcareous clays Calcareous earths	Compaction Wind erosion	D8,E6,G1,G35,S1
Pine--belar woodland, mallee scrub	Calcareous earths	Wind erosion Compaction	F3,F6,G1,G2,G14, S1-Sunset
Samphire shrubland, saltbush shrubland, tall mallee scrub	Calcareous earths Saline loams Shallow loams on copi	Salting Wind erosion Compaction	A3,C6,F2,G various,N2, N3,S1-Millewa and Cowangie
Low mallee scrub	Sandy red duplex soils Shallow loams on copi	Wind erosion Salting	S1-Sunset
N/A	Saline clays	N/A	G34,N2,S1-Sunset
Grassland, pine--belar--buloke woodland	Sandy red duplex soils Saline clays	Wind erosion Salting	A2,N2,S1-Sunset
Pine--belar and pine--belar--buloke woodland, tall mallee scrub	Red duplex soils Yellow duplex soils	Wind erosion Water erosion Salting	A4,E6,G24,G25,G28 S1-Neds Corner
Grassland, pine--belar--buloke woodland, tall mallee scrub	Sandy red duplex soils Grey gypseous clays Calcareous earths	Wind erosion Salting Compaction	A3
Low mallee scrub	Pale sands	Wind erosion Leaching	S1-Sunset
Low mallee scrub, heath			A1,A4,B1,C7,C10,D6, S1-Big Desert
Low mallee scrub			A2,A3,C5,F2,S1-Sunset and Big Desert

Table 12 (continued...)

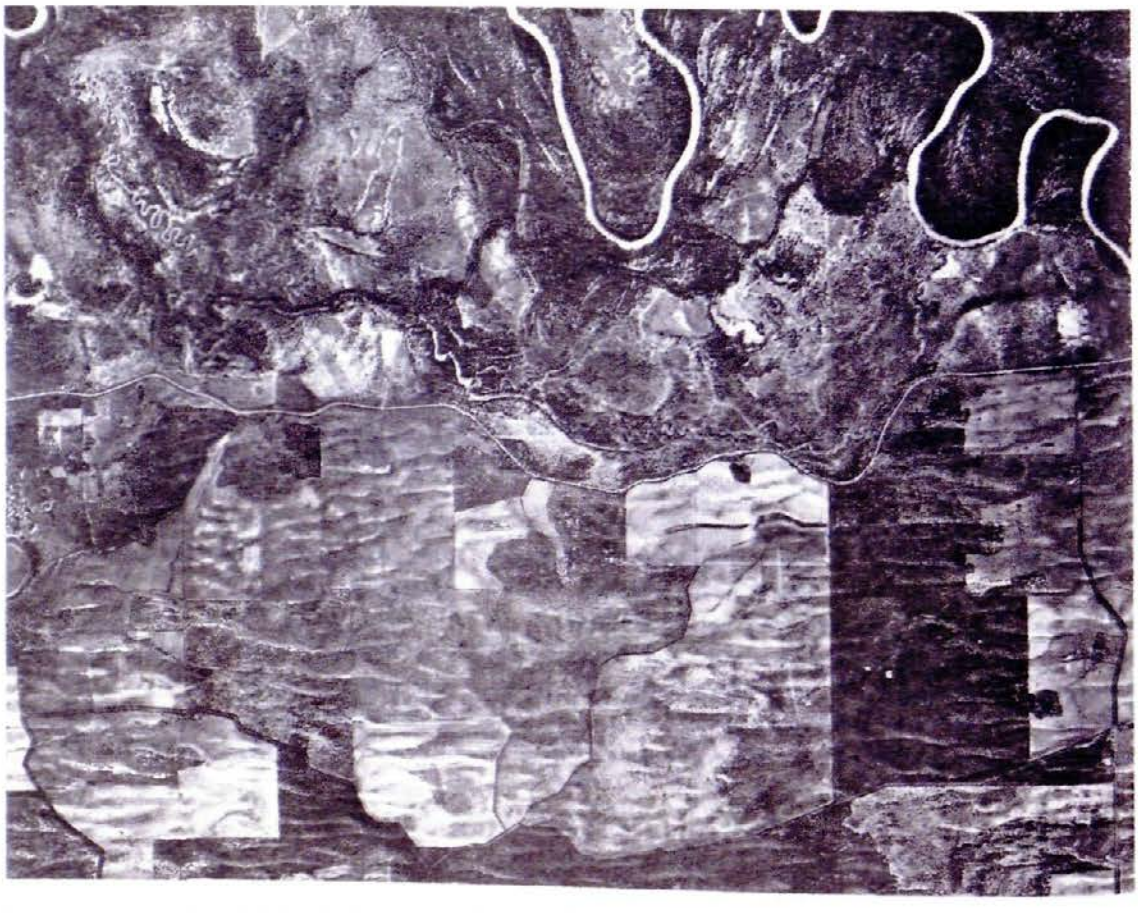
Geomorphic unit		Land system symbol (see key, Table 11)	Area			Correlation with land systems in 1974 LCC report
			Total (ha)	Percentage		
				of study area	in public land	
MALLEE DUNE-FIELD (continued...)						
Very closely spaced pale east--west dunes	on plains and ridges	EPRc2	60 000	1.4	95	Berrook
		EPRc3	360 000	8.4	84	) Big Desert 1 (
		EPRc4	48 000	1.0	32	) (
	on plains in Raak depression	EPc2	50 000	1.2	98	) Berrook ( ) ( ) (
	on plains in Noora depression	EPcl2	60 000	1.4	96	) ( ) (
RIVERINE PLAIN						
Present flood-plains	Beside Murray River and some creek courses in Mallee dune-field	Ffc2	55 000	1.3	83	Lindsay Island
		Ffc3	102 000	2.4	53	Tyrrell Creek
	with areas of sandy weakly oriented dunes, Kulkyne	FWcf2	25 000	<1	98	Lindsay Island
Higher alluvial plains	terraces beside Murray River and some creek courses in Mallee dune-field	Pf2	78 000	1.8	35	Neds Corner
		$Pf3_1$	213 000	5.0	6	Tyrrell Creek
	terraces with east--west dunes west of Mildura	PEfc2	4 000	<1	50	Neds Corner
	broad plains in south-east	$Pf3_2$	30 000	<1	0	Wycheproof

Dominant dependent features			Public land use (as indicated on Map 8)
Indigenous vegetation	Soils (in order of occurrence)	Soil deterioration processes	
Low mallee scrub	Pale sands	Wind erosion Leaching	A3,F2
Low mallee scrub, heath	Pale sands Sandy mottled duplex soils Calcareous earths in east	Salting	A1,A4,B1,C9,C10,D4--6, F2,H1,S1-Big Desert
Low mallee scrub	Pale sands Sandy mottled duplex soils		A2,C5,G5
			F2,S1-Sunset
River red gum and black box woodland, grassland	Grey clays Grey sands	Compaction Leaching	A1,A2,A4,A5,C2,C8,D various, E1--9,F2,G23, G27,H1,S1-Big Desert and Neds Corner
River red gum and black box woodland, pine woodland, mallee scrub	Grey sands Reddish yellow sands Grey clays	Wind erosion Leaching Compaction	A2,A5,C4,H3
Saltbush shrubland, black box woodland	Red and brown duplex soils, saline at depth	Wind erosion Compaction	A2,A5,C2,E1--4,F2,N1, S1-Neds Corner
Grassland, black box and buloke woodland	Red duplex soils Grey clays	Salting	A1,D various,E4--9,F2, G various,S1
Bluebush shrubland	Sandy red duplex soils Red and brown duplex soils, saline at depth	Wind erosion Compaction	S1-Neds Corner
Black box--buloke open woodland	Red-brown clays Grey clays	Compaction Wind erosion	

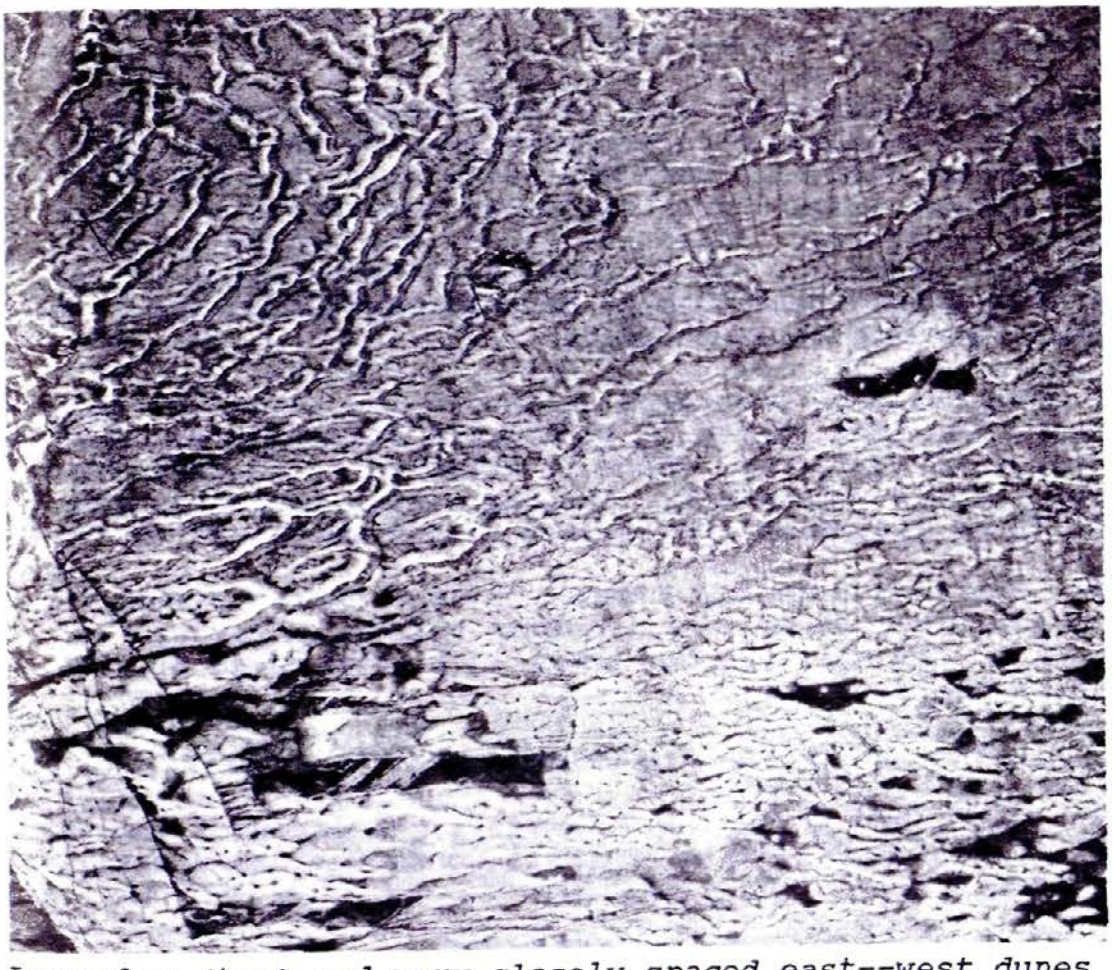
A third low area, the Tyrrell depression, occurs further east. These depressions have curved eastern boundaries that suggest an ancestral lake system. Saline groundwater evaporates in the lowest parts of the depressions. These low areas lack the ridges that trend mainly NNW--SSE elsewhere in the study area, which originated as coastal strand lines when the Tertiary sea retreated westwards.

Mallee dune-field occupies most of the region. Sand dunes trend mostly east--west here, usually on a basement of level plains alternating with ridges. Very closely spaced reddish-yellow dunes with soft clayey sand cores and with sandy swales are widespread in the unsettled parts of the Sunset Country and Annuello block. Closely spaced dunes in (and to the east of) the Ouyen--Murrayville settlement corridor have compact sandy clay cores containing lime layers, characteristic of the Woorinen Formation. Similar dunes, although more widely spaced, occur in the Millewa and in the south-eastern Mallee. The dunes are linear but weaken towards the south-east, where they are replaced by weakly oriented, more clayey dunes.

The Big Desert and a smaller belt of Lowan Sand in the Sunset Country contain a mosaic of two land form patterns, dominated either by very closely spaced, mostly east--west dunes or by irregular dunes that are often relatively large.



Present floodplains (Ffc3) and higher alluvial plains (Pf3) along the Murray River, south-east of Robinvale. The cleared Mallee country to the south has very closely spaced east--west dunes on plains and ridges.



Irregular (top) and very closely spaced east--west dunes (bottom) of the Big Desert. Fire effects are also obvious.

Riverine-plain landscapes occur to the south-east of the Mallee dune-field, and also as terraces along the Murray River and creek courses entering from the south.

The above landform patterns influence the distribution of land systems, as shown in Table 12. Further subdivisions are based on climate, which is semi-arid, verging on arid in the extreme north-west. The climatic index used for subdivisions is the mean annual rainfall, which varies from 250 mm in the north-west to more than 400 mm in the more elevated south-west.

Soil terminology in the table is based largely on texture of the various horizons. Soils with little variation in texture throughout the profile are regarded as uniform, and may be termed sands, loams, or clays. Earths have a gradual increase in the clay content with depth, and are regarded as gradational soils. The downward increase of clay in duplex soils is sudden, usually with a conspicuous change from sands or sandy loams to subsoil clays.

The indigenous vegetation is classified broadly, based largely on Specht's structural system. The predominant Mallee dune-field usually carries mallee scrub, but this has great variation in height, density, and understorey. Low mallee scrub of the sandy linear dunes and sand-plains has prominent understories of porcupine grass or shrubs. Stands

tend to be taller and more open on heavy plains, often with a ground cover of halophytes.

The landforms and soil types in the Mallee strongly influence the vegetation communities growing on them. Map 10 - Vegetation - reveals definite patterns in the distribution of the floral communities, which are indicative of the underlying landforms. Fields of linear and weakly oriented dunes, for instance, can be readily differentiated on the map. The strong relationship between vegetation and land systems can also be identified.

Soil deterioration processes listed in the table are those to which the land system is considered susceptible. They do not refer to incidence, which is affected by an additional factor, namely management. The table also indicates the major forms of use of public land within each land system.

Note: The legend to Map 7 mentions land system symbol Pcf2. There are minor occurrences of this system in association with Pfc2, but they are too small to be indicated at the scale of mapping used.

Reference

Rowan, J.N., and Downes, R.G. (1963). 'A Study of the Land in North-western Victoria.' (Soil Conservation Authority: Melbourne.)

Part III

CURRENT LAND USE

10. *NATURE CONSERVATION*

The goal of nature conservation has been described as: 'to conserve for present and future use the diversity and integrity of biotic communities of plants and animals within natural ecosystems, and to safeguard the genetic diversity of species on which their continuing evolution depends' (UNESCO, 1974).

This chapter deals with nature conservation - not only the protection of native plants and animals, but also the protection of natural features and landscapes.

Philosophy of a Nature Reserve System

The widespread and growing impact on the natural environment of human cultural activities, such as agriculture, urban development, and harvesting of natural resources, and the habitat changes resulting from such activities, taken together, mean that the conservation of flora and fauna will rely increasingly upon reserves set aside especially for this purpose. In many situations these reserves are already, or will soon become, 'islands' of natural habitat within expanses of developed land.

Two primary criteria are essential to the delineation of a nature reserve system:

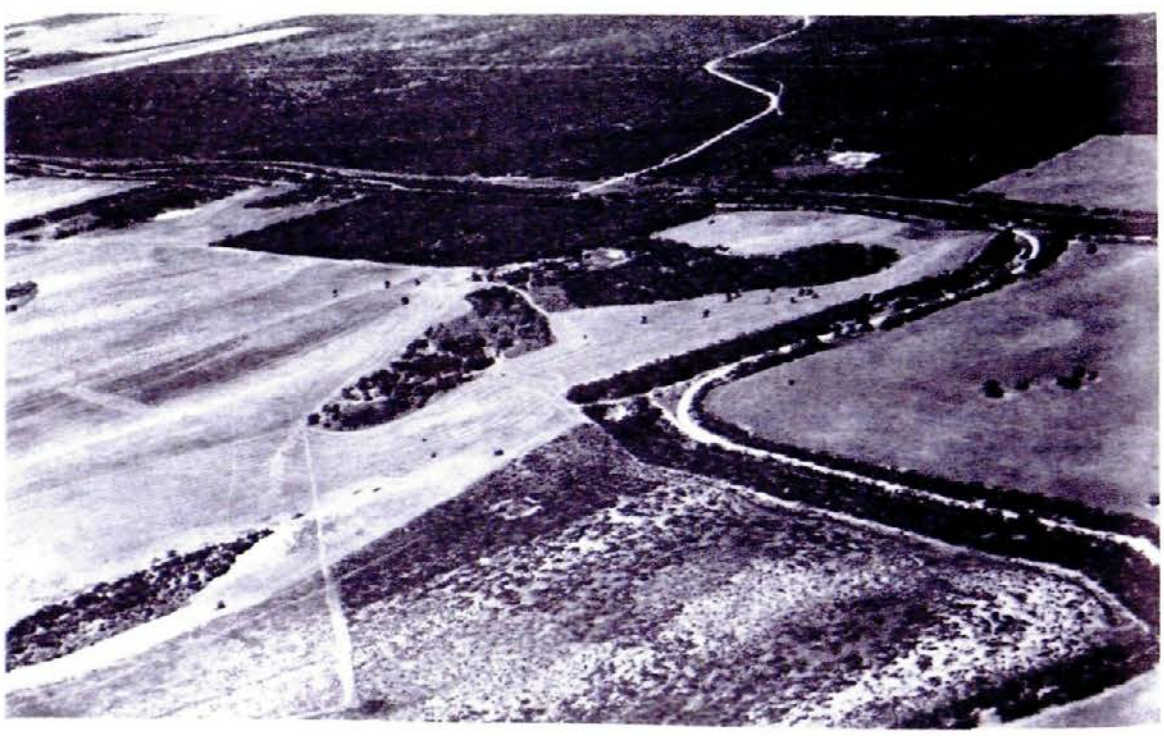
- The system must represent the range of habitats and communities within the region.
- The size and structure of each reserve should be adequate to satisfy the long-term ecological and genetic requirements of its communities and their component species.

To achieve representation of habitats and communities requires the incorporation in the major reserves of contiguous and different land systems or habitats so that each reserve includes a range of these and each land system or habitat is included within a reserve. Replication of habitats and communities is essential to provide a refuge for species and a source for recolonization when severe disturbance occurs in one area, and also because a greater genetic diversity is retained when species populations are preserved in different parts of their geographical ranges of distribution than when they are confined to a single location.

In addition to major reserves that span a range of habitats, specialized reserves are also necessary in some situations, such as where important habitats like lakes or other wetlands have been isolated by developed land, or where there is an isolated occurrence of a rare or threatened species that needs protection.

The most important determinant of reserve size is the need to preserve sufficiently large populations of the species to be self-sustaining in the long term. If the area requirements are based on the needs of species with naturally low population densities, such as large-bodied animals, or species with specialized habitat, then the requirements of other members of the total community should also be met. A reserve should be large enough to cope with the type of disturbances to which it is likely to be subject (such as wildfire or flood), so that it will always contain an undisturbed remnant to serve as a source for recolonization.

Continuity between habitats - both within a reserve and, wherever possible, between reserves - is an important feature of the design of a system. This continuity may be achieved either by including a series of contiguous habitats or communities within a single reserve, or by linking reserves with corridors of natural habitat. These links enhance the conservation value of otherwise-isolated reserves by facilitating the interchange of populations and thus reducing the likelihood that extinctions may occur.



Conservation value of some reserves may be enhanced by corridors of natural habitat.

Nature Reserve System in the State

Since its inception under the *Land Conservation Act* 1970, the Land Conservation Council has endeavoured to establish a State-wide system of reserves containing adequate representations of all major ecosystems and habitat types.

Council has sought to protect these reserves by recommending that areas with important nature conservation values be permanently reserved under the *Crown Land (Reserves) Act* 1978, the *National Parks Act* 1975, or, in the case of reference areas, by proclamation under the *Reference Areas*

Act 1978. A major benefit of reservation is that it demonstrates the necessary long-term commitment to conservation, without which there is no real surety of protection.

The major types of reserves established to protect the most significant nature conservation values include national, State, and coastal parks, flora reserves and flora and fauna reserves, reference areas, wildlife reserves, and marine reserves. All have the protection of nature conservation values among their major aims.

Other areas placed in different land use categories also play a part in the protection of native flora and fauna and their associated habitats. These include land set aside as wilderness, State forest (which includes hardwood production areas and uncommitted Crown land), regional parks, natural features and scenic reserves, and lake reserves. Permanent reservation is also usually recommended for most of these land uses. Nature conservation, however, is generally a secondary rather than a primary aim of management.

It should be noted that selection of reserves for conservation depends on the existence of suitable areas, in the context of 60% of the State being cleared freehold land, and with the constraint of balancing conservation needs against other uses of public land.

In total, the Council has to date recommended that about 2.1 million hectares, or 9.4% of the State, be permanently reserved primarily for the protection of nature conservation values. Other areas totalling 4.7 Mha (including State forest), or 21% of the State, provide some lesser degrees of protection. (In the case of State forest, such values are protected by management prescriptions, appropriate codes of practice, or temporary reservation under the *Forests Act* 1958.) Prior to the establishment of the Council in 1970, only 640 000 ha or 3% of Victoria was reserved for this purpose.

In recognition of the importance of nature conservation as an integral part of the development of the State, the Victorian government, in 1987, endorsed the National Conservation Strategy for Australia, and developed a conservation strategy for Victoria: 'Protecting the Environment'. The main goals outlined in this strategy are the:

- maintenance of essential ecological processes and life-support systems
- preservation of genetic diversity
- sustainable use of renewable resources
- protection of natural systems and their diversity for the non-material needs of society

To achieve these results, three levels of approach are necessary:

- the establishment of a system of reserves within which nature conservation is a primary land use and conflicting activities are restricted

- management to preserve nature conservation values on other areas of public land where nature conservation is not the primary land use, such as in State forest or a bushland reserve

- encouragement and promotion of practices on private land that will enhance the value of the land for nature conservation

In the strategy, the government also endorsed the Council's approach to nature conservation, stating that it will 'add to the parks and reserves system in line with those Land Conservation Council recommendations already adopted by the government'. The Council's endeavours to protect a wide selection of viable examples of the State's major ecosystems and habitats is also reflected in 'Protecting the Environment'. In this, the government stated its aims for protecting flora and fauna, which are to:

- ensure that all Victorian native species of flora and fauna, natural ecosystems, and communities can survive, flourish, and retain their potential for evolutionary development

- protect representative and ecologically viable samples of all Victoria's natural ecological systems, including land systems, native vegetation types, and native animal communities

- preserve genetic variability within Victorian plant and animal species

- preserve remaining areas of high wilderness quality

- protect areas of special value for natural heritage, for flora and fauna habitat, or for maintenance of ecological processes or life-support systems

Nature Conservation in the Mallee area

In its final recommendations for the Mallee area, published in 1977, the Land Conservation Council recommended the establishment of a number of reserves in which nature conservation is a primary or secondary use. These reserves were subsequently approved by the government in 1978 and 1979. They are listed generally in Table 1 and described in more detail below. Although not all are set aside primarily for nature conservation purposes, this use is a major aim of management or results from the primary use.

Parks

The study area contains five parks covering some 210 950 ha of public land, shown on Map 8 (Public Land Use).

All of these parks have been placed on a schedule to the *National Parks Act* 1975. Nature conservation is the primary object of both national and State parks, and is an object of regional parks consistent with providing for recreational opportunities.

Table 13

EXISTING PARKS

Name	Category	Reference number on Map 8	Area (ha)
Wyperfeld	National	A1	93 400
Hattah--Kulkyne	National	A2	46 500
Pink Lakes	State	A3	49 600
Lake Albacutya	Regional	A4	10 600
Murray--Kulkyne	Regional	A5	1 600

National parks

A national park is an 'extensive area of public land, of nation-wide significance because of its outstanding natural features and diverse land types, set aside primarily to provide enjoyment, education, and inspiration in natural environments'.

The study area contains two such parks (both reserved under Schedule 2 of the *National Parks Act*). Wyperfeld National Park is located on the eastern fringe of the Big Desert. It contains examples of the irregular and east--west trending dunes of the Big Desert and a chain of (usually) dry lakes and associated lunettes on the floodplain of Outlet Creek, the northern extension of the Wimmera River. River red gum and slender cypress pine woodlands, mallee scrub, and heathlands provide habitats for a wide variety of faunal species.

Hattah--Kulkyne National Park contains dunes of reddish-yellow and pale sands and a floodplain of the Murray River.

National parks have been set aside to provide enjoyment, education, and inspiration in natural environments,

Chalka Creek, a flood-anabranch of the Murray, feeds a chain of lakes that comprise the focal centre for recreation in the park. River red gum woodlands on the floodplain and slender cypress pine woodlands and mallee on the dunes provide a diversity of habitats for the abundant wildlife. When full, the lakes support fish and a wide range of waterbirds.

The park has been designated a World Biosphere reserve (one of 12 in Australia) in recognition of its value in showing the interaction between people and the natural environment - containing as it does evidence of both Aboriginal and European occupation.

An internationally designated biosphere reserve may contain terrestrial or marine areas and wildlife that meet one or more of the following criteria:

- representative examples of biomes
- unique communities or areas with unusual features of scientific and/or aesthetic interest
- examples of harmonious areas resulting from gradual human modification or traditional patterns of land use
- examples of damaged or degraded ecosystems capable of being managed to demonstrate human impact, but able to be restored to a more natural state

State park

A State park is 'an area of public land, containing one or more land types, set aside primarily to provide public enjoyment, education, and inspiration in natural environments'. It is intended that such parks include samples of land types that are not represented in national parks, and thus would complement the latter, so that together the two types form a State-wide system.

The Pink Lakes State Park (reserved under Schedule 3 of the *National Parks Act*) is centred on a group of picturesque, pink salt lakes. These get their pink colour from a pigment secreted by an alga. They are associated with samphire flats and copi rises and the park also contains an area of jumbled sand dunes (irregular orientation), fields of high east--west dunes, and broad grassland plains. In excess of 20 plants listed as rare or threatened in Victoria have been identified in the park.

In accordance with the Council's 1977 recommendations, grazing is being phased out from this park and will cease in 1989.

Regional parks

A regional park is 'an area of public land, readily accessible from urban centres or a major tourist route, set aside primarily to provide recreation for large numbers of people in natural or semi-natural surroundings'. The study area

has two, both of which are reserved under Schedule 3 of the *National Parks Act*. Protection and conservation of native flora, fauna, and natural features is an object of this form of reservation to the extent that it is consistent with providing opportunities for recreation.

Lake Albacutya is the focus of one of these regional parks. When it contains water, the lake is intensively used by local people and tourists for picnicking, swimming, boating, fishing, and hunting. The lake last filled in 1974 and had dried out again by 1983.

The long frontage to the Murray River east of the Hattah--Kulkyne National Park comprises the Murray--Kulkyne Regional Park. It is intensively used for river-based recreation and is particularly popular for camping. This park, together with the Hattah--Kulkyne National Park, is recognized as a World Biosphere reserve.

Wilderness area

Only two wilderness areas have been set aside in Victoria: one in the Big Desert, the other abutting Victoria's alpine region. Wilderness areas are 'large areas remote from, and substantially undisturbed by, the influence of modern technological society'. They offer opportunities for isolated non-mechanized recreation in a challenging natural environment.

To preserve their wilderness values it is necessary to protect the natural ecosystems and maintain the landscape in an undisturbed state. Because of this requirement, such areas have considerable value for nature conservation.

The Big Desert Wilderness, totalling 114 000 ha, has been listed under Schedule 3 of the *National Parks Act*. Surrounded by a buffer of public land in Victoria, and abutting large conservation parks in South Australia, the Big Desert Wilderness comprises an extensive area of heath, mallee heath, and mallee scrub, growing on sandy plains and dune systems. A recent survey of wilderness quality in Victoria has shown that the Big Desert contains the most extensive tracts of highest quality in south-eastern Australia, the largest contiguous area being within the Big Desert Wilderness. Further information on this survey is provided in Chapter 11 - Recreation.

Reference areas

Finding a solution to problems arising from use of a particular land type is often helped by reference to an undisturbed example of the land type. Here, the soils, vegetation, and fauna can be studied under natural conditions and the knowledge gained about the basic relations operating between these components may help solve land use problems.

Reference areas therefore act as standards against which the progress and effect of human alterations and utilization of the land can be measured. They may also provide a valuable gene pool for some plant and animal species.

The Council's previous recommendations set aside 10 parcels of land in the Mallee totalling 18 700 ha as reference areas (indicated by the prefix 'C' on Map 8). These comprise representative samples of the major land types identified in the study area at that time.

As far as possible, natural processes should be allowed to continue undisturbed within reference areas; access should be restricted and experimental manipulation is not permitted. Only two - namely, Sunset (C3), and Dattuck (C9) - have so far been proclaimed under the *Reference Areas Act* 1978.

Grazing of stock on the Purnya reference area (C6) will cease when this activity ceases in the Pink Lakes State Park in 1989. However, both the Millewa and Lake Walla Walla reference areas (C1 and C2 respectively) are still grazed, C2 is not fenced out of a licensed grazing block, and a main track passes through the Sunset (C3) reference area. A track through the Telopea Downs reference area (C10) was recently closed by the Department of Conservation, Forests and Lands, but has been re-opened illegally.

Reference areas should be protected from human interference so that natural processes can continue undisturbed. The status and representativeness of these areas in the Mallee will be reviewed in the light of the conflicting uses and, more importantly, in terms of the new land systems information indicated on Map 7.

Flora reserves and flora and fauna reserves

Flora reserves are managed to preserve plant species that may be rare or endangered, or to protect associations of

Conservation of habitat is important in providing food, shelter, and breeding opportunities for many species of birds found in the Mallee.

native species that are poorly represented on other public land. Flora and fauna reserves provide valuable habitat for populations of native fauna, and contain examples of native vegetation with considerable floristic value in a natural or semi-natural state.

In 1977, the Council recommended 33 flora and fauna reserves, ranging in size from 1.8 ha to the 2270-ha reserve at Yarrara. The latter reserve (G1 on Map 8) includes one of the few surviving remnant woodlands of belah (*Casuarina cristata*) and cattle bush (*Heterodendrum oleifolium*) with a diverse shrubby understorey. The earlier slender cypress pine (*Callitris preissii*) stands in this vicinity were harvested for fence-posts and badly damaged by the 1942--45 drought followed by a beetle attack.

The Towan Plains (G22 on the map), west of Nyah West, comprise a large depression with flat salt-pans and low ridges or dunes of powdered gypsum (commonly known as copi islands). In 1977, the plains were covered by a lease for the extraction of gypsum, but, because of the high faunal habitat values provided by the large old mallees growing on the copi islands, the Council recommended that the area become a flora and fauna reserve and that the mining lease not be renewed but a new lease be issued for the adjoining uncommitted and private land. The government accepted the recommendation to the extent of proclaiming the flora and fauna reserve, but modified it to allow the lease area to be worked out. A condition of licence here is that mining can only take place on treeless ridges.

Subsequent to the acceptance of the Council's recommendations, two further reserves have been set aside by the government: one, a small (4.7-ha) reserve in the Parish of Kaneira (G35 on the map), has a well-developed shrub layer and is a good example of the regional vegetation; the second, comprising two parcels totalling 3660 ha in the Parishes of Carool and Goonegul (G34), is known as the 'Raak Reserve'. For the present, both of these areas are listed as 'flora reserves' until their use is reviewed by the Council. Although the Raak Reserve was set aside 'for the preservation of species of native plants and features of geological and archaeological interest', grazing is still a licensed, but inappropriate, activity.

It is the intention of the Department of Conservation, Forests and Lands to have all fauna and flora reserves listed under a schedule of the *National Parks Act*, following reservation under the proposed *Land Act*.

Wildlife reserves

Conservation of faunal species depends on the conservation of their habitats, and by far the largest remaining areas of natural habitat are on public land.

Although national and State parks contain substantial natural habitat where wildlife conservation is an important priority, some areas have been specifically designated for wildlife conservation and for developing wildlife conserva-

tion techniques. These may contain the habitat of endangered species or a notable faunal association, or may have particular wildlife values, such as specialized breeding grounds, stop-over sites for migratory or nomadic species, a high species diversity, or special educational or scientific interest.

In the Mallee 13 areas have been recommended as wildlife reserves. These range from the Kings Billabong reserve (D1) near Mildura, which comprises a mosaic of wet- and dryland habitats found on the Murray River floodplain and supports a large waterfowl population, to the Red Bluff reserve (D6) in the south-western corner of the study area, which contains extensive stands of mallee broombush, believed to be an important habitat of the rare western whipbird.

A number of the reserves have additional uses, such as the supply or receipt of irrigation water (as for Lakes Murphy and Yando, D11 and D12), hunting of game species in season, grazing, timber harvesting, or apiculture.

Nature Conservation on Other Public Land

The study area contains other blocks of public land that also have value for nature conservation.

Substantial parcels of uncommitted land remain in the study area, where, together with those along the floodplains designated for hardwood production, they comprise more than 70% of the public land. Although many of the outstanding natural features and values occurring on public land are included in parks and reserves, hardwood production areas and uncommitted land have major significance for flora and fauna conservation. They contain a range of vegetation communities that supports a diverse assemblage of flora and fauna, and this is exemplified in Chapters 7 and 8 - Vegetation and Fauna.

Bushland reserves are set aside to protect remnants of native vegetation on small areas of public land situated in predominantly cleared agricultural land. Their major uses are to provide diversity in the landscape and to maintain the distinctive Australian character of the countryside. More than 200 separate parcels of land in the Mallee were recommended as bushland reserves (indicated by 'I' on Map 8). Many of these have now been gazetted. Some, however, have been rejected because of conflicting land uses and new blocks have been included in the system of reserves by government action independent of the Land Conservation Council process. Areas within this latter group are included within the general numbering system for bushland reserves on the map. Even small and scattered blocks of native vegetation can provide valuable habitat for wildlife, and thus retain a range of wildlife species within the cleared agricultural landscape.

Education is an important use of land in a natural or semi-natural state. Forests, rivers, dune-fields, and other natural landscapes have many applications in education (from primary to post-graduate levels), by giving students oppor-

Red Bluff Wildlife Reserve.

Bushland reserves are important for the maintenance of the distinctive Victorian landscape.

tunities to see natural land forms, to observe, interpret, and monitor biological processes, and to collect specimens.

In some cases this may involve long-term studies or alterations to the environment for experimental purposes. The Council's previous recommendations set aside four parcels of land, covering 2200 ha, as education areas to be developed specifically for such purposes. Outlet Creek Education Area (H1), on the edge of the Big Desert is representative of floodplains with river red gum and black box woodlands,

dunes supporting slender cypress pine woodlands and mallee, and mallee-heath. At Timberoo, H2 contains dunes and broad swales carrying slender cypress pine, mallee, and grasslands, while at Wemen (H3) the education area includes Murray River floodplain and lakes. The plains and low dunes in the Koorlong area (H4), near Mildura, carry belah and sugarwood (*Myoporum*) woodland, savannah grassland, and mallee.

The conservation value of tracts of native vegetation increases greatly if they are interconnected. These connections, by facilitating the dispersal of fauna between otherwise-isolated habitats, maintain gene flow between populations and reduce the possibility of population extinctions. Corridors of natural vegetation will be most effective where they are of sufficient size (width), and comprise suitable habitat, to support resident populations of wildlife species.

In 1986, the government negotiated the retention of land that was in the process of alienation, to establish a corridor between a large tract of mallee west of Annuello and the extensive tracts of mallee of the Sunset Country (west of the Calder Highway), following concern that agricultural clearing would result in the isolation of these tracts of natural vegetation. Revegetation of the corridor (photographed in part on page 202) is presently under way.

Vegetation along streams, roads, and railways may also facilitate the movement of some species of wildlife between larger tracts of native vegetation, or provide rest sites during migratory or nomadic movements. These narrow strips of vegetation are also important habitats as they are frequently the only remnants of a region's native plants. They may support populations of rare plant species, allow the persistence of wildlife species within cleared farmland environments, and are often useful in land studies, as they may permit scientists to piece together the original pattern of the vegetation.

Community groups such as field naturalist clubs are active in tree-planting programs, and areas subject to high visitor use - such as recreation reserves and parklands - receive particular attention.

The value of roadside vegetation is now receiving recognition as being aesthetically desirable as well as contributing to the stabilization of the soil and the groundwater table and for its importance for wildlife habitat. Some Shires within the Mallee are replanting roadsides with local tree species. Retention of existing native vegetation on roadsides and unused roads receives high priority in local planning, while rental incentives are offered by the Department of Conservation, Forests and Lands for significant afforestation programs on licensed unused roads and water frontages.

Nature Conservation on Private Land

Native vegetation retained on private land may also serve a valuable role in nature conservation, particularly in areas

where the original vegetation has been largely cleared. Even small patches and strips of natural vegetation can provide a habitat for a range of native wildlife, but clearly larger areas are required for conservation of entire communities. Patches of native vegetation have greatest value for conservation where they are linked to larger tracts, and where the shrubs and ground vegetation of the understorey have been retained.

In some situations, areas of particularly high conservation value on private land have been acquired and managed by the State. Sometimes also the Victoria Conservation Trust has acquired private land and vested it in a Shire or City Council acting as a management committee, or in the State to be managed under the provisions of the *National Parks Act*, or retained the title and appointed a committee of management. However, not every area of conservation value on private land can, or necessarily should, be acquired to ensure its protection.

The Victoria Conservation Trust was established under the *Victoria Conservation Trust Act* 1972 to assist in the conservation of lands of significance and the preservation of native flora and fauna. It has acquired more than 40 properties and has assisted in the acquisition of many others that are managed by other authorities.

More recently, however, the Trust has developed the concept of conservation covenants, through which an agreement is entered into between a land-owner and the Trust. This is a voluntary agreement drawn up to achieve the conservation goals of the land-owner and may be used to protect such features as bushland, individual trees, rock formations, wetlands, or buildings. Once its terms have been agreed upon, the covenant is registered on the title to the land and will bind future owners. At present, no areas in the Mallee have been acquired by the Trust nor has any land here been covenanted in this way.

Government Conservation Strategies - Implications for the Mallee

The government has prepared several statements on nature conservation in Victoria, which have relevance to the Mallee study area, including:

- 'Protecting the Environment: a Conservation Strategy for Victoria'
- 'Discussion Paper on the Program for a Native Flora and Fauna Conservation Guarantee'
- 'Victoria's Wetlands: a Draft Wetlands Conservation Statement'

These statements have a number of implications for the management of public and private land in the Mallee. For example, 'Protecting the Environment' outlines specific actions to be undertaken on issues such as:

- salinity control
- rural tree decline

- soil erosion
- river management, irrigation management, and environmental flows
- wilderness areas
- protection of flora and fauna and areas of special heritage value
- limiting of fuel-reduction burning in mallee areas

In addition, the government has endorsed several international conventions on nature conservation.

The Ramsar Convention (the Convention on Wetlands of International Importance especially as Waterfowl Habitat) arose out of increased international awareness that wetlands are an important habitat for birds, particularly migratory species, and that natural wetlands are being reduced at a rapid rate. It requires contracting parties to designate wetlands of international significance. Three within the Mallee area have been declared: the Hattah Lakes complex, the Kerang wetlands, and Lake Albacutya.

As part of the UNESCO 'Man and the Biosphere' Program, the Hattah--Kulkyne National Park and the Murray--Kulkyne Regional Park have been listed as a World Biosphere reserve.

Seven areas in the study area have been listed in the Register of the National Estate by the Australian Heritage Commission. These are the Big Desert Wilderness, Hattah--Kulkyne National Park, Pink Lakes State Park, the Wathe, Wandown, and The Marshes Wildlife Reserves, and Cullens Lake. Information on the establishment of the Australian Heritage Commission and the effects of registration are provided in Appendix XVII.

Major Issues in Conservation

Major changes to the natural environment have occurred as a result of human land use over the past 200 years, and many forms of use continue to affect it. Some of the important issues in conservation are briefly discussed below; a number of these are also addressed in other chapters of the report (for instance, Chapter 8 Fauna, and Chapter 16 Hazards and Conflicts).

Flooding

Alteration of flooding patterns and frequency - as a result of the regulation of rivers and the diversion of water for irrigation and domestic water supply purposes - has a variety of effects on the riverine ecosystem. These include unsuccessful regeneration of river red gums and interference with breeding of fish and water-birds. For example, vegetation on the Outlet Creek floodplain (Wimmera River system) is much reduced in diversity and severe die-back of river red gums at Wyperfeld National Park is continuing; both are believed to be due to the absence of water.

Fire

Fire is a naturally occurring source of disturbance in the environment and the native flora and fauna are remarkably resilient to such perturbation. However, changes in the fire regime (timing and frequency) and the extent of wildfires have important implications for nature conservation. In mallee vegetation, regeneration occurs readily following fire. However, extensive wildfires since 1975 have depleted the remaining old stands, which are vital for the breeding of the mulga parrot, the Mallee ringneck parrot, and other hollow-nesting fauna. Old stands are also important for the malleefowl. The few remaining areas of mallee greater than 30 years of age have highest priority for protection from fire. Map 11A indicates the extent of the 1959 fire in the Big Desert. Superimposing this on Map 11, which shows the more recent fires in the area, gives some indication of the limited extent of mature mallee here.

Grazing

Grazing by introduced domestic stock and by rabbits and goats has a detrimental effect on the conservation value of natural vegetation, as it alters both the floristic and structural composition of the vegetation. In woodlands of *Casuarina* and *Callitris*, grazing has prevented the species' regeneration, in some areas compounding the effects of previous fires and insect attack. Many stands of these trees are now depleted or senescing.

Grazing by kangaroos is a natural environmental process, but in the Hattah--Kulkyne National Park the high density of western grey kangaroos is imposing severe grazing pressure on the natural vegetation. Several management options are being followed to limit this impact.

Alteration of the natural flood regime can have an effect on the riverine landscape.

Resource utilization

Felling of trees for timber products, such as sawn timber, firewood, fence-posts, and railway sleepers, and the harvesting of resources such as mallee roots and broombush (*Melaleuca uncinata*) also affect nature conservation values on public lands. Selective removal of *Callitris* trees, which produce a durable timber suitable for fence-posts and other uses, has severely depleted this species in a number of woodland areas, particularly west of the Millewa settlement.

References

Australia Council of Nature Conservation Ministers (CONCOM) (1986). 'Guidelines for Reservation and Management of Wilderness Areas in Australia.' (Australian Government Publishing Service: Canberra.)

Department of Home Affairs and Environment (1983). 'National Conservation Strategy for Australia (Living Resource Conservation for Sustainable Development).' (Australian Government Publishing Service: Canberra.)

Government of Victoria (1987). 'Protecting the Environment; a Conservation Strategy for Victoria.' (Government Printer: Melbourne.)

Kitchener, D.J., and How, R. (1982). Lizard species in small mainland habitat isolates and islands of south-western Western Australia. *Australian Wildlife Research*, 9, 357--63.

Margules, C., and Usher, M.B. (1982). Criteria used in assessing wildlife conservation potential: a review. *Biological Conservation*, 20, 79--109.

Pickett, S.T.A., and Thompson, J.N. (1978). Patch dynamics and the design of nature reserves. *Biological Conservation*, 13, 27--37.

Preece, K., and Lesslie, R. (1987). 'A Survey of Wilderness Quality in Victoria.' (Report to the Ministry for Planning and Environment and Australian Heritage Commission: Melbourne.)

Saunders, D., Arnold, G., Burbidge, A., and Hopkins, A. (1987). 'Nature Conservation. The Role of Remnants of Native Vegetation.' (Surrey Beatty & Sons: Sydney.)

Shaffer, M.L. (1981). Minimum population sizes for species conservation. *Bioscience*, *31*, 131--4.

Slatyer, R.O. (1975). Ecological reserves: size, structure and management. In 'A National System of Ecological Reserves in Australia. Report to the National Academy of Science, No. 19', ed. F. Ferner, pp. 24--38 (National Academy of Science: Canberra.)

11. 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 8 (Public Land Use).

People seek a variety of recreation experiences during their respective leisure times. For some, this may involve areas with well-developed and maintained facilities where large numbers of people could be expected and management presence is regular. Other's seek locations where they can avoid the intrusions of vehicles and other people and where the emphasis is on self-dependence and self-sufficiency. Between these extremes, recreation settings with a variety of facilities, access, and levels of use are sought.

The public land of the Mallee area provides the local communities and visitors with a diversity of recreational opportunities. These range from formal activities - such as football and cricket contests using public land reserves, rifle-range shooting, motor-cross sports, and horse-racing - to the informal ones like fishing or just relaxing beside the Murray River, bird-watching, or experiencing solitude within the Big Desert Wilderness.

Outdoor recreation is therefore an important use of public land, which is a major reason why we should allocate areas specifically for recreation - to be either developed or retained as natural areas.

Table 1 indicates the various land use categories for which public land in the study area has been set aside. It can be seen that the bulk of public land is available for recreational uses of some sort and that a variety of reserves provide for a range of recreational opportunities. While specific reserves have not been set aside for each form of recreation, most activities can be accommodated somewhere on public land. Nevertheless, a total of almost 1900 ha of public land in the Mallee area has been set aside specifically for recreation such as horse-racing, rifle-shooting, golf, other sports, and boating. Many of the recreation areas are indicated by the prefix 'L' on Map 8; they include the 34-ha marina on King's Billabong (L38 on the map), set aside subsequent to the Council's 1977 recommendations.

Diverse natural features within the study area include: the dunes and plains of the Sunset Country and Big Desert, with their mallee scrubs, heaths, and savannah; the impressive river red gum woodlands beside the Murray River, which epitomize the Australian riverine landscape; the cliffs, beaches, billabongs, and swamps along the course of the river; spring wildflowers and abundant wildlife; and rela-

Paddle-steamers are a popular attraction on the river.

tively undisturbed areas such as the Big Desert Wilderness. This diversity makes it one of the more interesting and enjoyable places in Victoria for dispersed outdoor recreation, particularly during the mild winters. Nature study here is especially popular, as the Mallee fauna are unique in Victoria and the area contains the largest variety of parrot species in the State.

The cultural and historical associations of the Murray River give it additional attraction for visitors. The Swan Hill Pioneer Settlement, for instance, has been a significant catalyst to the growth of Swan Hill as a major tourist town. This tourist feature is located on the public river frontage reserve. Other attractions include vineyards and orchards, wineries, historical homesteads, and paddle-steamers.

In planning for recreation on public land, the Department of Conservation, Forests and Lands has used the recreation opportunity spectrum approach, which is based on assuming that the best way to provide for the diverse recreation needs of the community is to establish and maintain a variety of recreation settings. In these settings, recreation experiences will be influenced by the degree of development of access and facilities, the level of use, and the evident presence of management. An explanation of this approach and its application to the Mallee area is set out in Appendix XVIII. The appendix tabulates the recreational opportunities available in the larger parcels of public land in the Mallee and indicates that, from a preliminary assessment, almost 80% of these larger blocks of land can be classified as offering remote or semi-remote recreational experiences.

Recreation demand

Even if the popularity of various outdoor recreation activities remained constant, it can be expected that demand for recreation resources (much of which will need to be provided

on public land) will increase as the population and its discretionary income and leisure time increase.

Much of the recreational activities currently undertaken in the Mallee area are based on the Murray River, principally in the vicinity of the major towns and, since the 1970s, tourism has been actively promoted as an industry. Mildura and environs have long provided a tourist haven for both Victorians and South Australians. Tourists spent some 2.2 million visitor-days in Mildura during 1984/85. During peak times of spring and autumn, up to 90 000 tourists a month visit Sunraysia. Further, the 'Domestic Travel in Victoria' study conducted by the Victorian Tourism Commission indicates that, while growth has fluctuated considerably, the number of visitors to the region is growing and from 1982/83 to 1983/84 registered a massive 11.4% rise. Across the State, Mildura and the north-west recorded the highest increase in interstate visitors (23.6%) during this period.

Recreation activities

Table 14 indicates estimates of the numbers of people visiting and camping in the major parks in the area. Most of the

Table 14

VISITOR STATISTICS FOR PARKS IN THE MALLEE

	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86
Hattah--Kulkyne National Park							
Day visitors[1]	31 600	35 900	29 800	30 000	30 000	30 000	30 000
Campernights	17 100	14 800	16 100	10 400	19 600	23 900	23 000
Murray--Kulkyne Park							
Day visitors[1]	NA	1 500	5 000	5 000	5 000	5 000	5 000
Campernights[1]	NA	4 000	13 500	12 200	10 000	10 000	10 000
Wyperfeld National Park							
Day visitors[2]	17 000	30 800	24 300	19 200	21 700	26 300	25 800
Campernights	12 600	8 600	12 700	8 500	11 700	8 200	8 200
Lake Albacutya Park							
Day visitors[3]	3 000	10 000	10 000	15 600	13 500	9 500	7 700
Campernights	NA	14 900	22 000	4 800	1 000	700	300
Pink Lakes State Park							
Day visitors	500	500	800	1 300	6 100	4 800	6 900
Campernights	50	50	400	300	300	400	500
Big Desert Wilderness							
Campernights[1]	50	50	50	50	100	100	

Notes:

1 Estimates only

2 Day visitor figures may be underestimated

3 Visits to Lake Albacutya decrease with drop in water levels in the lake

4 Wildfires in 1980/81 reduced visitor numbers at some parks such as Wyperfeld National Park

NA Figures not available

recreational activities are concentrated where facilities have been constructed or adequate vehicle access exists. Activities in the parks include short and extended walks, sightseeing, picnicking, nature walks, photography, canoeing, nature drives, and swimming, depending on the area and season. The spring wildflower displays are a particular tourist attraction.

People visit many other areas in the Mallee in various numbers. Many camp along the Murray River, gaining access either from the river or from roads and tracks; others favour spots in the Big Desert or Sunset country or visit the larger wildlife reserves. No data are available on visitor numbers, however.

As in most other areas of the State, recreational usage of the parks fluctuates with the season, but the Mallee's comparatively pleasant winter climate makes camping and sightseeing activities more attractive in winter than in other seasons.

The Pink Lakes State Park came into operation in 1979 and facilities for recreation here have recently been developed. This is reflected in the low, but increasing, visitor use for the period shown in Table 14.

Development of visitor facilities has been concentrated mainly in the parks and at various locations along the River Murray. Appendix XIX - Vehicle-based Visitor Facilities in Mallee Parks - lists the types available here.

A number of problems arise from the recreational use of public land and these are discussed in Chapter 16 - Hazards and Conflicts.

Wilderness recreation

A survey of wilderness quality in 1987 indicated that the largest areas of highest wilderness quality in south-eastern Australia are centred around the Big Desert and Sunset Country, the largest continuous area being the Big Desert Wilderness.

This survey used four indicators to assess variation in wilderness quality, and focused on the two essential attributes of wilderness - remoteness and naturalness:

- remoteness from settlement - remoteness from settled (cleared) land or points of permanent occupation
- remoteness from access - remoteness from constructed vehicle-access routes
- aesthetic naturalness - the degree to which the landscape is free from the presence of the permanent structures of modern technological society
- biophysical naturalness - the degree to which the natural environment is free of biophysical disturbance caused by the influences of modern technological society

In recommending the Big Desert Wilderness in 1977, the Council used similar criteria and noted that wilderness requires land that still retains its primeval character and is without human modification or habitation. The appeal of a wilderness area is the opportunity for isolated non-mechanized recreation in a challenging and undisturbed natural environment.

River Murray

The study area includes about 770 km of the River Murray frontage. Much of the 60-m-wide river frontage reserve is accessible to the public and is used for a wide variety of recreational pursuits. Almost half of Victoria's wetlands associated with the River Murray are also found here.

Characteristically, the riverine environment contains river red gum and black box woodlands, billabongs, creeks, and wetlands. West of Mildura, locks on the river maintain permanent water within many of the billabongs and creeks, which form an 'oasis'-type environment in this semi-arid region of the State.

The River Murray is increasing in popularity as a recreation venue. In addition, the recreational use of the river is expected to continue. The Murray is promoted as Victoria's 'inland coast'. Most of the river-based recreation occurs near the popula-tion centres of Mildura, Swan Hill, and Robinvale. Popular activities include swimming, power-boating, water-skiing, fishing, duck-hunting, house-boating, and canoeing. In addition, paddle-steamers are a noted tourist attraction, providing daily tours.

Access to the extensive forested river bends and frontage is seasonal due to flooding. Here, vehicle-based camping is the most popular activity, along with horse-riding, trail-bike-riding, walking, and car-touring. Near Mildura and Swan Hill, walking and cycling tracks have been developed.

A survey in 1982 carried out by the Department of Conservation, Forests and Lands indicates that, within the study area, some 460 000 visitor days are spent in the vicinity of the River Murray each year, with some 200 000 of these being generated by overnight visitors. These estimates exclude the use of Hattah--Kulkyne and Murray--Kulkyne parks.

Easter is considered the peak period of the year for use of the river environs, with the greatest number of visitors at this time being found in the Robinvale district; areas around Mildura are the next most popular.

Fishing

Fishing is also a very popular recreation in the Mallee, and the Murray River and its anabranches and billabongs are the most important fishing waters. The river has a long frontage of Victorian public land, and access is generally good. The Murray River itself, however, lies in New South Wales and is therefore just outside the study area, and a New South Wales angling licence is required for this stream.

Opportunities for fishing are also provided by many of the small lakes that are fed by the Wimmera--Mallee Domestic and Stock Water Supply System in the otherwise-dry study area, and by some evaporative basins.

Appendix XV lists the 27 fish species of the Mallee and their abundance; it also indicates the principal water bodies in which they may be found and those species of commercial or recreational value.

The Lindsay River, Wallpolla Creek, and other anabranches of the Murray River west of Mildura provide probably the best angling waters for most native species of fish in northern Victoria. This is probably attributable to the many snags in these watercourses, which provide habitat for the fish. Kings Billabong is similarly popular.

Permanent lakes, including Lake Boga near Swan Hill, Lake Cullulleraine, and the Hattah Lakes system are favoured fishing areas. The last-named also provides for yabbying. When holding water, Lake Albacutya is netted for redfin and provides exceptional catches of yabbies. The saline Lake Hawthorn, near Mildura, is fished for carp and Lake Cardross at Red Cliffs is popular for catching redfin. Netting is also permitted in most of the lakes of the Kerang wetlands.

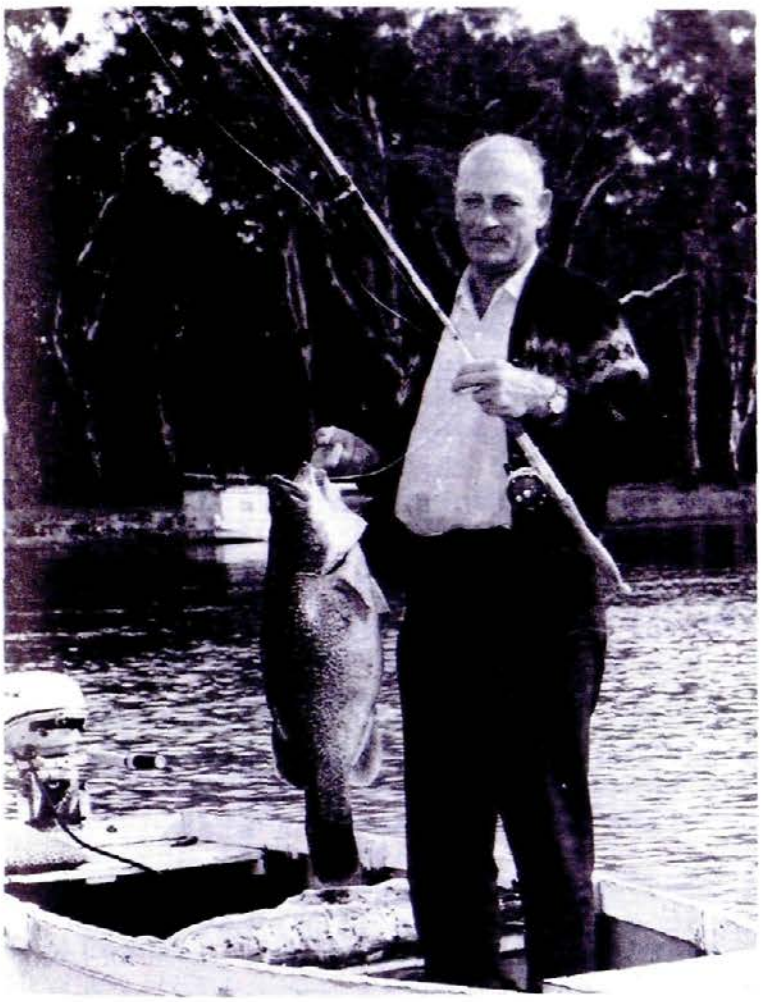
Both commercial and amateur netting are permitted in the Lindsay River--Potterwallkagee Creek--Wallpolla Creek anabranch systems. The impact of these activities on local fish populations has not been investigated. They do, however, compete with recreational angling. A closed season for the netting of native cod and perch species in these waters applies from late August to late November. A number of farmers raise fish in farm dams for home consumption.

The following species of recreational or commercial value occur in the study area. Further information on commercial fisheries is provided in Chapter 12 - Primary Production.

Murray cod (*Maccullochella peeli*). Although its distribution and abundance have fallen dramatically during the last 50 years, the Murray cod is still taken regularly. It occurs in the River Murray and its anabranches, the Loddon River, and some lakes and irrigation basins. It has been recorded to a weight of 90 kg, but specimens of more than 40 kg are now rare.

Golden perch, yellow belly, or callop (*Plectroplites ambiguus*). This is one of the most common native fish in the study area. It occurs in all the waters that carry Murray cod, and has been introduced into many private waters. Fish to about 3 kg are taken regularly. It provides good sport and is excellent eating. The small commercial fishing industry in the Wallpolla and associated creeks is based on this species.

Silver perch (*Bidyanus bidyanus*). Like the golden perch, silver perch is common here and occupies similar waters. It provides good sport and good eating, and is excellent for stocking in farm dams.



Fishing is popular along the River Murray and its anabranches, particularly for Murray cod.

Freshwater catfish (*Tandanus tandanus*). Although a common species, particularly near Mildura, this tends to fluctuate in numbers. It is a tenacious fighting fish when caught on light tackle and is excellent eating. Freshwater catfish prefer sluggish water and thrive in lakes. An unusual feature is that the species builds a large nest of sticks, pebbles or gravel, where the male both tends and defends the eggs.

Bony bream (*Nematalosa erebi*) is relatively common in the anabranch systems of the Murray River. It is of little sporting or table value, being far too bony for good eating, but is caught commercially, probably for pet or stock food or bait.

Redfin, also called English perch (*Perca fluviatilis*). This introduced fish competes directly with Murray cod and golden perch for food and habitat. It is believed to prey on both the eggs and young of some native fish. Redfin occur in most waters in the region, are taken commercially from ephemeral lakes such as Albacutya, and are released in farm dams. They provide good sport and are excellent eating. They are fresh-water species, but can tolerate salinities of up to 50% that of sea water.

European carp (*Cyprinus carpio*). This introduced species was declared a noxious fish in Victoria in 1962. Despite an eradication campaign, it spread from two centres in the State: one in South Gippsland, which led to its eventual spread into the Gippsland Lakes; the other, Lake Hawthorn near Mildura, allowed it to gain access to the Murray River. It now occurs in all waters of the study area and can tolerate a wide range of salinities and temperatures. Its impact on the native aquatic fauna has long been suspected, as it competes for both food and habitat.

The success of carp here may be attributed to a number of factors, including the suitability of the general physical conditions of the waters into which it has spread. The inherent instability and harshness of the aquatic environment suits a species such as carp that can reproduce and spread quickly when conditions are favourable and survive adverse conditions because it is so hardy. It had relatively little competition or predation from existing fish species when it was introduced, as stocks of native predatory fish such as Murray cod and golden perch were at a low ebb before carp spread throughout the Murray--Darling River system.

Carp is now thought to be a less serious pest than first feared. It appears that native fish are preying on its young and the numbers of carp have dropped and stabilized.

European carp provides good sport on light tackle and when properly prepared is an acceptable table fish, but it is mostly used for pet food or crayfish bait.

Tench (*Tinca tinca*). Although sparse over much of its range in the State, the introduced tench is relatively common in the Mallee water bodies, principally in slow-moving or still waters. It can tolerate brackish water. The flesh is quite edible but not particularly tasty. While popular in Europe, it is seldom sought in Australia.

Other common fish species in the Mallee area include the introduced **goldfish** or golden carp (*Carassius auratus*), which is often wrongly referred to as native or crucian carp. This species does not provide good sport and is considered to be poor eating.

Rainbow trout (*Salmo gairdneri*). A popular sport fish occasionally found in the study area, it is sometimes taken by commercial fishermen operating in the Wallpolla Creek system. **Brown trout** (*Salmo trutta*) is more common here. Both species are introduced.

Yabby (*Cherax destructor*). Yabbies are crustaceans common throughout the State. They are caught both commercially and recreationally in the Mallee area and are either eaten (the larger individuals) or used for bait. They can remain viable in salty waters of around 14 000 mg TDS per litre and can survive salinities as high as 25 000 mg TDS per litre.

Commercial fishing for yabbies is permitted in Lake Hindmarsh and, when these contain water, in Lakes Albacutya and

Walla Walla. Up to 30 professional yabby fishermen have been based on Lake Albacutya.

Amateur fishermen are permitted up to three nets to fish for yabbies in the lakes used by commercial operators (where the professionals are permitted up to 20 nets), and in other waters are permitted up to 10 nets. Probably more people net for yabbies in the Mallee than take part in any other form of fishing in the area.

Murray crayfish (*Euastacus armatus*). These are caught occasionally from the Little Murray River near Swan Hill. They were also common in the Wallpolla Creek system, but have not been recorded there since the 1956 floods.

Murray crayfish reach a maximum size of some 200 mm. Their range extends throughout the Murray River and its tributaries in both small and large streams and in both forested and agricultural lands. The species is thought to be approaching extinction in the South Australian portion of the Murray River, however.

The Department of Conservation, Forests and Lands stocks native fish in inland waters for both conservation and recreational purposes. To date, small numbers of golden perch have been released into Lakes Cardross and Cullulleraine. Brood fish from creeks west of Mildura may be taken under licence for use by native-fish hatcheries.

Hunting

Ducks are the major game species hunted in the study area, with some 60 permanent and ephemeral lakes providing good hunting. The Kerang lakes and The Marshes are popular hunting grounds, as is Lake Albacutya when it is holding water. Opportunities also occur on many smaller wetlands found on both public and private land, mainly associated with the River Murray or irrigation drainage basins.

The wetlands found in the Mallee offer excellent duck-hunting opportunities.

The most numerous game ducks in the Mallee area, and those comprising the greater part of a hunters' bags, are wood duck or maned goose (*Chenonetta jubata*) and grey teal (*Anas gibberifrons*). The former is more common along the frontage and anabranches of the Murray River, while grey teal prefer lakes in the southern Mallee.

The other species of game ducks, in order of frequency in the Mallee are: black duck (*Anas superciliosa*); hardhead or white-eyed duck (*Aythya australis*); pink-eared duck (*Malacorhynchus membranaceus*), which appears in large numbers in the Mallee when inland Australia is suffering drought; mountain duck or chestnut-breasted shelduck (*Casarca tadornoides*); Australian shoveller or blue-winged shoveller (*Anas rhynchotis*); and chestnut teal (*Anas castanea*), which is rarely taken in the Mallee.

Increasing concern over the accumulation of lead shot in wetlands may have implications for Victorian duck-shooters. It has been estimated that on opening day for duck-shooting in 1982 at Lake Buloke, south of the Mallee area, more than 1300 kg of lead was added to the environment.

In South Australia, the National Parks and Wildlife Service has found concentrations of lead shot-gun pellets in Bool Lagoon of up to 55 pieces of shot per sq. cm in the top 10 cm of mud. Samples of the resident population of black duck indicate that about 12% had recently ingested lead in their gizzards and that the number with lead in their body tissues is considerably higher. Both black duck and black swans are at risk there from lead accumulation. The South Australian Government has banned the use of lead shot in Bool Lagoon pending further notice. Steel shot is now used.

Rabbits are often hunted throughout the Mallee and some holders of the large grazing licences encourage rabbiting as a means of controlling this pest. Foxes and feral goats in the Big Desert and Sunset Country and feral pigs along the Murray River are also hunted.

The abundance of quail is influenced by local conditions. The best quail-shooting occurs in the crops and pastures of the southern and eastern parts of the study area.

References

Burt, T.J. (1982). Aerial survey of campers along the Murray River. (Unpublished report, Department of Conservation, Forests and Lands, Horsham, Victoria.)

Cadwallader, P.L., and Backhouse, G.N. (1983). 'A Guide to the Freshwater Fish of Victoria.' (Government Printer: Melbourne.)

Department of Conservation, Forests and Lands (1985). The Murray in the Mallee; a concept for river frontage management. (Unpublished report, Mildura.)

Hill, R. (1976). 'Australian Birds'. 2nd edition. (Nelson: West Melbourne.)

Marriott, K.L. (1986). 'Leisure Services Planning Study.' (Hepper, Marriott and Associates: Melbourne.)

Preece, K., and Leslie, R. (1987). A survey of wilderness quality in Victoria. Report to the Ministry for Planning and Environment (Victoria) and The Australian Heritage Commission.

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

Zeidler, W. (1982). South Australian freshwater crayfish. *South Australian Naturalist*, 56: 36-43.

12. PRIMARY PRODUCTION

AGRICULTURE

Agriculture is a major form of land use throughout the 43 230 sq. km of the Mallee area. About 31 000 sq. km (72%) comprise freehold land, principally used for dryland cropping and grazing. In addition, grazing licences cover more than 5000 sq. km of the public land, and a further 132 sq. km are licensed for cultivation.

Although much of this chapter deals with agriculture on freehold, it places the agricultural use of public land in perspective. Hazards associated with the agricultural use of land in the Mallee are discussed in Chapter 16.

Agriculture in the economy

Agriculture is carried out on about 5200 commercial holdings involving more than 7000 farm families, some permanent employees, and a large number of casuals who assist at peak periods, particularly with harvesting in horticultural enterprises.

The gross value of agricultural production in the study area in 1985/86 was $415 million. This was 12% of the State total. Field crops provided $172 m of this, horticultural crops $170 m, and livestock slaughterings and products $73 m. Agriculture is by far the largest single industry in the study area.

Most agricultural industries undergo cycles of profitability, largely based on prices in volatile export markets. Between 1982 and 1984, the dried vine-fruit industry went through a major crisis, with prices falling by 33%, and many growers were forced to leave the industry. However, by 1987 the prices had more than recovered.

During the 1970s, since the end of wheat quotas in 1971, the wheat industry enjoyed relative prosperity compared with other broad-acre industries, which all had major economic downturns. However, since 1982, many Mallee farms have suffered a dramatic financial downturn. Factors affecting this have included a major drought in 1982, significantly below-average seasonal conditions in 1984 and 1985, a 25% fall in the on-farm price of wheat, a 50% rise in costs of production, and a major rise in interest rates. Prices are expected to fall slightly or stabilize over the next 3 years before any rises can be expected.

Many farmers have had to borrow to continue farming operations and, for the 50% (1200 farm holdings) of farms in debt, average debts have increased from about $70 000 in 1982 to more than $200 000 in 1986. An estimated 10% of

farm families will have to leave the industry during the next few years.

The severe cash flow restrictions on farms due to negligible profit margins have had a dramatic flow-on effect to the small businesses in the 20 small towns of 200 to 1500 people throughout the dryland parts of the Mallee area. These towns have existed solely to service the wheat industry, and now, many businesses are with the downturn in the wheat industry, facing severe financial difficulties.

In order to survive, both farms and businesses have shed labour (younger family members and employees respectively) and a 10--20% loss of population from the dryland area since 1985 has resulted. Many communities fear for their survival and are now attempting to find alternative employment opportunities, for young people particularly, so that towns will not be so dependent on the financial health of the wheat industry in future.

Previous recommendations

At the time of the Council's 1977 recommendations, some of the public land held under grazing leases or licences issued under the *Land Act* 1958 had been cleared and developed for intensive cropping and grazing. In most cases this was an outcome of the history of the settlement of the Mallee.

In the Parishes of Berrook, Nulkwyne, Wymlet, and Kia, for instance, the land was occupied under settlement purchase lease by the 1920s, but depression, drought, and reduced wheat prices forced many people out. The areas either reverted to the Crown or were allocated to the remaining settlers in order to provide them with larger, more viable holdings.

Through the Closer Settlement Commission, the government had loaned large sums of money for the agricultural development of the land, some of which was deteriorating through revegetation, erosion, and vermin infestation. Some blocks were cleared and well developed, others only partly cleared. Most were fenced and many carried other structural improvements, including houses.

The blocks were, in most cases, re-allocated under annual grazing licences. In order to maintain the agricultural capability and condition of the land pending more favourable farming years, special conditions were included in the grazing licences, which required the holders to keep the structural improvements in good order and condition, and gave them permission to cultivate cleared land.

In other instances, settlers were allocated virgin land under annual grazing licences, with an obligation, as a condition of the licences, to clear and cultivate agreed areas to the satisfaction of the local Lands inspectors. However, this condition was not properly supervised and, indeed, little regular surveillance of any of the grazing licences was undertaken. As a consequence, significantly more public land was cultivated than was authorized.

Many settlers therefore cleared, fenced, and cultivated public land in good faith (although in a few cases unsuitable land was cleared, and some areas were cleared without permission). At the time of the Council's first investigation, much of this land was relatively sound, and some was being used productively for rotational cropping and grazing. Some, however, had regenerated since clearing or had not been cleared.

Following an examination of the use of public land held under the then-existing grazing tenures, the Council in 1977 recommended that the cleared and developed parts of most of the leases and licences should continue to be used for agriculture - either through alienation or under a special Limited Cultivation Lease (discussed below).

The Council also took into account the necessity to rationalize public land boundaries. Many of the parcels of licensed land were in scattered blocks, some extended into the proposed Hattah--Kulkyne National Park, and others included land that, although rolled or even cleared in preparation of ploughing, contained soil types considered unsuitable for development. Areas for development were consolidated where possible - principally in the Parishes of Wymlet and Kia (north of Ouyen).

On the advice of the (then) Soil Conservation Authority, areas designated for cultivated agriculture were divided into two groups based on the inherent hazard to soil deterioration.

Some 73 200 ha of land were identified for alienation, representing - at that time - about 4% of the total area of public land. A further 34 000 ha were approved for Limited Cultivation Leases.

By the commencement of this review, most of the land for alienation had been allocated for that purpose and clearing had commenced. The rate of clearing accelerated in May 1985, as land became available through the alienation process - resulting from the Council's previous recommendations - and as the financial situation improved. Local farmers have also expressed the view that the rate of clearing increased at this time partly in anticipation of possible future controls on the clearing of freehold land, as had occurred in South Australia. The clearing was taking place on land already held under freehold title or in the process of alienation.

Concern expressed about the increased rate of clearing, especially in corridor areas such as between the Annuello block and the eastern Sunset Country, and the lack of comprehensive ecological data provided the impetus to the government to request an early commencement for the Council's review of the Mallee area.

In the interim, also, the government has negotiated the retention of certain parcels of land that would otherwise have been cropped. This action - to provide biological links between blocks of public land that would have become

isolated had alienation proceeded - involved two parcels of land, one comprising flora and fauna reserve G5 and the other linking the large block of uncommitted land at Annuello and public land to the west (see Map 8-West).

Regional variations in agricultural practices and productivity occur across the study area, mainly as a result of variation in soil type, rainfall, and the availability of water in the case of irrigation, and in land tenure and licence conditions. The following general descriptions on agricultural production have been regionalized accordingly, into the regions indicated on Map 1.

Horticulture

Murray Valley

The Mallee includes one of the most important horticultural regions in the State. About 95% of the study area's production comes from around Mildura, Robinvale, and Nyah--Woorinen, which are within defined irrigation districts controlled by the Rural Water Commission and the First Mildura Irrigation Trust (see Chapter 6 - Water Resources and Utilization). Many horticultural blocks also lie between these districts, particularly at Boundary Bend, Nangiloc, and Colignan, using water pumped by private diversions from the Murray River. Table 15 indicates the output of the main horticultural crops grown in these districts, together with their percentage of the Victorian total production.

Table 15

HORTICULTURAL OUTPUT[1]

Produce	Production (tonnes)	Percentage of Victorian total
Grapes for drying	270 000[2]	100
Wine grapes	53 000	80
Table grapes	17 600	90
Almonds	850	97[3]
Citrus	68 000	86
Nectarines	800	40
Plums	800	30
Apricots	1 300	18
Melons	4 800	92
Pumpkins	3 900	44
Carrots	5 200	17
Lettuce	2 900	11
Tomatoes	6 000	6
Olives	300	43

Notes:

1. The Murray River region as a proportion of the State's total production in 1985/86
2. Fresh weight
3. 83% of the total nut output for the State

The area planted to vines has fallen by 15% over the last 12 years to 16 500 ha, while the orchard fruit plantings have increased by 30% to 5100 ha, and a 10% increase has raised vegetable-producing areas to 1600 ha. During the same period, corresponding changes in numbers have occurred, with viticultural producers falling by 11% to 1652 and citrus-growers down to 456, but stone-fruit-growers rising slowly to 280. The average size of a horticultural property is now about 10 ha, up 40% from 12 years ago.

Some of the areas formerly used for viticulture have been taken up for small sub-commercial holdings (hobby farms), which have been cleared of permanent plantings and reverted to pasture - particularly horse paddocks.

The majority of viticulturalists are still involved in dried-fruit production, but there has been a big increase in wine production, particularly from the dual-purpose grapes sultana and gordo, although the increase has slowed in the last 2 years.

Viticulture is an important agricultural enterprise in the irrigated areas of the Mallee.

The price of dried vine-fruit fell by 33% in the early 1980s, although between 1985 and 1987 most of this fall had been recovered. Because productivity is increasing, it is not expected that output of the fruit will fall much, but the vine-pull scheme and evidence of a fall in wine consumption will have some effect. The vine-pull scheme is part of the Commonwealth's Rural Adjustment Scheme, under which growers are paid on a per-hectare basis to remove vines, with a commitment not to plant them again for at least 5 years, as a means of lowering production.

Table-grape production increased quite rapidly in recent years, mostly due to the diversion of sultanas from dried fruit production, but also because of a steady increase in plantings of specialist table-grape varieties. A recent trend to eating more grapes domestically will increase if

quality and packaging can be improved further. A major market penetration into South-East Asia caused exports from Melbourne to increase from 500 tonnes in 1979 to more than 10 000 tonnes in 1987. It is hoped that additional penetration can be made into the Middle East, European, New Zealand, and Canadian markets.

The medium- to long-term outlook in the citrus industry is uncertain because of potential competition due to international over-production, such as that in Brazil, particularly affecting the juice markets.

The industry is placing increased emphasis on fresh citrus production, concentrating on export to South-East Asia, Europe, and Japan and out-of-season export to the United States. However, Australia is still a net importer of citrus products despite a rapid increase in output.

Since 1972, citrus production has partly moved out of the rostered irrigation districts and a large increase in large family or corporate farming has occurred on private diversion areas along the Murray River, particularly from Karadoc to Colignan and at Boundary Bend.

Because of the large world over-production of the dried fruits, growers have shown interest in diversifying into other crops, including nuts, stone fruits, and subtropical species such as avocados, due to their greater potential return. Nearly 500 ha of the 1000-ha increase in orchards has occurred in stone-fruit plantations around Swan Hill, half of this being planted to nectarines and 20% to both plums and peaches.

Most of the remainder of the increase in the area of orchard fruit has been in broad-acre developments carrying, for example, almonds and pistachios. These enterprises need more water and require access to cheaper land. Major commercial developments have occurred at Boundary Bend, Nangiloc, and Lindsay Point, and almond production has increased by 550% over the last 10 years.

The potential exists to plant another 2000 ha to almonds, which has attracted the interest of South Australian concerns. This would satisfy the Australian demand for almonds.

The vegetable industry has been characterized by growers rapidly entering and leaving it, regarding vegetables as a short-term cash crop. Moreover, a trend to specialization has developed among the vegetable-growers in the Sunraysia, Robinvale, and Boundary Bend areas. Some of them are now exclusively involved in vegetables. Generally they grow a range of crops, but are trending towards single crops such as carrots, potatoes, and tomatoes.

In the last couple of years, the number of enterprises growing asparagus has increased rapidly. Farmers can supply produce earlier in the season than other growers servicing the fresh domestic market, and there is also export potential. The long-term future for melons looks promising,

both for early- and late-season domestic production and for export - to South-East Asia, mainly, and to the Middle East.

Broccoli production could also expand over the next few years, and lettuce and carrots have some export potential.

Loddon Valley

Most of the land used for horticulture here is in the Tresco Irrigation Area (about 1000 ha) near Lake Boga, and north of Boort, with smaller areas at Mystic Park and Kangaroo Lake. In total, some 853 ha are under vines, 205 ha carry fruit orchards, and 600 ha support vegetable production.

The changes at Tresco are similar to those experienced in the Murray Valley although dried vine-fruit production has declined to almost nothing since the mid 1970s. Orchard trees have been replacing dual-purpose grape varieties and stone fruit particularly will continue to expand at the expense of wine and table grapes because of its better profitability. Diversification also enables growers to take advantage of seasonal variations.

Of the vegetable production, 450 ha located just north of Boort are used exclusively for tomatoes for processing and this area has expanded from a very small one 12 years ago.

Irrigated Agriculture

Murray Valley

Most of the irrigated agriculture carried out here depends on private diversions from the Murray River. The exception is the Swan Hill Irrigation District, which receives its water under gravity from Torrumbarry and Little Murray Weir, as part of the Goulburn Murray Irrigation District. Annual and perennial pastures take up more than 18 000 ha of the total 23 000 ha irrigated. Dairy cattle are run almost exclusively on perennial pasture, but the current total of 7300 head, which has fallen nearly 40% in the last 12 years, is likely to fall further as freight rates increase. The closest dairy factories are at Leitchville and Rochester.

Beef cattle are run on both annual and perennial pasture, but their numbers too have fallen 35% to 17 000. However, they are likely to remain reasonably static in future.

About 65 000 sheep graze on irrigated and dryland pastures. Some 1300 pigs, a fall of 35% in 10 years, are also run.

The irrigated cereal and oilseed crop area of 4000 ha has been rising steadily over the last 12 years, particularly in the private diversion area - largely at the expense of annual pasture. It will continue to increase in future as farmers gain more experience and yields increase with better irrigation management.

Lucerne production, currently covering 700 ha, is also increasing rapidly with government encouragement and the development of export markets.

The use of laser grading to improve efficiency in water utilization has increased rapidly since the technology was introduced in the late 1970s and now covers about 18% of the irrigated area. This has been a major reason for the increase in the area of irrigated crops.

Loddon Valley

Of the nearly 29 000 ha of irrigated pasture in this area, some 20 000 ha carry annual pasture and the rest carry perennial species. A further 7000 ha support crops, and irrigated lucerne occupies 1200 ha. Crops have increased in the last 10 years at the expense of annual pasture, at a greater rate than in the Murray Valley. A greater range of crops will also be grown in the future, particularly rapeseed and sunflowers.

Dairy cattle are mainly restricted to the region around Fish Point and Pental Island, with a few near Benjeroop, Lake Charm, and Appin. They now number only about 5000, a fall of 35% over the last 10 years. Most beef cattle are run on properties that have irrigation and their numbers have fallen by 40% to 25 000 during this period.

Dryland Farming

Appendix XX shows the major statistics for dryland farming in each of the regional subdivisions of the Mallee area indicated on Map 1. It also includes relevant percentage changes in the 12 years since the previous report by the Council.

Wheat is by far the major dryland farming crop.

A consistent trend towards a reduction in number of farms has occurred right across the study area. As the area of freehold land has virtually not changed, this indicates a corresponding increase in property size, which arises as one moves into the lower-rainfall areas of the central Mallee and Millewa.

The area under wheat and barley has increased in all regions. Wheat is by far the major crop and is still generally sown after a 9-month fallow period. Barley is generally grown in wheat stubble.

Farmers are increasingly growing pea crops before the wheat crop, and the area of field peas has increased from nil in 1975 to 40 000 ha across the Mallee. The widest adoption of field peas by far is in the Tyrrell region. The growing season in the Millewa is generally too short and variable to sustain the varieties of field peas acceptable to the trade. The central Mallee similarly supports very few, possibly because the larger property size, which means less pressure for improved farm production, and greater conservatism among the farmers. Certainly field peas are well adapted to the soils and climate in this block.

The intensity of cropping has also risen quite markedly due to the increase in crop areas. Both fallow and pasture area have fallen at its expense. This rise occurred slowly up to and including 1982, but accelerated in 1983 as farmers attempted to recover from the drought as quickly as possible. This rapid increase in intensity has been maintained.

The intensity of cropping is lowest in the areas of largest property size. The factors responsible include lower rainfall, absence of alternative crops (at least in the Millewa), larger areas of as-yet-uncleared land, and unsuitable (saline) land.

Yields from dryland crops rise towards the south and southeast where the rainfall is higher. The range in yields shows the extreme variability of rainfall from year to year. In all cases the lowest yields were achieved in 1982 and the highest in 1983.

Sheep numbers have fallen across the Mallee owing to a combination of the following:

- a fall in area of pasture for grazing as cropping intensity increased
- a decline in the quality of pastures since 1977 as the contribution by medics fell following the introduction and establishment of various forms of aphid from overseas
- low stock numbers in March 1986 because of significantly below-average seasonal conditions in 1984 and 1985 in much of the study area

The development and initially rapid adoption of aphid-resistant legume varieties since 1984 should help provide higher

Due to a number of factors sheep numbers have fallen in the Mallee.

quality and quantity of pasture, which could lead to a further intensification of cropping, but at least a maintenance of stock numbers.

Beef cattle numbers have fallen dramatically everywhere following the collapse of beef prices in 1974 to 1978. They are rising slowly at present.

Pig numbers have also fallen in all blocks except the central Mallee, although it is noteworthy that near Birchip in the Tyrrell area, they have risen by 200%, no doubt due to the major co-operative pig-marketing group that exists in that area.

In the south-western corner of the Big Desert region, at Telopea Downs, about 30 000 ha have been cleared, mainly for lucerne- and phalaris-based pastures, this being the wettest part of the Mallee area.

An examination of production figures for the Tyrrell and Avoca regions gives some indication of the contribution these two areas make to Victorian agriculture. Together, they account for 40% of the freehold area and more than 50% of the area sown to wheat and, on average, produce 60% of the tonnage (570 000). This is nearly 20% of the average Victorian wheat crop.

Public Land Grazing

Grazing of native forage on public land has been an important factor in the agricultural development of Victoria. In the early days considerable time was required to clear and develop land, and the native pastures on the land that was cleared had limited productivity. Public land grazing was therefore an important source of income for many farmers.

The situation is different now. As a result of modern technology and management, much of the freehold land is cleared and sown to crops and improved pastures. The availability of water has enabled mixed wheat/sheep enterprises to develop. For many farmers the general importance of grazing on public land has declined; for others, however, it remains important or may be the only enterprise undertaken.

At present, some 519 000 ha of public land in the Mallee are licensed for grazing purposes to more than 70 licenceholders. Such grazing is usually an adjunct to farming on freehold land, although some of the licencees have little or no freehold land. Public land grazing now involves only 2.5% of the total sheep in the Mallee area and for the year 1985/86 the gross value of production from these was less than $1m. While this production was very important for many of the licensees concerned, it was a minute fraction of the $415m from agriculture in the study area as a whole. The licensing of almost all public land in the Mallee area is the responsibility of the Department of Conservation, Forests and Lands. A small area in the far north-west of the study area (near Neds Corner) is controlled by the Rural Water Commission. A number of hazards are associated with the grazing of domestic stock on the native vegetation of public land and these are discussed in Chapters 7 - Vegetation and 16 - Hazards and Conflicts.

In its Final Recommendations for the Mallee in 1977, the Council stated its belief that the grazing of public land carrying native vegetation could continue at a low intensity. In addition, it considered rabbit control, reclamation of damaged areas, and the fencing out of some areas for regeneration to be essential if public land were to be managed as a community asset.

The issue of a licence over public land only gives the licensee the right to use the specified resource (fodder, in the case of grazing) that is located on public land; it does not offer exclusive occupancy. A lease, on the other hand, gives the lessee a legal interest in the land itself and is usually interpreted as offering exclusive occupancy of the land.

Most of the grazing licences issued in the 1930s in the Mallee were on an annual basis and renewal occurred merely by the licensees paying the annual rentals. In the 1950s and 1960s, 21-year grazing leases were issued to about 40 licensees. As these came up for renewal in the years immediately prior to the Council's 1977 final recommendations, the then Department of Crown Lands and Survey converted them to annual licences so as not to prejudice subsequent government decisions. This conversion to annual licences continued after the recommendations, to achieve consistency of the licensing system.

Although the Council in 1977 recommended the granting of long-term grazing licences where appropriate, none have yet been issued in the Mallee area. In implementing the Council's recommendations, the then Department of Crown Lands and Survey gave priority to alienating those areas indicat-

ed. Limited Cultivation Lease areas were the next to be considered, followed by the grazing licences. The necessity to develop management plans for both cultivation leases and grazing licences has delayed action on granting the long-term grazing licences. At present, productivity and stocking levels have been estimated for these areas in preparation for granting tenure.

It is suggested that leases and longer-term licences generally tend to lead to the agricultural use becoming the dominant management goal of the land rather than the protection and preservation of the intrinsic values. A licence, however, is considered to enable the licensed activity to be used as a management tool to assist in meeting the primary land use object.

The Rural Water Commission manages some 1600 ha of land in the north-west of the study area. This land is leased to the adjacent landholders on a 12- to 15-year basis for both grazing and cultivation. The larger licensed grazing areas in the Mallee area are indicated on Map 5.

In 1987, the Land Conservation Council commissioned ACIL Australia Pty Ltd to conduct a study of the larger areas of public land in the Mallee that are used for grazing, to provide information on the way they are used and their condition. Some 40 separate licence areas of 1000 ha or more were investigated; these are licensed to less than 20 individual enterprises, however. Where appropriate, information from this study is included in the following comments on public land grazing.

Riverina

Along the floodplains of the Murray River, dense stands of grass, mainly swamp couch, develop in areas that are well watered by flooding or irrigation. Other red gum and black box areas support a lighter cover of grasses and edible shrubs. The areas most valuable for grazing are at Boundary Bend, Nyah, and Nangiloc. Other areas of moderate value are at Robinvale and at Belcher, Beveridge, Lindsay, and Wallpolla Islands. The susceptibility of this land to flooding means that the licensees often use the floodplains in association with the adjoining higher land.

Both sheep and cattle are grazed on the floodplains, although sheep are precluded from a number of areas because of the presence of the noxious weed Noogoora burr, which produces spiky burrs that become entwined in the sheep's wool, thereby reducing its value.

Grazing under agistment, chiefly by cattle, occurs mainly in the smaller areas of public land at Nyah and Mildura. The number of cattle permitted to graze on agistment is regulated according to the condition of the ground vegetation, and all cattle are excluded in times of drought.

For most of the larger licensed blocks along the river, however, the government has not specified the maximum number of stock that may be carried. In all, 28 grazing licences,

Public land provides opportunities for grazing on native forage on the floodplains.

Saltbush areas support extensive sheep grazing.

under which both sheep and cattle are run, cover 34 500 ha, and an additional 25 agistments on 13 000 ha allow for 814 cows and 25 horses.

The Council's consultant estimated that the floodplains could carry about 1 sheep to 3 hectares although in dry years, if flooding did not occur, this would reduce to 1 sheep to 10 hectares.

Millewa

Saltbush areas on the second river terraces, north of the Sturt Highway, support extensive grazing, mainly by sheep, and carry about 1 sheep per 2 to 4 ha. Three licensees run a maximum of 7800 dry sheep equivalents (DSE) on 35 000 ha. (An explanation of DSE is provided in Appendix XXI). Almos

all of the public land west of the Millewa farmlands and near Mildura is held under licences for sheep-grazing and this activity is most intense on the grassland areas. Savannah spear grass and exotic grasses are the major forage species, but scattered saltbushes, blue-bush, and other edible shrubs are also important. The amount of forage available varies greatly with seasonal rainfall. Ten licensees here run a maximum of 900 DSE on a total of 55 400 ha.

Water for livestock is reticulated to a number of tanks and troughs in each of the grazing blocks. Pumps along the Murray River service those in its vicinity, while, in the west, water is piped from the water supply system servicing farmlands east of Loxton and Berri in South Australia.

Sunset Country

Ten licensees run a maximum of 25 400 DSE on 350 000 ha in the Sunset Country.

The carrying capacity varies according to vegetation. In areas of dense mallee, grazing is limited to leaf litter and shrubs and carrying capacity is estimated at 1 DSE to 30 to 40 ha. These areas can only support dry stock. On the plains, carrying capacity varies - from very low on samphire areas to 1 DSE to 5 ha on saltbush and grassland.

Fencing and water supply are the main improvements made to the licensed areas. Catchment tanks, groundwater, diversions from channels, the South Australian reticulation system, and supplies from Lake Hattah are used to supply water to the various licensed blocks, and fences divide each extensive run into a few large areas.

Big Desert

Although the whole of the Big Desert was divided into grazing runs in the early days of settlement, grazing is at present restricted to the plains and woodlands associated with Outlet Creek. The licensee at 'Pine Plains', north of Wyperfeld National Park, is permitted to graze a maximum of 6500 DSE on 31 160 ha.

Some of the smaller parcels of public land in the eastern portion of the Mallee area also carry grazing stock. These include many bushland reserves and some of the hardwood production areas.

Forms of land tenure for grazing

In the 1977 recommendations, the Council noted that grazing on public land should be controlled by issuing long-term licences, annual licences, or agistment rights, depending on the circumstances as outlined below, with the intention that the management authority must be able to control stocking rates.

It was believed that long-term licences (up to 21 years) with conditions that permit the government to exercise general supervision of grazing management, especially with

respect to stocking rates, would give the licensee reasonable security of tenure and thus encourage the conservation of the forage resource. These licences are best suited to relatively large areas that are grazed regularly, and would normally cover uncommitted land.

The issue of agistment rights, or annual licences with stock limits, was thought to be suited to situations where:

- the areas to be grazed are small
- the demand for grazing is intermittent
- grazing is used occasionally as a management tool
- the use for grazing is clearly subordinate to other uses
- grazing is being phased out

On these criteria, it was considered that long-term licences would not be applicable to grazing on small reserves, water frontages, and the small river forests in northern Victoria.

The government approved the Council's recommendation that light grazing of native and volunteer pastures be permitted, at the land managers' discretion, on those areas of uncommitted land already licensed for that purpose, under either long-term grazing licences or agistment rights, or under annual grazing licences (with stocking limits) should the former be impracticable. On the river forests the approved system is with agistment rights or annual grazing licences with stocking limits.

In several cases, the Council's consultant noted that the Department of Conservation, Forests and Lands' assessment of the carrying capacity of the licensed blocks took into account the whole block, regardless of whether the whole was used or not. Particularly for those blocks containing dense mallee, not all of each block is used and the allowable stocking (or more than that permitted in some instances) is concentrated into the more suitable areas - creating the potential for overstocking the licence area. Given the susceptibility of the Mallee environment to degradation and the eventual loss of the more palatable native plant species, this situation causes considerable concern.

In estimating the number of stock to be permitted on a grazing block, the Department of Conservation, Forests and Lands attempts to take into account the need to conserve the range of native flora present. However, the long-term grazing of a number of the areas, under all seasonal conditions, has the propensity to convert them to agricultural grazing land rather than public land in which grazing is a management tool.

The consultant also noted that, although each grazing licence requires the licensee to destroy and suppress vermin and noxious weeds, the degree to which this has been carried out varies. In some areas the expenditure now required to control rabbits could exceed the income derived from the use of the blocks for grazing. It is almost inevitable that the urgently required control works will need to be met by the government.

Limited Cultivation Lease

This lease was a new form of tenure that the legislation existing in 1977 did not cover. The Council recommended its introduction to permit the government to exercise general supervision of the use and management of areas of public land that had been cleared and used for cropping and grazing, but that have greater-than-average erosion or salting hazards. In some cases also, Limited Cultivation Leases were recommended for allotments in which less-productive areas with high erosion or salting hazard were interspersed with good-quality agricultural land. These lease areas are indicated on Map 8 by the symbol 'F2'.

In most cases, these areas have a similar history of occupation to those recommended for alienation in 1977. The occupiers generally cleared and cultivated the land under written permission, or with an understanding that this was possible, and held an expectation that the land would eventually be alienated.

The Council suggested a number of terms and conditions for Limited Cultivation Leases, and these included: a lease term of 35 years with a review after 25 years; negotiability of the lease (subject to Ministerial approval); advice to the Crown's managing authority by a group such as the District Advisory Committee (which comprises representation from the managing authority and from regional landholders); and general supervision of the management of the leases by the Crown managing authority - now the Department of Conservation, Forests and Lands.

Many of the areas designated as 'Limited Cultivation Lease' are in good condition, probably by reason of their management. The potential for deterioration is only realized if land management is poor; the same could be said about the management of any land.

Limited Cultivation Leases cover 47 parcels of land, totalling 34 000 ha. None of these leases has formally been let, however. The Department placed these areas on a lower priority for implementation than those needed for conservation reserves and other purposes recommended by the Council. In addition, each lease requires the development of a management plan. As a result, by the time of this review, none of the leases had been processed.

Another 6000 ha of public land to the south of the township and irrigation areas of Robinvale are covered by cultivation licences. About 5000 ha are cleared and yield about 1.2 tonnes of cereal crops per ha. This land was held by the government for possible future extension of the irrigation settlements. It is not indicated separately on Map 8, but forms the bulk of the land categorized as 'uncommitted' in the vicinity of Robinvale.

Several of the allotments near Robinvale are owned by the Rural Finance Commission and are used for share-farming; these, too, are included within the uncommitted land category.

Cultivation under licence is also undertaken on public land in association with two of the grazing blocks. In the far north-west of the study area, cropping and grazing are carried out under the one licence - clearing being restricted to the swales between the sand dunes. Near Nowingi, cultivation is practised under a separate licence. Throughout the Mallee area, many small reserves such as unused roads are also cultivated by adjoining landholders.

In 1987, the Council commissioned McGowan International Pty Ltd, in association with Australian Biological Research Group Pty Ltd, to investigate those parcels of land recommended for Limited Cultivation Leases and the cultivated public land near Robinvale to determine the stability of the land to be used for agriculture and the extent and nature of the indigenous vegetation present. The majority of the areas carry indigenous vegetation to varying extents; one is completely uncleared. The consultants observed that in most cases the land had been maintained in a sound condition. Some licensees had halted land degradation processes, although problems still exist in other areas.

Licensees' degree of dependence on the cultivation blocks varies considerably. Some are almost wholly dependent on the licensed areas.

The Rural Water Commission also manages several parcels of land near Lindsay Island, in the north-west of the study area, on behalf of the River Murray Commission. This land was purchased for the now-disbanded Chowilla Dam project. Most of it is leased and some is used for irrigated pasture.

Agricultural Capability of Public Land

The following descriptions are in general terms only. Specific instances do occur where the capability of an area may differ from that indicated - in the Annuello block, for instance, pockets of public land have a greater capability to support cultivated agriculture then adjacent freehold land.

Murray and Loddon River floodplains

Soils on the river floodplains are predominantly either brownish sands or grey self-mulching cracking clays.

The brownish sands have low inherent fertility and a very low capacity to retain moisture, are susceptible to salting and the development of hard-pans, and are very prone to wind erosion. Their capability to support either cropping or grazing is therefore low, especially given the low rainfall. Crops could be established under ideal conditions of moisture and with adequate fertilization, but evaporation rates are high. Irrigated crops, particularly citrus, can be satisfactorily established in some areas.

Of the cracking clays, non-friable types occur in much of the public land on the floodplains and are difficult to work with machinery. In the low-rainfall situation, the limited moisture is not easily accessible to plants and they find it

Grazing capability of public land depends on soil type and vegetation. Here lignum is growing on grey cracking clay.

difficult to penetrate the subsoil and find moisture at depth. The capability of these soils to support grazing, however, is probably the greatest of any of the public land areas used for grazing in the Mallee.

Millewa

The soils of the public land are predominantly calcareous earths and are similar in all respects to the soils already under cultivation in the occupied areas - except that the saline areas of the evaporative basins, which are not suitable for agriculture, are interspersed on the plains (see Map 7). Wind erosion would also be a greater hazard on the dunes in this drier climate.

Although the native grasslands in the Millewa are capable of supporting a higher stocking rate for grazing than the dense mallee scrub, they would have to be regarded as having very low capability by State-wide standards.

Sunset Country

Reddish-yellow sands, sandy duplex soils, and calcareous earths make up much of the northern part of the public land and, together with brownish sands in the south, comprise the main soil types.

The sands retain very little moisture and have low inherent fertility, and their non-coherent nature makes them very prone to wind erosion; they are always in need of protection. They are not suitable for anything except extensive sheep grazing. The saline soils of the salinas and gypsum flats in the groundwater-discharge areas are also unsuitable

for cultivated agriculture, but the vegetation on these soils can support a low level of grazing.

The calcareous earths generally have a better moisture-retention capacity, higher natural fertility, and slightly lower soil erosion potential than the sands. Capability for agriculture improves with increasing rainfall. In the north, the lower rainfall is associated with more sandy soil types, so the capability (1.0 tonne per ha) is lower than in the adjacent Millewa and the erosion potential higher. Capability of some public land in the south would equal that of the adjacent cleared land in the central Mallee (1.3 tonnes per ha).

Capability for grazing on native vegetation here is low by State-wide standards, especially in the dense mallee.

To the east of the Sunset Country (north-east of Ouyen) the Annuello block contains very dense dunes and therefore, in general, the soils are sandier than is typical of the calcareous earths. Their productivity for agriculture is therefore generally lower than that of the surrounding occupied land, and erosion hazard higher.

Big Desert

Public land here is almost exclusively dune country. The small alluvial plain associated with Outlet Creek is included in the Albacutya Regional Park, Wyperfeld National Park, or the Pine Plains licensed grazing block.

The dune country of the Big Desert comprises both irregular and closely spaced east--west dunes. The locations of the respective dune-fields are indicated on Map 7 - Land Systems. The east--west dunes carry duplex soils with pale sands overlying reddish-yellow clayey sands. The heavy subsoil is very sodic and gives rise to salinity problems when water-logged, difficult water penetration, and high resistance to root penetration, thereby reducing plants' ability to use the subsoil moisture and nutrients. The surface soils have very low moisture-retention capacity due to their low clay content and are susceptible to wind and water erosion. Inherent fertility is low.

On this soil type, the public land would have a lower capacity for agriculture than the adjacent occupied land, which consists of extensive sand-plains with few dunes and a higher rainfall.

The pale sands of the irregular dunes also have a very low moisture-retention capacity and very low inherent fertility. Their non-coherent nature and topography give them severe wind and water erosion potential. Agricultural capability without very heavy applications of fertilizer is much lower than in the surrounding land systems.

The grey clays and grey sands of the Pine Plains area have an agricultural capability for cropping and grazing similar to that of the nearby private land (about 1.4 tonnes per ha), with similar erosion hazards.

Other public land

The lakes and adjacent public land associated with the Tyrrell Depression are saline and unsuitable for agriculture.

On the alluvial plains of the Avoca and Loddon Rivers most of the public land either consists of wetlands used as part of the irrigation distribution and drainage system, or comprises marshy areas designated as wildlife reserves.

The public land near Lake Tutchewop is used as a floodway for the Avoca River and therefore has limited capability for agriculture, or has saline soils, as in the Mystic Park forest, and therefore has very low capability.

Soils of the Wandella, Leaghur, and Appin forests resemble those on the adjacent farms, and are suitable for irrigated pasture.

Elsewhere, most of the remaining public land comprises stream frontages and wildlife, bushland, flora and fauna, and recreation reserves.

Agricultural Education and Research

Sunraysia Horticultural Centre

The Sunraysia Horticultural Centre is located on two sites near Irymple and is managed by the Department of Agriculture and Rural Affairs. Of the total of 81 ha, one parcel of 45 ha is arable, but is not irrigated and is retained in its natural state. Some 10 ha are planted to vines and almost 10 ha to citrus and other horticultural crops. The Department also manages, as an integral part of the Centre, an adjoining 4-ha parcel of land owned by the Australian Dried Fruits Association.

The Department's functions of research, extension, and regulation for the Sunraysia region are integrated within the Centre, which also includes four operational sections concerned with viticulture; citrus, tree crops, and vegetables; protection of crops and agricultural products; and irrigation and salinity.

Goals of the Sunraysia Horticultural Centre are to:

- increase the market competitiveness of the dried vine-fruits industry through the improvement of the quality of fruit and the adoption of mechanical harvesting
- encourage the diversification of horticulture in the region in line with, particularly, export market opportunities
- use innovative methods to improve the viability and short-term productivity of the industry
- foster the adoption of more efficient irrigation methods by growers and define suitable strategies for salinity control in the Mallee

Irymple Technical School Farm

Incorporating some 140 ha of land, of which about 50 ha are public land, this farm provides educational services to about 80 apprentices and 25 full-time students, as well as short courses for about 300 farmers annually.

Run by the Sunraysia College of Technical and Further Education, it offers courses in business studies and glasshouse horticulture as well as studies of citrus and vine crop production, feedlots, dryland and irrigated production, and livestock.

Mallee Research Station

This station is also managed by the Department of Agriculture and Rural Affairs. It is located north of Walpeup and incorporates 1032 ha of public land, including 804 ha of cleared arable land suitable for cultivation and 228 ha of uncleared shelter belts or building reserves.

In any one year about 100 ha are sown to experimental plots and 200 ha to bulk areas consisting of wheat, oat, barley, rye, pea, lupin, and triticale crops. The remaining 500 arable hectares are under medic-based pastures or bare fallow prepared for the following season's cropping program. Pastures and crop stubbles are grazed by sheep.

The station conducts a wide range of research projects, both here and on farmers' properties across the Mallee region, on the following topics:

- variety and species evaluation (wheat, barley, oats, triticale, field pea, rapeseed, lupin, chickpea and narbon bean, annual medic, and lucerne)

The office and seminar complex - Mallee Research Station, Walpeup.

- comparison of soil preparation methods
- rotational studies for disease control and soil fertility improvement
- chemical control of cereal cyst nematode
- herbicide suitability in defined circumstances
- nutritional requirements of field crops
- comparison of flock-mating strategies

APICULTURE

The apiculture industry depends on the introduced honey bee, *Apis mellifera*. This 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, and they store this protein food, along with nectar, for feeding. Their pollination activity - in relation to agricultural and horticultural crops - is probably more important than their commercial value as producers of honey. Bees normally range within 2--3 km of the hive, although they sometimes forage up to 14 km away.

Products

Bee-keepers harvest honey, beeswax, and some other minor products. Honey is used for table consumption, for confectionery manufacture, as a stock food, and in the preparation of meat products, tobacco, vinegar, and some pharmaceutical and cosmetic products. Beeswax has many uses, including candle, cosmetic, and polish manufacture and other industrial purposes. The minor products - pollen, royal jelly, and propolis - are used as health foods.

Approximately half the honey crop is sold overseas, making Australia one of the main exporters of honey. Exports go to the United Kingdom, West Germany, Africa, Asia, and the Middle East. One of Australia's largest honey processing and packing plants is located at Maryborough, in central Victoria. Other packing plants are located in Melbourne, Broadford, and Bairnsdale.

The bee-keeping industry

Victoria has 2600 registered bee-keepers, 400 of whom are commercial operators, either full-time or supported by other work; most of the balance have only a few hives. All owners of hives must be registered with the Department of Agriculture and Rural Affairs. A number of the commercial operators live in or close to the Mallee area.

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 bees can build up their stocks of pollen and honey. The public lands of the Mallee area are important in this regard, as they provide for both honey production and the overwintering of hives.

Public lands of the Mallee are important for the overwintering of bees.

Winter is a dangerous period for hives unless proper husbandry techniques are practised. Hive activity slows down with the cooler weather, and harvesting of the few eucalypt species that do flower is hazardous, as higher water contents in the nectar can cause hive fermentation and a consequent loss of bees through alimentary upsets.

Carrying of hives through the winter, called overwintering, can be achieved either by ensuring that the hives retain adequate food reserves of honey and pollen beforehand, or by moving them to warmer areas with winter-flowering species.

In the Mallee the combination of a mild winter climate and an abundance of pollen-bearing species during that season enables bee populations to be maintained and kept healthy. In this way, apiarists can bring their hives to full strength prior to moving them to sites that provide for late spring and summer honey production.

As at May 1987, 313 bee sites, held by about 100 licensees, were current in the study area, of which 92 were permanent. More than two-thirds of the sites are occupied by apiarists based outside the Mallee area.

Honey flora of the Mallee

A range of important nectar-producing plant species here flower at different times throughout the year, enhancing the region's value to the apicultural industry (see Table 16). Stands of desert banksia in the heaths of the Big Desert are low producers of honey, but the high yields of pollen from this winter-flowering species make it important for maintaining hive vigour through the winter.

Table 16

HONEY FLORA

Common name	Scientific name	Flowering times	Seasonal production of honey (kg) per hive	Pollen production
White mallee	*Eucalyptus gracilis*	August--November	40--55	None
Yellow mallee	*E. incrassata*	September--December	40--55	Good
Grey (Christmas) mallee	*E. socialis*	December--January	27	Fair
Dumosa mallee	*E. dumosa*	February--May	40	Good
Slender-leaf mallee	*E. foecunda*	January--February	27	Good
Acorn (oil) mallee	*E. oleosa*	January--March	40--55	Fair
River red gum	*E. camaldulensis*	November--January	55--80	Good
Black (river) box	*E. largiflorens*	January--February	55--80	Fair
Tea-tree	*Leptospermum laevigatum* var. *minus*	August--October	27	None
Sugarwood	*Myoporum platycarpum*	November	9--14	Good
Ham and egg daisy	*Myriocephalus stuartii*	October--November	9--14	Good
Desert banksia	*Banksia ornata*	April--August	14--18	Good

White mallee and yellow mallee (known locally also as giant mallee) flower during late winter and early spring, and are the first nectar flows utilized after winter.

Tea-tree can be utilized during spring, but, while the nectar flow can result in reasonable honey production, pollen production is negligible. Ground flora, including such weed species as wild turnip and onion weed, are important both to supplement production from the woody species and as a source of nectar and pollen in their own right. The ground flora can be particularly important as a source of pollen in areas where the dominant nectar-producers, such as tea-tree and white mallee, are poor producers of pollen.

Both river red gum and black box are important summer-flowering species. They are consistent producers of nectar and pollen and yield substantial quantities of high-grade honey.

Grey, slender-leaf, and acorn mallee can also attain importance during summer; while dumosa mallee is important in autumn and is usually the last species to be utilized before winter. As the production of honey in autumn requires a considerable energy output by the bees, the high protein provided by desert banksia through the winter revitalizes the hives for the spring.

Areas utilized

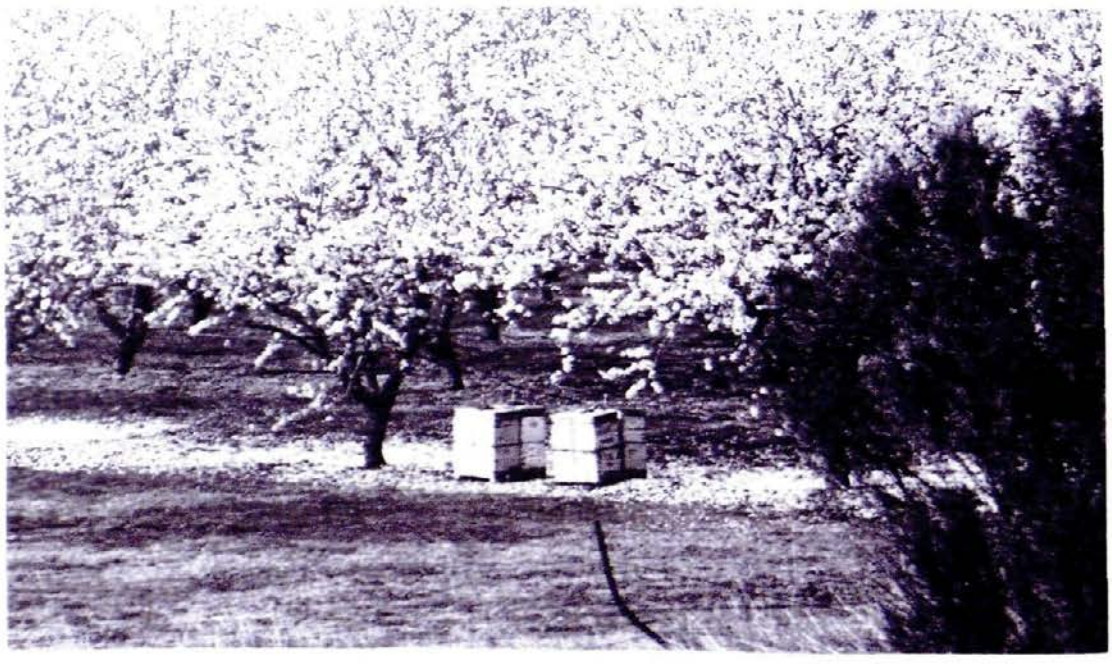
Public lands vary in importance to apiculture according to the honey flora they support. Apiarists view the red gum--black box woodlands along the River Murray as the most important sites for honey production. These areas are easily accessible and provide a consistent nectar flow.

The eastern Big Desert and, to a lesser extent, Sunset Country are sought for their spring- and autumn-flowering mallee species. Improved access into the Sunset Country since the early 1980s has brought more of this into honey production, and apiarists will probably seek it increasingly, particularly if biological control of Patersons curse (*Echium plantagineum*) is introduced.

Much of the banksia-dominated heaths of the Big Desert were badly damaged by the 1980 wildfire and the severe frosts of 1982. Consequently some areas were rendered unsuitable for use in the short term.

The lack of surface water during summer and the difficulty of vehicular access in the sandy terrain have previously hampered the use of the Big Desert and Sunset Country for apiculture, but four-wheel-drive vehicles are now being used to overcome the access problems and small reservoirs of water are transported to the bee sites. In winter, when the Big Desert is extensively used, the provision of water is less of a problem.

Bee-keepers are required by the Department of Conservation, Forests and Lands to take out permanent or temporary bee-site licences to occupy public land for apiculture. A licence allows bee-keepers to use a small area to set up their hives and equipment, and they have the exclusive right to work their bees within a radius of about 1.6 km. Permanent site licences are issued annually and temporary licences are issued for either a 3- or a 6-month period. Current licence-holders are given the option to occupy their sites for the next period. Apiarists frequently lease a number of sites across the region to overcome the problems of variability in the quality and quantity of flowering. While the apiarists may not utilize some of these sites for several seasons, this allows them some flexibility and security.



Bees are used for pollination of agricultural crops - here flowering almond trees are being pollinated.

Pollination services

Apiculture involves mutual benefits in agricultural and horticultural areas, where the bees are used for pollination of fruit and seed crops. The almond plantations in the Mallee currently occupy some 1700 ha and, at maturity, will require about 10 000 hives over the late July to late August flowering period. The production of stone fruits, avocado, rock-melons, and oil seeds such as sunflowers also utilize hive bees for pollination.

Irrigated pastures and lucerne crops between Swan Hill and Kerang also utilize honey bees for pollination; lucerne has considerable export potential, as both hay and compressed cubes for stock in feed-lot situations. Commercially managed bees are also important in pollinating alfalfa seeds to make shoots for human consumption.

Clearing of native vegetation from the readily accessible blocks on freehold land is decreasing the resources available to the industry and increasing the importance of public lands. Although the increase in agricultural weed species helps build up hive vitality in and near farmlands, insecticide sprays are being used increasingly in agriculture and horticulture, further reducing the value of private land to the industry.

Apiculture is compatible with most other uses of public land. However, the extent to which bees may compete with native insects, birds, and mammals for nectar is still not clear. Research in this area has been under way for some 10 years and most projects have utilized honey bee hives, so results are mainly applicable to apiculture rather than to the effects of feral honey bees.

The relatively high density of hive bees in an area, their highly developed system of communication, and their pattern of movement all contribute to honey bees' efficiency at exploiting nectar resources. Competition occurs between honey bees and indigenous fauna such as native bees, beetles, and honeyeaters, which also harvest nectars. Although populations of most of these other species do not appear to be reduced, knowledge of the extent and effect of the competition is limited, mainly in terms of the fluctuations over time in nectar-feeding by both honey bees and native species.

Some evidence suggests that the presence of honey bees changes the foraging behaviour and territorial boundaries of a nectar-feeding bird, the New Holland honeyeater, and reduces the density of native bees in the vicinity of the hives. Other research suggests that honey bees may only harvest nectar when it is very abundant, due to the high energy requirement of their complex societies. There are indications that honey bees are less species-specific during foraging than are native fauna and the resultant cross-pollination may lead to hybridization between native plant species.

The effects of feral bees are also little known. They have the potential to colonize in suitable sites in reference

areas from which apiculture is excluded, they may displace native fauna from tree hollows, or become the carriers of disease.

In the Mallee heathlands, particularly, bee-keepers are pushing tracks into previously untracked country in the search for suitable sites. This leads to the proliferation of tracking in the area and further compromises its wilderness quality. The passage of heavily laden vehicles is also damaging the soft sand roads and tracks of the region, particularly main routes such as the Murrayville--Nhill road.

Under the Council's recommendations, the only areas specifically excluded from apiculture are reference areas. However, because vehicles and bee sites are not permitted in the Big Desert Wilderness, apiculture is also excluded from the bulk of this area. It is the current policy of the management of conservation reserves such as national parks and flora and fauna reserves that apiculture, where it is a traditional use of the area, may continue. However, concern has been expressed that honey bees are an exotic species that use a resource (nectar) in competition with the native fauna and therefore apiculture may be inappropriate in these reserves.

FISHING

Both commercial and amateur netting for fish are permitted in the Lindsay River--Potterwallkagee Creek--Wallpolla Creek anabranch systems of the Murray River. Most of the lakes of the Kerang wetlands, Lake Albacutya (when it holds water), and Lakes Corroong and Hawthorn are also available for this activity.

The main fish species taken commercially are Murray cod, golden perch, silver perch, bony bream, redfin, European carp, and catfish - the bulk being caught from the Murray River environs. Yabbies are also caught commercially in Lakes Albacutya and Walla Walla when these contain water. Additional information on fish and fishing in the study area is provided in Chapters 8 - Fauna and in Chapter 11 - Recreation.

More than 30 licensed commercial fishermen operate in the Mallee streams and lakes; not all of them are full-time, however, and fewer than 15 live in the area.

Most of the commercial fishermen operate on Lake Albacutya at some time when it contains water. Those catching yabbies for resale are permitted to use a maximum of 20 drop nets, whereas amateurs are permitted to use only three nets in commercial fishing waters and up to ten elsewhere.

In 1986, commercial fishermen caught 33 kg of Murray cod from the Lindsay River--Wallpolla River anabranch systems. In addition, they took almost 1330 kg of golden perch, 2330 kg of bony bream, 1280 kg of European carp, and 3 kg of silver perch. No information is available about the quantities of fish caught elsewhere.

A closed season to both the commercial and amateur catching of native cod and perch species in the Murray River and its anabranches applies from late August to late November each year.

TREES ON FARMS

Under the original *Land Act*, settlers in the Mallee were required to leave some 3% of their holdings under native vegetation in locations approved or directed by the Closer Settlement Board.

Strips of native vegetation from 40 to 100 m wide were also retained along certain roads by the then Department of Crown Lands with the object of preventing drift sand from accumulating on roads.

Settlers protested that the scrub areas provided harbour for vermin and weeds. Agitation began for the removal of the vegetation, and in many instances this was permitted. Shire Councils also removed the vegetation from some roads as an experiment in clearing them of sand, some farmers took the opportunity to cut all the scrub from their holdings to extend their wheat-growing areas.

Tree decline is now a recognized problem in many agricultural areas, including the Mallee. Many of the remnant patches of native vegetation, retained at the time of clearing, have declined in quality and diversity. This is due to the impact of rabbits and domestic animals that disturb and compact the soil, graze existing plants, and reduce or eliminate regeneration, as well as to the effects of dryland and irrigation salting.

The southern and eastern parts of the region are those most seriously affected by tree decline. These areas lack the

Tree-planting along roads and wetlands helps to beautify the area.

substantial areas of remnant native vegetation that typify the north and west of the Mallee.

Many landholders have recognized the current decline of farm trees, and are acting independently to reverse the trend on their properties.

The Department of Conservation, Forests and Lands and the Department of Agriculture and Rural Affairs, in conjunction, have helped local people establish farm-tree groups at Manangatang, Ouyen, and Wycheproof. The Departments have promoted tree-planting on farms and roadsides as one technique to tackle land degradation in the region and have assisted in the establishment of demonstration plots as well as providing technical information on site selection and preparation and species selection and establishment.

Trees suitable for the Mallee environment are available from the former Department's Mildura Extension Nursery. Approximately 150 000 plants are now raised annually to meet the demand by the Department, local land-owners, and tree groups.

Various tree-planting and re-establishment assistance schemes, such as the Land Protection Incentives Scheme and the National Tree Program Project, are being used to encourage farmers to undertake plantings. Three farm-tree groups have also been established to promote the value of trees on farms, especially for salinity control and, during the 1986/87 financial year, $20 000 was provided in tree-establishment grants to these groups.

Plantations are used to provide stock shelter, restore wildlife habitat, and combat salinity. One group has established a vegetation corridor between two areas of public land. Another is using slender cypress pine to establish woodlots for timber production. More than 20 organizations or groups have undertaken tree-planting in the Mallee. The Rainbow Primary School, for instance, has planted endemic species on a denuded lunette north of Lake Hindmarsh; at Ouyen the primary school has undertaken planting on a rehabilitated tip site. The Australian Trust for Conservation Volunteers has also been involved in tree-planting near Lake Tyrrell.

There is increasing emphasis on planting species that are native to the region. Indigenous species have the advantage in tree-planting projects of being adapted to local climatic and soil conditions; in turn, they are more likely to provide the best habitat for indigenous wildlife. Local species are also more likely to regenerate naturally, and therefore provide long-term, low-maintenance, self-perpetuating plantations.

Establishment of trees is usually expensive, and this provides an added incentive for the active conservation of remnant vegetation. Natural regeneration can be fostered by fencing to exclude stock or rabbits. Slender cypress pine and buloke seedlings are particularly vulnerable to grazing. The Land Protection Incentives Scheme may meet the full cost of fencing materials, but the landholder is expected to provide labour.

Improved techniques in the direct seeding of tree species have potential for application in the Mallee. Both farmers and government agencies are experimenting with tree-seeding here and this has the potential to substantially reduce the costs of establishment.

Tree plantations have application in the utilization of waste-water from sewage treatment, winery effluent, and irrigation drainage. Current trials include Broken Hill red gum (*Eucalyptus camaldulensis* ssp. *obtusa*), river she-oak (*Casuarina cunninghamiana*), and swamp yate (*E. occidentalis*). Trees have the potential to use large quantities of water over a short time, with the added potential benefits of a long-term economic return from wood production.

References

Badawy, N.S. (1982). Soils of north-western Victoria, their characteristics and significance to local agriculture. *Department of Agriculture, Victoria, Technical Report Series* No.55, April 1982.

Sugden, Dr E. (1986). Research on honey bee environmental impact. *The Australian Bee Journal*, 67 (8).

Torpey, D. (compiler) (1986). "The Way It Was; a History of the Mallee 1910-1949." (Sunnyland Press: Red Cliffs).

13. FOREST PRODUCE

Five main types of forest found on public land in the Mallee area - river red gum (*Eucalyptus camaldulensis*), black box (*E. largiflorens*), mallee (*E. oleosa*, *E. dumosa*, and *E. incrassata*), mallee broombush (*Melaleuca uncinata*), and cypress pine--belah (*Callitris preissii* and *Casuarina cristata*) - have the potential to supply a range of forest products. Licences from the Department of Conservation, Forests and Lands are required for the removal of any produce from public land forests.

Current licensed sawlog production is confined to river red gum forests and woodlands designated as timber production areas and uncommitted lands by the Land Conservation Council in 1977 (indicated respectively by the prefixes E and S1 on Map 8).

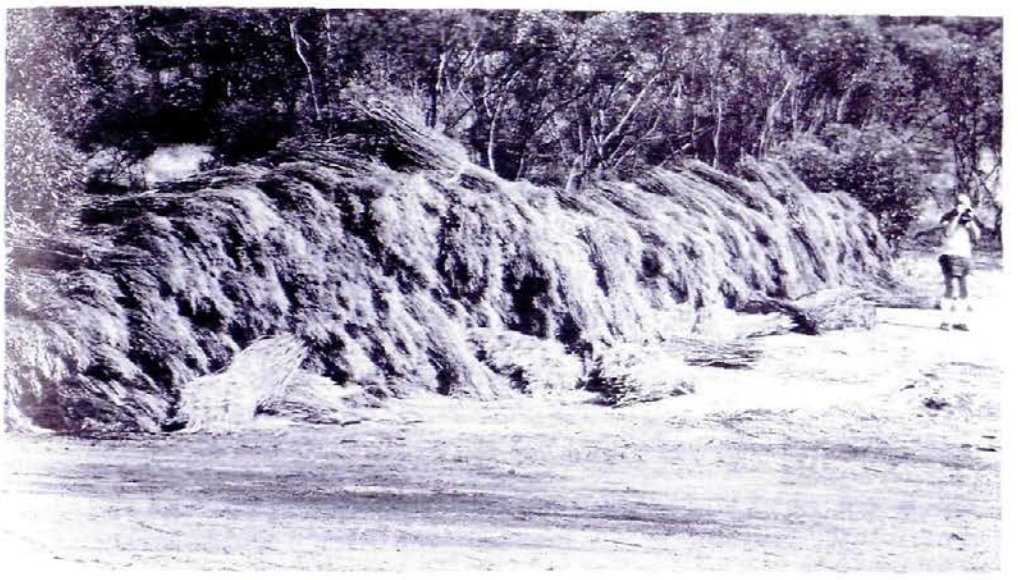
In all, the floodplains of the study area contain some 18 500 ha of river red gum, about 5700 ha of which are included in nature conservation reserves and are not available for harvesting. A further 6100 ha are excluded by management prescription, leaving about 7000 ha currently available for timber production.

Production of railway sleepers from the region's river red gum forests began in the late 1800s, and the last sleepercutter to work in the area retired in 1985 and has not been replaced.

The black box forests previously supplied posts, poles, and farm timbers including vine trellis material, but the Department of Conservation, Forests and Lands has now restricted harvesting pending a reappraisal of the growing stock. Black box forests are usually located on the higher alluvial plains of river and creek frontages and total some 38 300 ha gross within those areas where timber production is permitted (including the Wandella Wildlife Reserve - area D13 on Map 8). A further 15 400 ha gross are contained within nature conservation reserves and are not available for timber production.

The bulk of public land in the study area carries mallee growing on a variety of soils and land forms, in broombush pure stands or in mixture with other plant species.

Licensed harvesting of mallee broombush occurs in the western portion of the study area within uncommitted land, while fuelwood is obtained under permit from the riverine forests (river red gum and black box) by both commercial operators and local householders, mainly for domestic consumption. A small quantity of charcoal is also produced, and about 1700 ha of mallee scrub are available for eucalyptus oil production.



Licenced harvesting of mallee broombush occurs in the west of the study area.

Historically, the durable timbers of slender cypress pine and belah have been highly sought after for post and pole material. As a consequence of previous harvesting, fire, drought, and insect attack, and the impact of grazing by rabbits and stock on subsequent regeneration, suitable stands of these trees have diminished. Cutting of either species is no longer permitted in the study area by management prescription.

Sawn timber

Sawlogs are obtained from the river red gum forests growing along the Murray River and associated floodplains. Sawn

River red gum sawlogs are harvested from the forests abutting the Murray River.

products - including timbers for housing, landscaping (more than 50% of the output), and furniture and for fence posts - are marketed in Melbourne (50% of output), Adelaide (30%), and locally - including the South Australian riverland, Robinvale, and Horsham. As an additional local use, red gum provides timbers for paddle-steamers.

Only one sawmill - Merbein Sawmills Pty Ltd, located at Yelta, 15 km north-west of Mildura - is at present licensed to harvest river red gum sawlogs from the study area. It currently holds a licence for 2750 cu.m of logs from public land, subject to the availability of this material. Over recent years the average annual volumes actually harvested have been:

- 1800 cu.m of sawlogs - including low-quality material used for such products as gardening and landscaping timbers
- 190 cu.m of other round timbers that do not meet normal sawlog standards and are used to produce railway sleepers

In accordance with the government's Timber Industry Strategy, the volume of timber harvested will be set at sustainable levels and a long-term licence will be issued. Current estimates of the area of available river red gum forests in the region and growth rates indicate that the present average annual harvesting level can be sustained. However, an assessment of the available timber resource is being undertaken by the Department of Conservation, Forests and Lands and, together with future government decisions on land use, will be the basis for determining the sustainable level of sawlog production and the granting of long-term sawlog licences.

Merbein Sawmills Pty Ltd also obtains logs from private land and from State forests in New South Wales. It employs 29 full-time and 3 casual staff.

Stands of river red gum suitable for timber production are dispersed along the floodplain of the Murray River. Important areas lie between Colignan and Karadoc and young stands with high growth potential occur upstream of Wemen. Stands on Lindsay and Wallpolla Islands are also well suited to timber production.

Areas excluded from harvesting by prescription

More than 6000 ha of river red gum forest are excluded from timber harvesting through prescriptions in order to protect natural and cultural values.

Prescribed areas include those within:

- 60 metres of the high bank of the Murray River
- 40 metres of the high bank of major creeks or anabranches
- 20 metres of the high bank of major billabongs

- 60 metres of areas of recreational, environmental, or historical significance

In addition, individual trees are not harvested if they are:

- likely to damage regeneration if felled
- of particular value for wildlife habitat - due, for example, to the presence of hollows
- seed trees on areas not stocked with regeneration
- Aboriginal canoe trees or other significant trees
- located on high ground above the floodline

River red gum silviculture

Silviculture - the science of cultivating forest crops - is concerned with all aspects of harvesting forest produce and of regenerating and treating the forest.

River red gums can produce tall straight-boled trees when growing in relatively dense stands, but have a tendency towards heavy branching and short bole lengths in open stands. Water availability is the main criterion determining growth and they survive in the semi-arid climate of the Mallee because of flooding by the Murray River. Trees on good sites can grow in diameter at a rate of a centimetre a year and may achieve a height of some 50 m. In terms of total volume production, the mean annual increment may be up to 6 cu.m per ha on the best sites, but sawlog growth rates of 0.3 to 1.5 cu.m per ha. per annum are more usual.

Regulation of water flows in the Murray River, however, has altered the flooding regime and the silvicultural system used has been modified to take account of this change.

The harvesting method used depends on the location and characteristics of the particular stand of trees - particularly their numbers and age. Individual trees or small patches may be felled, but generally at least 50% of the trees in an area are retained.

A receptive seed-bed is prepared by burning the crowns of felled trees or by minor cultivation. Regeneration normally occurs following seasonal flooding. The seed for regeneration is supplied either from trees retained around the patch or by direct hand seeding; on occasions, planting of seedlings may be necessary. The regeneration method employed is determined following an assessment of the rate at which the area has regenerated naturally.

Thinning of river red gum regeneration enhances the future productivity of the mature forest, and the material removed has potential to produce posts and poles (although there is little interest in this resource at present) and firewood.

Logging residues (chiefly branchwood and excessively defective boles) may be used for firewood and, in some cases, posts or poles and charcoal. Some of this material was recently billetted and chipped for the landscape-gardening

market. Burning of logging residues as a means of achieving successful regeneration, however, is considered locally to be of greater value than the small returns possible from its sale for domestic consumption. In addition, debris on the ground provides important faunal habitat.

Generally, the future productivity of the river red gum forests depends on the provision of the appropriate flood regimes to maintain their health and vitality.

Flooding and red gum forests

The vigour and regeneration of river red gum are closely linked with periodic floods, and the timing and duration of flooding is critical to seedling establishment. A wetting and drying cycle is also essential for the viability of many of the riverine wetlands.

Flood regimes of the Murray and its effluent streams have changed over the last century as a result of river engineering and regulation works. There has been a decline in fre-quency, intensity, and seasonality of floods, reducing the potential winter/spring flows. Effective flooding of the riverine forests, woodlands, and wetlands now only occurs in years when winter/spring rainfall is above average. When floods do occur, drainage of the low-lying forests may be delayed - the water receding in summer rather than spring.

The major impoundments affecting river flow and seasonal flooding lie upstream of the study area. However, six weirs and locks, established to maintain river height for irrigation and navigation, are located adjacent to the study area. The weirs are managed to minimize variations in the level of the river. Weir pools, immediately upstream of the locks, have permanently flooded small areas of forest, and trees have died as a consequence.

Investigations by the Department of Conservation, Forests and Lands have indicated that the change in flooding pattern is causing a shift in plant species distribution. River red gum is colonizing wetlands that were regularly flooded prior to river control. Most of these wetlands are close to the river and are now flooded infrequently. The species is declining from some of the more elevated areas that it occupied prior to regulation and black box is replacing the red gum, but it too is contracting from its former upper limit. However, no significant change in the total area of forest is expected, although site productivity may decline. These trends are similar to those observed in the Barmah Forest - upstream of the study area.

Railway sleepers

At the turn of the century, the rapidly expanding railway system placed heavy demands on the river red gum forests of the Murray River for railway sleepers.

Two sleeper-cutters were still operating in the study area in the 1970s and in 1976/77 they produced 4758 sleepers.

Only one cutter continued to work here from 1981 to 1985 and in the last year produced 938 sleepers. Production of sleepers from the Mallee areas ceased in 1985 when the last cutter retired.

The use of concrete railway sleepers is increasing, but there is a continuing need for timber sleepers to maintain existing rail lines because it is impracticable to use both types of sleeper in the one length of track. Approximately 6000 timber sleepers will be required to relay 20 km of the Mildura--Yelta line. At present, supplies may be drawn from outside the study area - the nearest source is Balranald in New South Wales - or may be produced by the sawmill at Yelta if this is more economically attractive than other markets for sawn timber.

Mallee broombush

Production of broombrush is a recent and significant forest product enterprise. Whole stems of mallee broombush (*Melaleuca uncinata*) are harvested, bundled, and sold to consumers both in Victoria and South Australia for use in domestic fencing, shade-house construction, and feature ceiling panels, and as wind-diffusing material for tennis courts.

Mallee broombush is an erect multi-stemmed shrub, 1 to 3 m high, arising from a lignotuber. The lignotuber - a conspicuous swelling at the base of the stem, at or below soil level, bearing dormant buds - is a feature of myrtaceous plants. This adaptive feature has survival value, as the development of the buds into suckers is stimulated by destruction or loss of top growth through fire, frost, or mechanical damage.

The species grows in discretely scattered stands, either alone or in association with broom baeckea (*Baeckea behrii*), usually on siliceous sands overlying a clay subsoil - where the surface soil is damp for several months during winter. It readily shoots from ground level after firing, but can be killed by ploughing. The plant has no pastoral value as it is not grazed by stock. Flowering occurs during spring to early summer.

The extent, location, distribution, and condition of Mallee broombush stands here have not yet been fully documented. However, the vegetation surveys undertaken for this resources report will greatly facilitate an assessment of the broombush resource and major stands are indicated on Map 10 - Floristic Vegetation.

Stands of broombush are located by the broombrush-cutters sometimes on foot, often by driving 'cross-country' in tractors - who then develop access tracks to the sites. They cut the stems by machete or power saw about half a metre above the ground, tied them into 20-kg bundles, and cart them away on large trailers pulled by tractors or four-wheel-drive trucks. Plants about 10 to 30 years old are harvested, and larger plants and associated species are left standing unless inadvertently crushed or damaged during the harvesting operation.

Bundles of mallee broombush on their way to market.

In the south-eastern Big Desert, one licensee used a tractor-mounted mechanical broombrush-harvester. The effects of this operation are being evaluated by the Department of Conservation, Forests and Lands, but observation suggests that cutting is less selective and inflicts considerable damage on non-target species.

Five commercial licensees currently operate in the Mallee, employing about 18 people. Small quantities are also cut under licence for local use, and some illegal harvesting is suspected to occur.

Licences restrict the number of cutters who may operate under each licence, set the allowable cut and the area in which harvesting may take place, nominate the royalty applicable, and specify fire-protection requirements. Licensing also requires the lodging of deposits to cover the licensee's *'bona fides'* of operation and requires them to bring their production to account by the most suitable verifiable method.

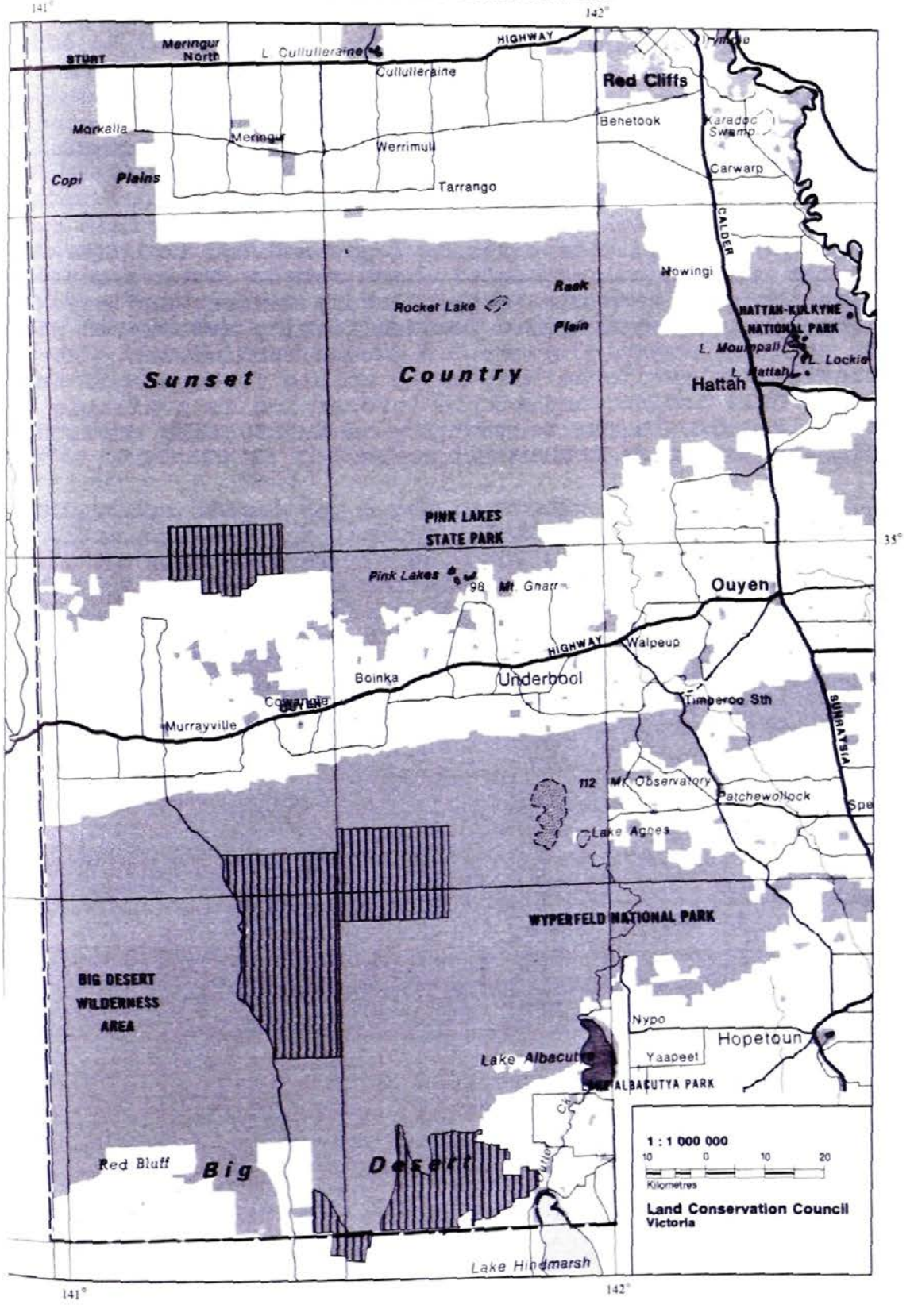
Broombrush cutting occurs within three main districts: in the south-west section of the Sunset Country (17 500 ha); central Big Desert, east of Murrayville Track (77 500 ha); and the south-eastern section of the Big Desert (34 000 ha). These are indicated in Figure 24.

In addition, cutters frequently switch their activity from the Mallee districts to private property and between South Australia and Victoria. The quantity of broombrush from these sources used in Victoria is unknown.

Broombrush is measured by weight or, more usually, by number of 20-kg bundles. Since 1977, 456 484 bundles or approximately 9130 tonnes of broombrush have been reported to be cut under licence within the Mallee. At present, the total allowable annual cut here is 47 800 bundles or 956 tonnes. There is no mechanism at present to determine the amount of broombrush cut illegally.

Figure 24

BROOMBUSH HARVESTING



Land currently available for broombush harvesting.

Public land

Economic broombrush areas typically yield between 3.5 and 5.7 tonnes per hectare and it is estimated that since 1977 some 1600 to 2600 ha net have been harvested, while the annual harvest covers between 170 and 273 ha.

Broombrush from the southern Sunset Country and northern Big Desert is sold in Adelaide, that harvested from the southern Big Desert is sold in Melbourne. Brush fencing is erected as pre-fabricated panels or packed on site. Brush panels are fabricated at a factory in Kaniva.

As a fencing material, broombrush is four to five times as expensive as an equivalent paling fence and two to three times the cost of colour-bonded sheet metal. Consequently it competes more with wire mesh, feature timber, and brick, and its use is restricted to feature fencing associated with front gardens, swimming pools, or garden subdivision. No statistics are available that would enable forecasts of demand for this product and little information is available that would indicate the feasibility of cultivating broombush on private land on a commercial scale.

Some concern has been expressed about the impact broombrush-cutting is having on floristic, faunal, and wilderness values of the public land found here. This concern is largely based on the premise that the distribution, extent, age-classification, condition, regeneration requirements, and growth rates of broombush and its associated plant species are not known. A recent study on the effects of brush-cutting on certain vertebrate fauna found that, while harvesting has had little serious impact on the status of those vertebrate species studied, it led to short-term changes in species composition and abundance - for example, in such species as malleefowl, which requires stands of old broombush.

A site recently harvested for broombrush.

The clearing of access tracks and stock-pile areas associated with cutting has considerable impact within the site and on the main access tracks, and the proliferation of tracks intruding progressively into previously untracked parts of the Mallee is compromising wilderness value.

Fuelwood

The forests of the Mallee, particularly the river red gum and black box forests, have been, remain, and are expected to continue as significant suppliers of fuelwood.

Development of river-boat transport gave rise to the first large-scale use of the forests for fuelwood production. The paddle-steamers that plied the River Murray consumed substantial quantities of fuelwood - estimates suggest that an average steamer burnt half a tonne of fuelwood an hour in its boilers.

After the 1880s various irrigation schemes replaced the paddle-steamers as the main consumers of fuelwood, which was

Large quantities of fuelwood were consumed to fire irrigation pumping stations located on the Murray River.

used to fire irrigation pumping stations located on the river. Other industrial uses for fuelwood included wine distillation, brick-making, hospitals, bakeries, fruit-packing sheds, and abattoirs. Liquid fuels have now replaced wood for most industrial purposes, leading to a decline in the demand for fuelwood.

Today, fuelwood is cut by both commercial operators and private individuals, with commercial operators rarely exceeding 60 cu.m per annum. During 1986 some 1000 licences were issued for both commercial and domestic cutters, producing about 2800 cu.m.

Most of the fuelwood is cut from fallen or dry timber found within the riverine forests and is therefore predominantly river red gum and black box. Such fuelwood is found in

abundance within these forests - mainly as a consequence of past sawlog-, sleeper-, and post-cutting operations, although there is a paucity of suitable material near the larger urbanized areas of the Mallee. Only limited gathering for domestic use is permitted near Mildura, Robinvale, and Swan Hill. Chapter 8 - Fauna - discusses the value of debris on the ground for wildlife habitat.

The Department of Conservation, Forests and Lands has ceased to issue licences for the cutting of live mallee for fuelwood from public land. The cutters operated in large grazing blocks south-west of Morkalla. This is no longer permitted because the large mature mallees they prefer are valuable wildlife habitat.

Many householders in the central and southern Mallee obtain their fuelwood in the form of 'mallee roots' (the lignotuber of mallee eucalypts). These are mostly obtained from land-clearing operations, and some mallee roots are sold in Melbourne.

It is expected that due to rising costs of other domestic fuels, coupled with the development of efficient solid-fuel burners, fuelwood production from the forests of the Mallee will continue to increase in importance.

Other forest products

Charcoal, a major fuel source in developing countries, has an advantage over firewood because of its much-reduced weight per unit of energy output. In Australia, at present, it is used only in specialist industries as a source of carbon or in the production of certain filters. One small-scale commercial producer operates upstream of Robinvale at Boundary Bend, utilizing dry river red gum residue.

In 1977, the Council recommended that an area of about 1700 ha be set aside south of Berrook (south-western Sunset Country) for eucalyptus oil production. The small industry working here suffered mechanical problems in 1982 and there is currently no licensed harvesting of mallee eucalypts taking place in the study area.

When the irrigation areas were being settled, several hundred thousand fence-posts were cut from the black box forests of the study area each year. This rate reduced to about 75 000 pieces annually in the early 1980s. Production from the forests is now restricted, pending a reappraisal of the growing stock.

New South Wales forests

The riverine forests found across the River Murray on New South Wales Crown land have shared a similar history.

In early settlement days they formed part of grazing runs or leases. Large areas of the River Murray floodplain here were ringbarked and converted into poor grasslands, which in nearly all cases were severely overgrazed. As the need for retaining forest lands as such was realized, some areas were

made timber reserves and, during the period 1917 to 1922, some of these reserves were dedicated as State forests.

Exploitation of these New South Wales riverine forests commenced in the latter half of last century. A shortage of durable hardwoods in Victoria, combined with the presence of the river system for water transport, resulted in the establishment of a milling industry. Mill logs were obtained mainly from the area immediately adjoining the river, both because of the easier access and the better-quality trees there.

Tree-fellers operated on the basis of single-tree selection, without regard to good forestry practice. In fact, until 1948, forestry activities in the Mildura district of New South Wales were primarily oriented towards revenue collection.

As in the Victorian Mallee area, the development of various irrigation schemes saw large quantities of fuelwood harvested to generate energy for irrigation pumps, wine-distillation plants, fruit-packing industries, abattoirs, brick-making, and domestic use. Round timbers were harvested extensively for use in fencing and the development of vineyards. These uses dominated the output from the New South Wales riverine forests, but their significance has declined over time and sawlog-production is now the major timber activity in the forests.

Today the State-owned riverine forests that abut the northern bank of the Murray River are managed by the Forestry Commission of New South Wales under its Mildura Management Area Management Plan 1982--92. Merbein Sawmills Pty Ltd is licensed to cut up to 5560 cu.m annually from these forests.

References

Ferguson, I.S. (chairperson) (1985). "Report of the Board of Inquiry into the Timber Industry in Victoria". (Government Printer: Melbourne). (Also Transcripts of Proceedings before the Board.)

Forestry Commission of New South Wales (1985). "Management Plan for Murray Management Area". (Government Printer: Sydney.)

Government of Victoria (1986). "Victoria Timber Industry Strategy". (Government Printer: Melbourne.)

14. MINERALS AND STONE

The known mineral and stone resources of the study area that are currently being exploited include sandstone, limestone, granite, gypsum, salt, and clay.

In 1977, the Council provided for the separate reservation of land for the extraction of clay, crystalline gypsum, and powdered gypsum (copi) (areas N1, N2, and N3 respectively on Map 8), and recommended that salt extraction be permitted from salt lakes and pans on uncommitted land as well as from two of the lakes in the Pink Lakes State Park.

Mineral exploration

This activity undergoes constant and often rapid evolution and change. New ideas and concepts on ore genesis develop and these, backed by changing technologies, lead to constant re-evaluation of prospective areas. Tied in closely with this is a basic tenet of mineral exploration - that mineral deposits currently regarded as uneconomic may become economically viable in the future, and some minerals not used at present may one day become important.

The new concepts and technologies have led naturally to investigations of land away from known mineralized areas. The search for hitherto-unsuspected ore bodies is now an important element in many mineral exploration programs.

Mineral exploration is a high-cost and high-risk activity. If a substantial ore body is found it can produce a great economic return, but the chance of such a find is low. Victorian experience shows that, since 1965, about 1500 mineral exploration licences have been issued in the State and, although a number of mineral deposits have been discovered, only one, the gold-mine at Stawell in western Victoria, has come into production. Detailed investigations are well advanced at several of the State's former gold-mining areas, however, as well as at a base-metal prospect near Benambra, and at a heavy minerals sand deposit near Horsham.

In this study area the major work being done by mining companies is exploration. As at February 1987, 22 operational exploration licences were current, about 10 of which cover some public land. However, most of the area covered is private land. In addition, applications were current for a further 12 exploration licences that also include some public land. The total area included in mineral exploration licences and applications is indicated on Map 4.

The continuing interest in mineral exploration in the Mallee area is due to the presence of geological environments known to be favourable for the occurrence of mineral and/or hydrocarbon deposits. These are being investigated by explora-

tion techniques including geological mapping, geochemical and geophysical surveys, and, in places, drilling.

The Mallee area has not previously been recognized as having high mineral potential, although evaporites such as gypsum and salt have been extracted for many years and the value of groundwater has long been acknowledged.

Since 1974, C.R.A. Exploration Pty Ltd has located substantial reserves of brown coal in the Renmark Group of sediments in the Kerang area. The overburden on these deposits is deep and the coal is not at present economically attractive.

C.R.A. has also located considerable deposits of heavy mineral sand in the Parilla Sand - first noted during groundwater investigations. The company is currently assessing a deposit of this material near Horsham in the Wimmera. Minerals in these sands include ilmenite, leucoxene, anatase, rutile, zircon, and traces of 'rare earths'.

The widespread occurrence of the Parilla Sand in the Mallee gives good prospects for finding further deposits of heavy mineral sand, as this material is known to occur in a number of bore holes and outcrops. An application from Balmoral Resources N.L. for a Development Lease on this unit is current for a site north-east of Lascelles.

The younger stratigraphic units derived from the Parilla Sand, such as the Lowan Sands, also have some potential for the occurrence of heavy mineral sand.

During the last 10 years, the amount of information about the pre-Tertiary deposits has increased, although this knowledge is currently confined to relatively widely spaced bore holes and to geophysical surveys, in particular gravity and aero-magnetic investigations (Figure 7). These indicate that the basement rocks beneath the Cainozoic rocks have been block-faulted into several poorly defined, relatively small basins containing sediments that have good potential for hydrocarbon deposits (oil and gas). One company (Continental Resources N.L.) is currently engaged in exploration for such deposits. There is also some possibility that black coal may be present.

A marked geophysical anomaly detected by both gravity and aeromagnetic means is interpreted as the extension of the Stavely greenstone belt beneath the Cainozoic sediments (Figure 7). This feature has a high potential for the occurrence of minerals such as gold, base metals, and chromium.

Recent detailed groundwater investigations have shown that the highly saline groundwater of the Parilla Sand is both acidic and oxidized. Under these conditions, it can readily mobilize and transport metal ions that are subsequently precipitated at the discharge areas. Although the only metals so far identified at such areas are iron and radium, others - including copper, silver, uranium, and nickel - could occur, depending on their availability upstream in the basin.

Concentration of these metals at the source may be very low, but, as saline conditions have prevailed in the area for at least 500 000 years, the potential exists for a significant deposit of this type.

Considerable expansion of information about mineralization of the region will continue as more detailed exploration is undertaken.

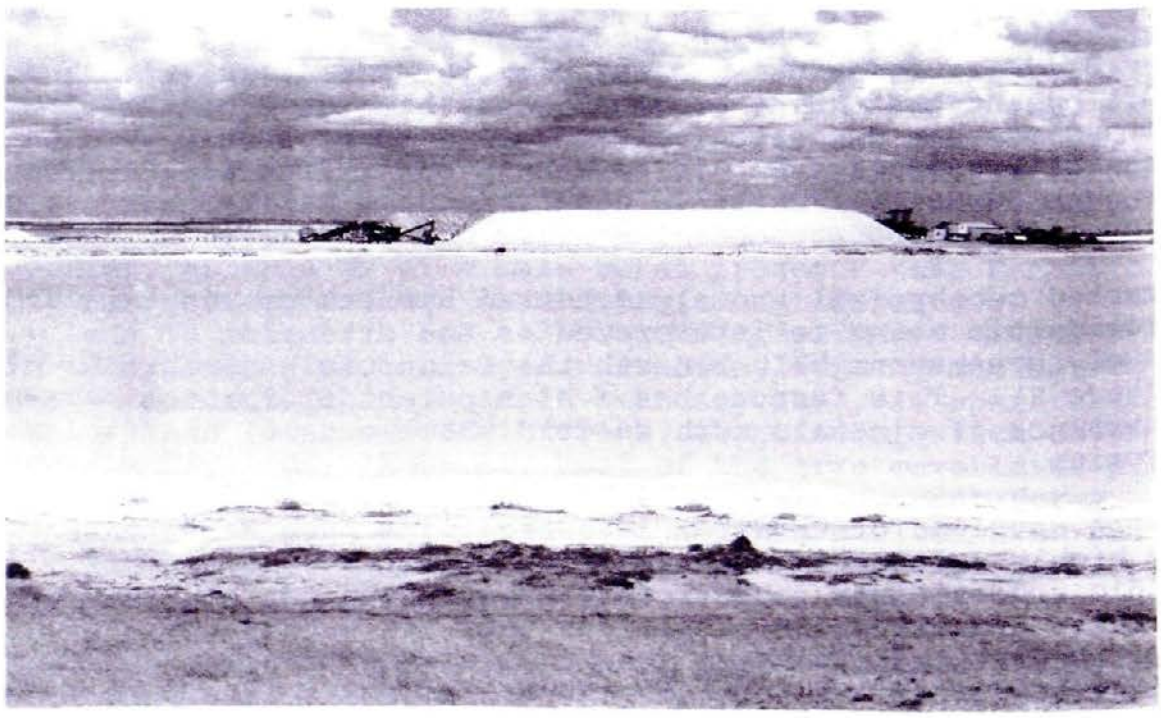
Salt

The harvesting of common salt (halite) from the many saline lakes and salt pans of the study area commenced soon after the turn of the century.

Commercial salt-harvesting began in the Pink Lakes, for instance, in 1916 - using shovels and wheelbarrows, then horse-drawn scrapers and tip drays. In the 1920s a rail line was built from Linga to Lake Becking, but this proved to be unsuccessful. Camel teams from Broken Hill were tried in 1922 and at one time 12 teams of 20 camels were operating. Salt-harvesting from these lakes has now ceased, but salt stock-piles are still evident on the edge of Lake Crosbie.

The bulk of salt-harvesting now takes place at Lake Tyrrell. When washed, this salt is of good chemical quality and is used largely by industry for the production of chlorine and caustic soda.

During winter the lakes or salinas are partially filled by rising groundwater rich in sodium chloride, which is precipitated as the water evaporates during summer. Salt is harvested both in its naturally occurring form directly from the lake-bed and from specially prepared crystallizing areas



Salt is harvested from salt lakes on public land.

in which salt from the lake dissolved by winter rains is recrystallized under controlled conditions during the spring and summer months.

Underground brine reserves also exist in the area, but these have not been commercially exploited.

Cheetham Salt Limited produce salt from its licensed areas, which extend out from the mid-western and south-western shores of Lake Tyrrell. Operating as Sea Lake Salt Pty Ltd, this company has harvested up to 50 000 tonnes annually and expects to produce 60-70 000 tonnes in 1987/88 and 120 000 tonnes in 1988/89.

Cheetham Salt Ltd has applied for a further three licence areas in the region:

- Lake Daytrap (north of Lake Tyrrell), from which some 4700 tonnes of salt were harvested in 1983/84 by a previous licensee
- Lake Hardy (Harding), within the Pink Lakes park, from which 172 tonnes were harvested in 1975/76
- Lake Sunraye

Hattah Salt Pty Ltd has recently established evaporation pans on Spectacle Lake, west of Hattah, and, although production for 1985/86 would be only about 340 tonnes, estimates an annual production rate of 3000 tonnes in the future.

All salt harvested on public land is carried out under a lease or licence issued by the Department of Conservation, Forests and Lands.

Gypsum

The highly saline groundwater is also the source of the Mallee's widespread gypsum deposits. This mineral is deposited by fractional crystallization within the capillary fringe above the water table, provided this lies about a metre below the ground surface.

As a result of the on-going process of fractional crystallization, a layer of coarsely crystalline gypsum about a metre thick has formed within the sediments underlying the gypsum playas or claypans (Yamba Formation). The time taken for this layer to develop has not been determined, but is probably of the order of thousands of years.

Gypsum also occurs as an efflorescent deposit on the surface of the playas. This whitish fluffy or crystalline powder forms as the capillary water evaporates. It is typically mixed with clay and/or sand and is called 'gypsite' or, locally, 'copi'. Wind action concentrates this material into low dunes or ridges called 'copi islands'.

Because of their limited thicknesses, both crystalline gypsum and copi are mined over extensive areas. Extraction

Gypsum deposits are mined over extensive areas - west of Rocket Lake.

is by open-cut. Near Nowingi crystalline gypsum is washed before being transported from the area to be used in the manufacture of plasterboard, and that from near Tutye is used for cement manufacture. Less-pure crystalline gypsum and copi are used for agricultural purposes such as soil-conditioning, paving, and the production of cement.

As gypsum is a mineral, it is extracted under the provisions of the *Mines Act* 1958, either from mining leases or Miner's Right claims.

Currently, 16 mining leases for the extraction of gypsum cover about 1130 ha of public land in the Mallee area, and 27 cover some 1150 ha on private land. Of four Miner's Right claims in the Mallee, two, covering 2 ha, occur on public land, while those on private land cover 6 ha. In addition, a 400-ha mining area licence over public land provides for the storage and treatment, but not the extraction, of gypsum. No surveys have been undertaken to determine the extent or quality of gypsum on either private or public land.

On Map 8 - Public Land Use - the areas of public land approved in 1977 for the extraction of gypsum are indicated by the symbol 'N2'. They are located west and south-west of Nowingi, and near to and north-east of Cowangie. West of Piangil, a 200-ha block of public land (N3 on the map) was set aside for the extraction of copi. In addition, in 1977 the Towan Plains (G22 on Map 8) were covered by a mining lease for the extraction of copi, but, because of the high conservation values of the area, the Council recommended that the area become a flora and fauna reserve. It recom-

mended that the mining lease not be renewed but a new lease be issued for the adjoining uncommitted and private land. The government accepted the recommendation for the flora and fauna reserve, but modified the recommendation to allow the lease area to be worked out.

A number of important plant species have been recorded growing on the gypsum-rich soils of the Raak Plain near Nowingi and a flora reserve has been set aside in this region - G34 on Map 8.

Table 17 includes information on the licensed production of both crystalline gypsum and copi from the study area during 1985/86. During this period, production was reported from only 22 of the 43 mining leases in the area.

Stone

'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 industries fall into two main categories for the purposes of licensing and regulation - non-commercial and commercial operations. When municipal bodies or the Road

Table 17

MINERAL AND STONE PRODUCTION
(Year to 30 June 1986 - cubic metres)[1]

Material	Public land	Private land
Granite[2]	-	30 000
Sandstone[2]	-	38 300
Crystalline gypsum[2]	56 200	-
Gypsite (copi)	4 900	22 400
Calcrete and gravel	92 200	233 800
Sand	-	1 500
Filling[3]	-	83 800
Limestone		95 900
Loam	900	56 900

Notes:

1. Where appropriate, information has been derived from returns to the Australian Bureau of Statistics, from royalty payment data of the Department of Industry, Technology and Resources, and from information provided by the Department of Conservation, Forests and Lands. Volumes have been rounded to the nearest 100 cu.m.

2. Production here is that under the provisions of the *Mines Act* 1958 and the *Extractive Industries Act* 1966.

3. 'Filling' as described by the Australian Bureau of Statistics is any mineral material other than gypsum, gravel, sand, crushed and broken stone, earth and soil, salamander or scoria; it may include rubble and overburden.

Construction Authority make non-commercial extractions they are not subject to leasing or licensing under the *Extractive Industries Act* 1966. They must, however, comply with the health and safety provisions of this Act. Non-commercial extraction may take place under a range of Acts, including the *Land Act* 1958, *Local Government Act* 1958, *Forests Act* 1958, and *Country Roads Act* 1958. As with commercial extractions, all operations less than 2 m in depth and more than 0.2 ha in extent are subject to the *Soil Conservation and Land Utilization Act* 1958.

Extraction for commercial purposes on both public land and freehold land is subject to the provisions of the *Soil Conservation and Land Utilization Act* 1958 for excavations less than 2 m deep and more than 0.2 ha in extent, and subject to the *Extractive Industries Act* 1966 for excavations deeper than 2 m. Operations less than 2 m deep on reserved Crown land are also subject to the provisions of the *Land Act* 1958, while extractions of any depth in reserved forest are subject to the *Forests Act* 1958.

The question of licensing of extractive industries on public land is being reviewed during the preparation of the new *Lands Act*.

Table 17 details the quantities of minerals and stone extracted from both public and private land in the Mallee area. Extraction under the *Extractive Industries Act* 1966 is taking place at only four sites here - one near Lake Boga for granite, the others for sandstone.

Calcrete, a hard limestone formed in the subsoil by soil-development processes under semi-arid conditions, occurs at several levels close to the surface in the Woorinen Formation. It has limited thickness (less than 2 metres); as a result, to obtain significant volumes of material, the operators must cover large areas.

Calcrete and gravel for road-construction purposes are extracted by local municipalities and State government instrumentalities from a large number of pits on both private and public land and, in the year to 30 June 1986, almost 326 000 cu.m were excavated in the study area. Six major pits are located on public land in the Parishes of Mildura and Bumbang and yielded some 92 100 cu.m in 1985/86.

Sandstone, consisting of the weathered zone of the Parilla Sand, is quarried from numerous pits on private land, mainly located in the south-east of the area where it outcrops or is close to the surface. It is used as a base course for roads.

The one small outcrop of granite within the study area is on freehold land near Lake Boga, and represents the only exposure of igneous rock within the area. This granite is quarried and crushed and is an important source of aggregate.

In 1977, the Council also made provision for more than 20 ha of land to be available for the extraction of clay (from the

Blanchtown Clay) for brick-making at Merbein (N1 on Map 8). Little use has been made of this resource in the interim.

In addition, almost 58 000 cu.m of loam (soil) were extracted from a number of localities in the Mallee area for the 1985/86 year, some 900 cu.m being derived from public land in the Shire of Mildura. The loam is used for landscaping in public and private gardens.

Reclamation of Mining Sites

Past mining and stone-extraction activity has left a legacy of abandoned quarries and gravel pits. Some 160 unreclaimed gravel- and clay-extraction sites occupy public land in the Mallee area. They occur on a range of Crown reserves, including State forest and national park.

Abandoned gypsum-mine sites, their overburden dumps, and wash areas are readily visible on the Raak Plain and the number of areas requiring reclamation is yet to be ascertained. In many places reclamation would be hampered by the high water table.

In many places reclamation of abandoned gypsum-mine sites may be hampered by the high water table.

Reclamation aims at returning the disturbed area to its pre-mining capability for the growth of plants. Complete rehabilitation is seldom if ever possible, however, although sites can usually be returned to something like their original landform.

Abandoned, unrehabilitated extraction sites pose both social and environmental problems. They are aesthetically displeasing and harbour vermin and weeds. The revegetation of unreclaimed sites is often slow or non-existent where topsoil or

overburden has not been replaced and, even when reclamation is undertaken, the semi-arid climate means that revegetation is slow.

In its 1977 recommendations, the Council specified that the (then) Mines Department and the mineral lessees of the crystalline gypsum workings devise and implement a method of spreading the overburden and possibly the washed fines into the excavations left by the mining. This is now undertaken by using a drag-line to draw overburden, that has been pushed to one side onto unworked land, back into the worked-out pits. The washed fines, however, contain a high percentage of gypsum and it is thought that, with further processing, they could be a valuable source of agricultural gypsum.

At Towan Plains, the areas from which copi has been extracted are scarified or contour-ripped and the previously stockpiled overburden is spread over the prepared site. No replanting is undertaken.

The Council also proposed guidelines, which should apply to all extraction sites from public land and which stipulated that all extraction sites should be fully rehabilitated where possible. Provisions for rehabilitation of extraction sites are contained within the conditions applicable to leases or licences issued under the *Extractive Industries Act* 1966 and *Mines Act* 1958 as conditions of approval for shallow extraction under the *Soil Conservation and Land Utilization Act* 1958.

Payment of bonds by the extracting body provides further incentive for rehabilitation. The cost of bonds is based either on a flat rate, related to the size of the area disturbed, or on the likely scale and extent of earthworks and disturbance. It is expected that the relevant company's budgeting for mining and extractive proposals should incorporate an appropriate rehabilitation component.

Reclamation is an expensive operation. The cost (based on 1986/87 prices, and depending on the scale and extent of disturbance) is estimated to be $100 per hour for equipment operation (back-fill and shaping), and $200 per hectare for revegetation (Department of Conservation, Forests and Lands 1987). The estimated total cost of reclaiming the 165 disused quarries and pits in the study area is $150 000.

The Department and local Shire Councils undertake reclamation of old gravel pits in the Mallee and, over the last 3 years, some 1000 native trees have been planted on gravel-stripped areas. Direct seeding of native species is also being tried.

Current mining and extraction works incorporate consideration of environmental values. They are required to be screened or visually integrated into the landscape. Progressive rehabilitation is encouraged or, where this is not possible, reclamation begins immediately extraction is completed. Where appropriate, a surcharge is incorporated into the licence fee to cover the cost of revegetation.

15. UTILITIES AND OTHER LAND USES

Many utilities occupy public land. They include roads, railways, trigonometric stations, power lines, hospitals, churches, cemeteries, public halls, shire offices and depots, garbage depots, sanitary depots, and sewage treatment works. In addition to these permanent forms of occupancy, periodic use is also made of areas of public land for military training.

Electricity Supply

Two main 220-kV electricity transmission lines pass through the study area - one from the terminal station at Horsham to Red Cliffs, the other from Kerang to Red Cliffs. Their routes are plotted in the base information of the 1:250 000 maps accompanying this report - Maps 7, 8, and 10. Red Cliffs itself is the site of the only major terminal station in the study area. There is no current requirement to extend these facilities.

Distribution of electricity from the Red Cliffs terminal station is by 66-kV subtransmission lines to substations at Merbein and Mildura and a switching station at Hattah. From the Hattah switching station, subtransmission lines run to Ouyen and Robinvale. Swan Hill is supplied with electricity by two lines from the Kerang terminal station. Road reserves carry most of these lines, although part of the Hattah--Robinvale line runs through the Hattah--Kulkyne National Park. Future developments will include the construction of 66-kV lines between Swan Hill and Sea Lake and between Warracknabeal and Hopetoun, rebuilding of the Red Cliffs--Hattah and Hattah--Robinvale lines, and an extension of the Nangiloc--Colignan line to Robinvale. The Horsham--Red Cliffs line has 37-m-wide easements and the Kerang--Red Cliffs line has mostly 52-m-wide easements.

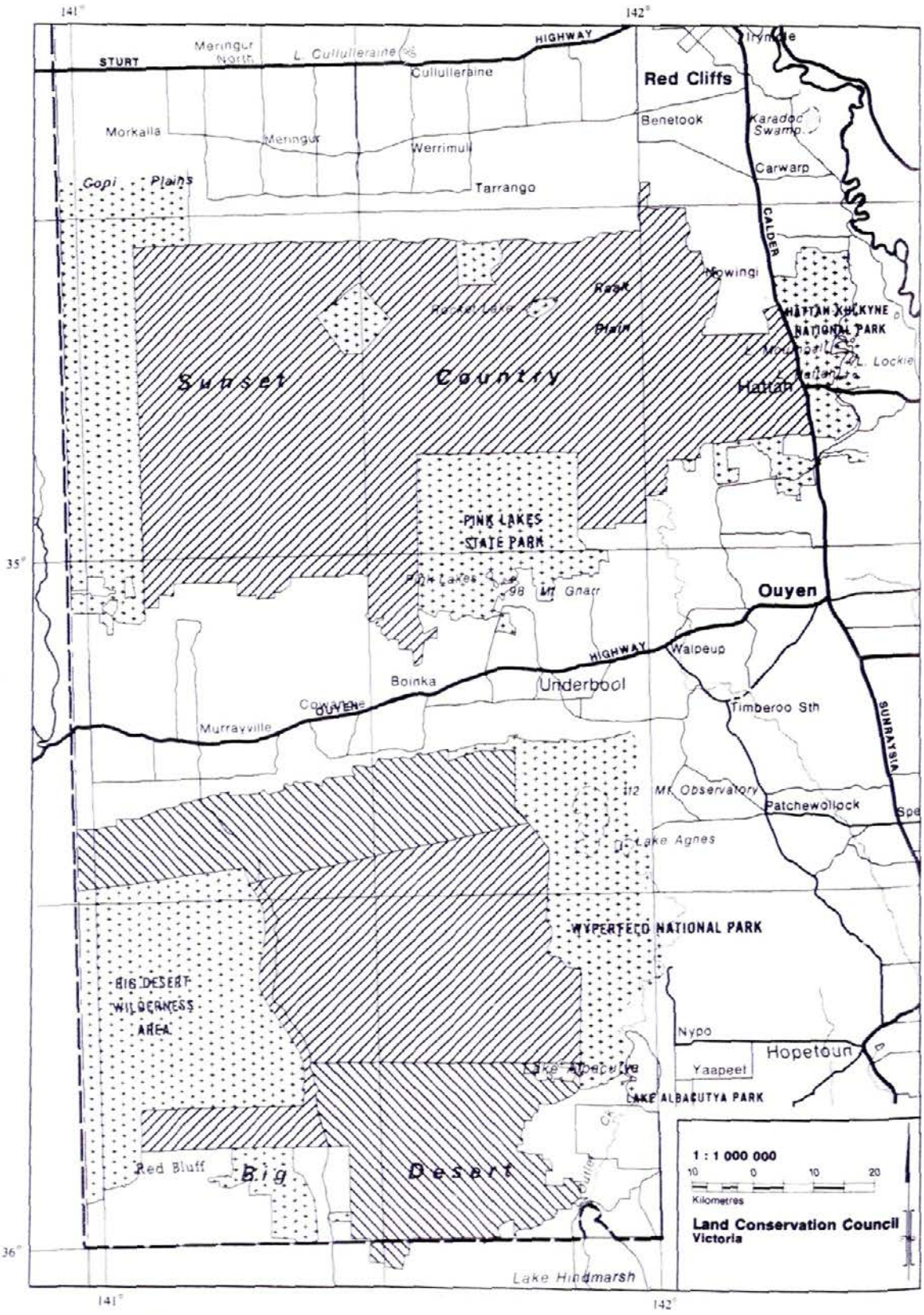
Low-voltage distribution lines are found along road reserves throughout the study area. They also run along irrigation channels and across the River Murray frontage in a number of places to supply power to pumping stations.

Military Training

In 1977, the Council delineated zones in the Big Desert and Sunset Country for use as military training areas. These are shown in Figure 25. The northern and southern fringes of the Big Desert were considered to be suitable for intensive military use, including the establishment of major base camps and exercises with tracked armoured vehicles, while the Sunset Country and the central portion of the Big Desert are considered suitable for more dispersed mobile training, including the use of tracked vehicles but without the establishment of major base camps.

Figure 25

MILITARY TRAINING AREAS



	Zone 1	Land that is not to be used for military training.
	Zone 2	Land that may be used for dispersed mobile training, including the use of armoured tracked vehicles. Establishment of major base camps should not be permitted.
	Zone 3	Land that may be used for more intensive training, including the use of armoured tracked vehicles, and the establishment of major base camps.

The Big Desert Wilderness, reference areas, parks, and other areas of conservation significance are excluded from military training exercises.

The types of training vary - from small-scale manoeuvres and bush survival exercises involving 15 to 60 persons on foot, to the occasional large-scale training exercise involving some 300 personnel and a variety of transport, including tracked armoured vehicles. Such a large-scale exercise was carried out during April 1985 in the Sunset training area. The current level of use here is limited to about twice per year, while the Big Desert area is used less frequently, mainly because of the relatively long distances from military bases and, consequently, the increased time and cost of conducting an exercise.

Exercises with tracked vehicles can have considerable impact on the land - the vehicles break down mallee and disturb the soil, especially where they turn. This activity may result in soil erosion and detract from the natural appearance of the land. In 1977, the Council was concerned that suitable areas be made available for defence forces training and considered that the use of those areas delineated on Figure 25 was justified at that time, given that the conservation reserves in the Mallee are excluded from this activity. It did, however, stipulate that no area should be used for training with tracked armoured vehicles more frequently than once every 4 years.

Public land is used for military training including the use of tracked armoured vehicles.

The Australian Army instructs participants in exercises in the Mallee to avoid movement of vehicles along the crests of sand dunes, but to cross them, if necessary, at right angles and at the lowest point. The development of new tracks is to be avoided where practical.

Railways

As described in Chapter 3, the rail system has played an important part in the development of the Mallee. Its extent is indicated in Figure 6. Although used for transporting a wide variety of goods in the past, including firewood and water, many of the lines are now only used seasonally to transport bulk wheat, and several have been closed and dismantled. Their present status is also indicated on the figure. The Hopetoun--Patchewollock and Red Cliffs--Meringur lines were closed recently and the land is being considered for disposal.

It is significant that the railway easements were laid out in most cases at the time of settlement. These areas have generally escaped intensive agricultural activities and their subsequent management has usually been confined to burning of excessive grass growth. As a result, they often support remnant native vegetation. An unpublished report to the Department of Conservation, Forests and Lands in 1985 identified a number of sites along rail easements in the Mallee area that contain significant or relict native plant species. Such a site occurs on the recently closed Red Cliffs--Meringur line.

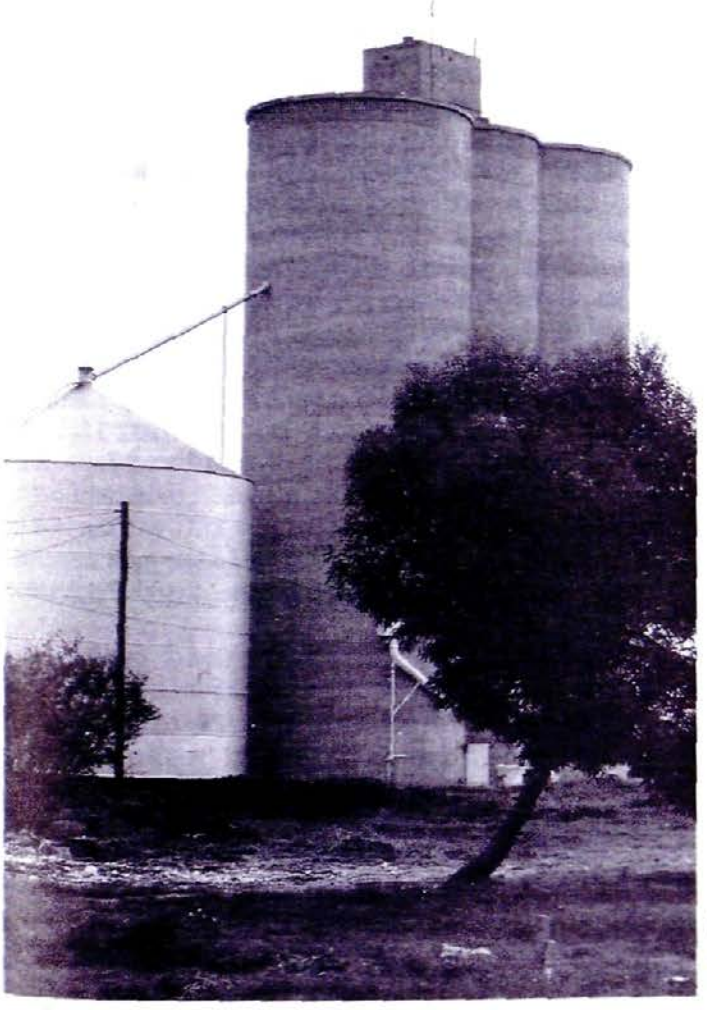
Other Utilities and Institutional Uses

Public land is also occupied by a number of other utilities for such purposes as roads, tips, airstrips, trigonometrical stations, radio and air navigation installations, and wheat silos.

Numerous small parcels of public land are associated with townships throughout the study area and are used for a variety of purposes. In most cases the Council considers that those not yet reserved for a specific purpose should remain as unreserved Crown land to meet future township requirements. Some township sites in the Mallee have not been fully occupied and this situation is likely to continue. Possible future uses for some of them will be considered during this review.

The Road Construction Authority is responsible for maintaining the major roads throughout the study area, including the Calder, Henty, Murray Valley, Ouyen, and Sturt Highways, while local shires maintain the secondary road system. Road reserves, both major and secondary, as well as unused road reserves, often contain stands of native vegetation that at times facilitate movement of wildlife between larger tracts of vegetation.

Because the area has such low relief and line-of-sight distances are short, trigonometrical stations have been established on many of the minor prominences. Trig stations are



Wheat silos are prominent features throughout the Mallee.

even established on many of the wheat silos here because they afford superior sighting distances.

The Commonwealth Department of Communications maintains a series of microwave repeater stations, such as those at Hattah and at Goschen (about 20 km west of Lake Boga), and various Victorian government agencies, including the State Electricity Commission and the Road Construction Authority, maintain radio masts and installations within the study area as part of their State-wide communications network.

Although the Mildura airport occupies land owned by both the Shire of Mildura and the Commonwealth, three other major landing fields in the area are on public land: the Mildura aeroclub and glider landing ground south of Mildura (indicated as L12 on Map 8); the Patchewollock airfield, set aside subsequent to Council's 1977 recommendations (P6 on the map); and the Robinvale airfield - part of P1 on the map.

East of the Robinvale airfield, and on public land, is an area set aside for the Robinvale sewage works (also indicated as P1). Cemeteries and many garbage disposal tips are

located on public land as well, and a number of these too are indicated by the symbol P1 on Map 8.

Locks were constructed across the Murray River after 1914 to ensure sufficient depth of water for river transport. Although the era of the river-boat had passed by the time the locks were completed, they receive considerable use with the passage of houseboats and other recreational traffic.

Most of the works associated with the locks are on the river-bed or below the top of the bank and are therefore not on Victorian 'public land'. Their influence, however extends into the State and in some cases dwellings and associated workshops are on public land here. Six locks adjoin the study area. Lock 11 at Mildura, is managed by the Rural Water Commission. Locks 7 (near Rufus River NSW), 8 (near Potterwallkagee Creek), 9 (north of Cullulleraine), 10 (at Wentworth), and 15 (at Robinvale) are managed by authorities from New South Wales or South Australia.

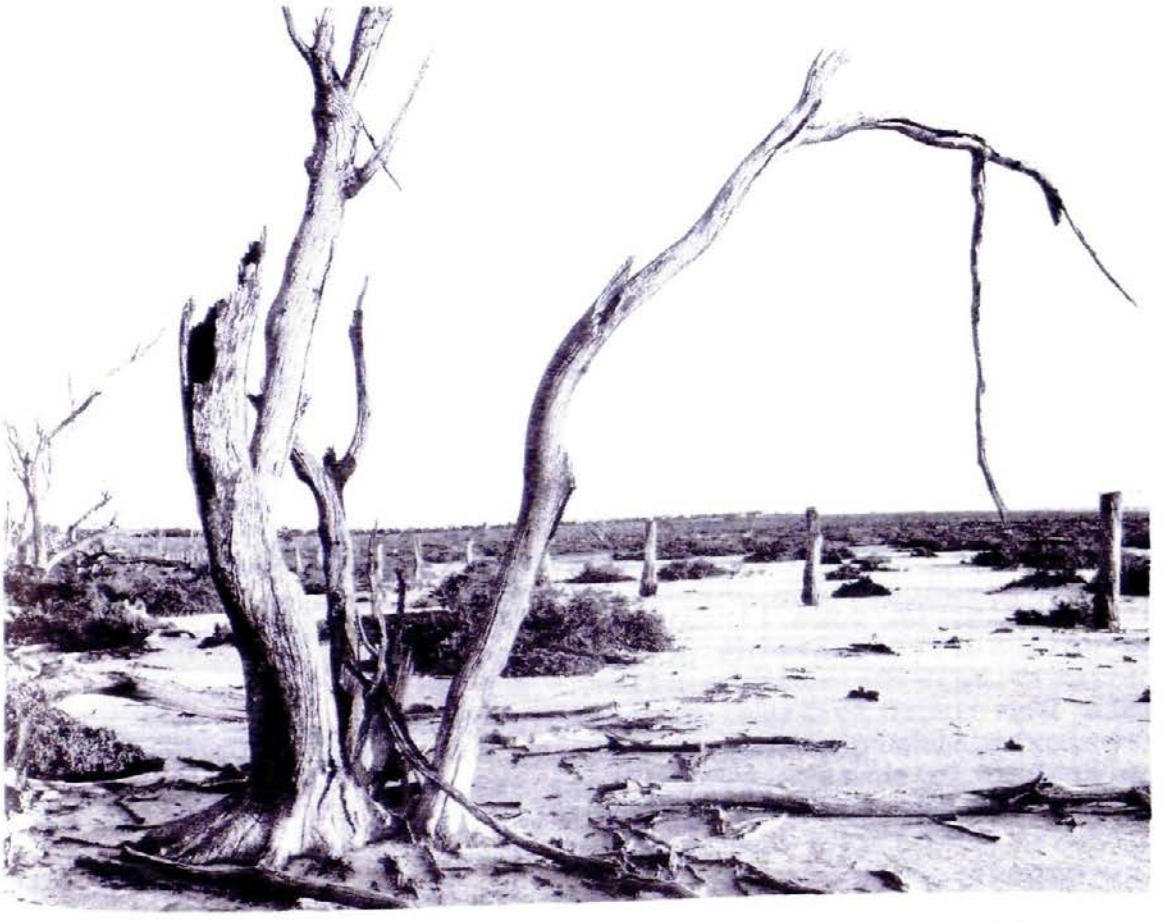
16. HAZARDS AND CONFLICTS

A hazard to the land can be defined as a change that reduces its productivity, stability, and aesthetic appeal, and the provision of habitat for fauna.

Prior to settlement, interactions between such factors as climate, topography, geology, and living organisms - and the actions of the Aborigines with fire and digging stick - had established a dynamic equilibrium between water regimes, soils, vegetation, fauna, and people.

The environment has been extensively changed by European settlement, however, and native vegetation and fauna have been removed or displaced by exotic pastures and introduced animals, soils have been cultivated, rivers dammed, and remnant 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.



A change that reduces the land's productivity, stability, or aesthetic appeal is referred to as a hazard.

PHYSICAL HAZARDS

Because of interdependence of vegetation, soils, and other environmental features, a change in one usually produces changes in others until a new equilibrium, which may be more productive, or less so, is attained. Complete understanding of the interrelations between environmental variables is not possible and much of our present knowledge of land use hazards comes only from experience. Consequently a knowledge of the present condition of the land in relation to the way it is used has great value. Conflicts occur where demands from competing uses vie for a given area of land.

The major forms of hazards to land use and conflicts that arise are described below. Mention is also made of hazards and conflicts in the respective chapters of the balance of the report.

Soil Deterioration

The stability and fertility of soils depend both on the proneness of particular land types to various processes of deterioration and on how the land is managed; off-site effects are involved where processes extend from one area to another.

Wind erosion has long been of concern in the Mallee. Salting is now regarded as a threat in many areas and this problem is discussed later. Other soil-deterioration processes known to occur here are compaction, loss of nutrients by leaching, and water erosion.

Leaching effects depend on both rainfall and the coarseness of soil particles and, under the semi-arid climate, may not be a great problem for Mallee soils *per se*, although leaching of nitrate from sandy topsoils has clearly visible effects on crops in wet years.

Many clay loams, sandy clays, and loam soils can form hard subsurface pans through frequent cultivation, stock trampling, and the movement of vehicles. In addition, they may also develop compact surfaces.

Most land types in the region are not prone to water erosion because of the low rainfall and generally permeable soils, although summer thunderstorms can cause erosion on undulating country. Sheeting and gullying do occur, however, where previous wind erosion has exposed compact clayey subsoils - for example, on some linear dunes, lunettes, and the higher red-soil terraces beside stream-courses.

Table 12, 'Land Systems of the Mallee', indicates the soil deterioration processes to which the respective land systems are susceptible. The systems are indicated and described on Map 7.

Wind erosion

Strong winds combined with weak vegetative cover are important factors in soil erosion throughout the agricul-

tural areas. Winds reach gale force on several days each year, with most erosion occurring during such periods. Fine particles form dust that may be carried for hundreds of kilometres before being redeposited. Heavier particles are blown across the surface (saltation) to be deposited along fence lines and other obstacles. Most high winds come from the west, resulting in a general movement of eroded particles towards the east. Improved farming techniques, particularly during the last couple of decades, have reduced the amount of wind erosion.

Semi-arid lands tend to erode when soils are exposed to strong winds, the soil surfaces being only weakly bound by humus and frequently dry. Soil factors that determine erodibility include local relief, aspect, soil moisture content, particle size, aggregate size and stability, and micro relief. The presence of a protective cover of vegetation and the prevailing wind are obviously also important factors.

The more susceptible lands are those with east--west or irregular sand dunes in the drier north and the Big Desert. These usually comprise deep infertile sands that are unsuitable for farming. They also face the risk of wind erosion following removal of the Mallee scrub cover by intense fires. Soils in the south-east of the study area are more stable due to their higher clay fraction, but they can be badly affected when poorly managed, particularly during droughts.

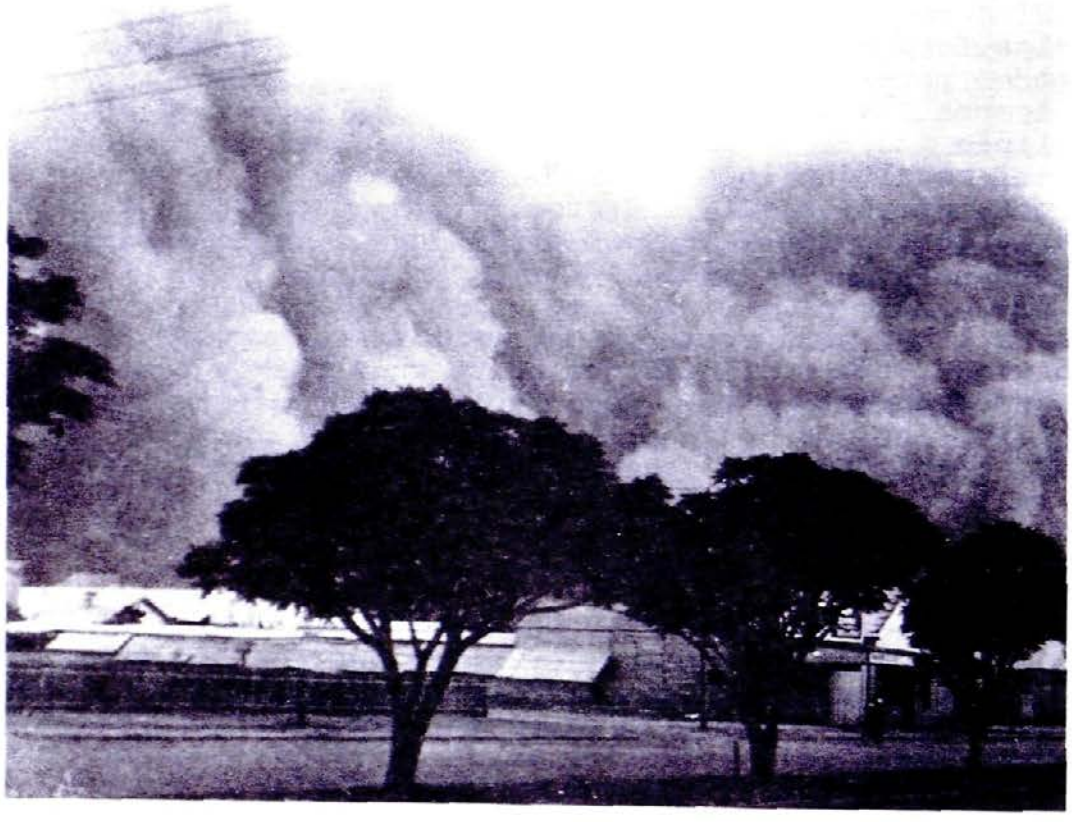
Protection against wind erosion may be afforded by living and dead vegetation, and sometimes by objects such as stones. Under undisturbed conditions, lichen on the soil surface is considered to be an important factor in maintaining soil stability - particularly so following severe wildfires. Erosion becomes significant where the projected ground cover of standing vegetation is less than about 25%.

Erosive winds can occur at any time of the year, mainly from a westerly direction. Cold fronts passing through the study area are usually accompanied by strong winds from the south-west at least 20 times each year. Strong hot northerly winds blow on at least 10 days during the warmer months. Dust storms that frequently occur under these conditions may have only a local or regional effect or may extend across the State, as did the one experienced over Melbourne in 1983, or across the Tasman Sea to New Zealand.

Effects on soils

This section deals with the on-site effects of wind erosion on the soils of the region, although other effects are important too. Off-site effects include air pollution by dust-storms, and the obstruction by drift sand of utilities such as water-supply channels, roads, fences, and railway lines. Erosion is also implicated in the spread of cereal pathogens.

Removal and deposition of soil materials affect the chemical and physical status of soils. Stripping removes nutrients,



Wind erosion has long been of concern. This dust storm was during the 1920s.

including the critical phosphorus, which is concentrated at the surface. Dust contains particles of clay and organic matter, both of which hold the soil nutrients.

Sandy soils inherently contain few fine particles, and therefore the loss of their small fractions reduces their water-holding capacity and nutrient-retention capability. These properties cannot be readily replaced, although nutrients lost in dust can be replaced by fertilizers. The fertility of heavier soils is effectively reduced when they are buried by sand drifts. Under strong wind conditions, newly emerged plants are sometimes sand-blasted.

Physical effects vary with soil type. At one extreme, deep sands can lose a metre or more of material without greatly affecting capability. On the other hand, loss of the shallow loamy surface of duplex soils exposes hard clays, which are difficult to cultivate and only slowly penetrated by rain-water. Some exposed subsoils are saline - for example, those on older red terraces beside stream-courses. On the widespread calcareous earths and clays, hard surfaces are produced by erosion of the surface and the exposure of subsurface hard pans.

Not all physical effects of erosion are detrimental, however. For example, moisture availability may be improved when heavy soils are buried by coarser materials. In addition, the eastwards movement of loess on a geological timescale has enriched soils, particularly on the riverine plains and adjacent bedrock hills.

Geological, physiographic, and soil studies all indicate that several periods of instability have occurred within the last 100 000 years. Dune-building, at least in the Woorinen Formation, has apparently been associated with regional changes to water tables. Evaporation from the regional water tables produced saline surfaces, weak vegetative cover, and hence soil movement. Major periods of dune-building occurred as recently as 16 000 and 25 000 years ago during periods of aridity.

By the time clearing began, some 100 years ago, climate and water-table levels had allowed vegetation to stabilize the land, except in some saline basins below 40 to 50 m elevation and on the crests of the more prominent irregular dunes. Replacement of the deep-rooted indigenous vegetation by annuals and the baring of the surface by cultivation have re-established instability in the more susceptible land types.

Wind erosion in grazed public land

Before European occupation, stability of the native grasslands and savannahs was maintained by perennial grasses and shrubs. The numbers of native fauna grazing these plants were limited by the paucity of permanent water supplies. The introduction of domestic livestock and the construction of permanent watering points, which have also allowed the numbers of native animals to increase, have greatly increased grazing pressure, and the perennial grass and shrub cover has degenerated.

The sparsely timbered public land parcels that are licensed for grazing, such as the grasslands north and west of the Millewa settlement, are subject to serious wind erosion.

Observations indicate that overgrazing exposes the soil to wind, particularly during drought when there may be little or no ground cover.

General observation here indicates that overgrazing periodically exposes the surface to erosive winds, particularly during droughts when there may be little or no ground cover.

Wind erosion also affects the soils on the upper Murray River terraces in the north-west of the area and, to a lesser extent, the grasslands in the evaporative basins. These generally flat areas are also used for grazing. Here, overgrazing and drought have weakened or removed the vegetative cover of the duplex soils and the wind has stripped away the topsoil, exposing the heavy subsoil. Where saline subsoils are left exposed, the process is termed scalding.

Scalding is found mainly in the Millewa and areas north-west of Birchip. Salt scalds were estimated to encompass 60 000 ha in 1971 but, because of better recent management, are not presently considered to be increasing.

Wind erosion in croplands

Some soil movement occurs each year on farms, particularly on bare sandy fallows. About 20% of each dryland farm is usually fallowed annually from September to the following May. On average, in areas containing closely spaced east--west dunes, erosion of cultivated land has been observed on 57% of those with light soil and 12% of those with heavy soil. For example, in 1979, which was a year of roughly average rainfall, almost half of the bare sandy fallows in the northern Mallee were drifting.

Paradoxically, in years with significant summer rainfall, wind erosion is often worse. Farmers cultivate after each rain to kill weeds that have germinated, destroying the protective surface mulch and exposing the soil to erosion. In dry summers, they have less need to cultivate for weed kill.

Wind erosion becomes widespread in drought years, however, when there has been little growth to produce a protective surface mulch, and especially where that small amount has been grazed by livestock.

The effects of differences in management, phase of crop rotation, and land type were obvious at the end of the severe drought in March 1983. Practically all bare fallows, failed-crop areas, and overgrazed pastures were drifting to some extent, showing that normal management practices cannot prevent erosion occurring on ground on which a vegetative cover has not been maintained.

Areas with a vegetative cover such as crop stubble were stable, and these occurred mainly on the heavier soils in the south. Here, wind erosion affected about 25% of the farmlands to some degree, whereas in the dune country to the north, 80% were affected.

Assessing the effects of erosion and deposition on yields of crops and pastures is particularly complex, as is determining the inputs required for amelioration. Few detailed case studies have been reported. Differences can be expected according to soil type, the vagaries of climate, previous

management, and effects such as redistribution of plant pathogens. In the extreme case of the red duplex soils on river terraces, for instance, the shallow loamy topsoil has been removed entirely. This has led to a permanent reduction in productivity because the exposed clays are saline and they seal over, thus reducing rain-water penetration. On the other hand, where soft surfaces remain, nutrients lost in dust can be replaced with fertilizers. Sandy soils inherently lack fine particles, however, and so any loss reduces the available water-holding capacity and increases the leaching out of nutrients such as nitrogen.

From another perspective, many farm practices may enhance soil stability - for example, the use of productive crops and pastures, the addition of fertilizers, and the control of grazing. However, modified methods of cultivation and cover management may also be required to further reduce erosion at certain times of the year, and to maintain soil fertility.

The effect on crop yields following loss of the soil surface has been studied at the Mallee Research Station on calcareous earths that developed hard patches through erosion. Over the 3-year study, wheat yields on the hard patches, from which approximately 25 mm of soil had been lost, averaged 24% less than on adjacent intact land. The yields recovered after 3 years under barrel medic pasture, which restored the humus to the soil surface and replaced the nitrogen. Other trials at the Station showed generally reduced grain yield and protein content where various depths of topsoil were artificially removed from previously uncropped loamy calcareous earths.

Erosion control and conservation cropping

The long bare summer fallow, from spring to seeding in autumn, is still common and is the prime predisposing cause of wind erosion. The safer practice of trash-retention farming, however, is gradually gaining acceptance. This involves the maintenance of a cover of dry pasture or crop-stubble residues on the soil surface through summer.

Weed growth on the fallow is controlled by using herbicide sprays. The cover of trash provides the necessary protection of the soil surface from the wind, provides some production (in the form of stock forage) during the fallow period, and, because fewer passes with tractors are required for ground preparation, helps reduce fuel and machinery costs. In some seasons, however, the residue has been insufficient to protect the soils for the whole fallow period.

Methods for preventing erosion of fallow land, either by reducing the length of the fallow or by protecting the soil surface through stubble retention and minimum tillage, are similar to those used to combat water erosion.

Present indications are that crop yields are reduced slightly through the use of shorter fallow periods, but protection of the soil through minimum tillage and stubble retention does not appear to affect yields.

Minimum tillage and stubble retention are methods for preventing wind erosion.

Soil erosion is the main hazard related to agriculture in the Millewa and is greater here than elsewhere because of the lighter soil types and lower rainfall. Big swings have occurred in recent years - from bare fallowing to trash retention to help prevent soil erosion, and from disced implements to tyned ones, which disturb less surface soil. However, the lower-yielding crops of the Millewa compared with those in other parts of the Mallee also provide less potential for adequate trash retention.

Lighter soils anywhere are at risk from wind erosion and this becomes evident where management does not vary to accommodate light and heavier soils on the one property.

In the past, the practice of cover-crop fallowing was used in the Mallee. This involved the late-winter sowing of oats, which were allowed to grow through the spring and summer, lightly grazed if practicable, then cultivated in autumn.

The roughness of the surface on ploughed fallows is increased by ridged cloddy cultivation, which increases air turbulence (thereby reducing wind speed) close to the surface. In addition, cloddy surfaces contain little unattached erodible material and, when loamy or clayey, are relatively resistant to breakdown, particularly if they are cultivated when moist and at low machinery speeds. On sand, emergency ridging is used dur-ing droughts, particularly when clods can be brought up by deep ripping, although some deep sands preclude this. Ridges 300 mm high and 3 m apart will give protection if they do not disintegrate. The use of ridging is widespread and can be useful in protecting roads, channels, or railways from saltating material.

Permanent windbreaks at right angles to strong winds give substantial protection for some 20 to 30 times their height - depending on their density, shape, and width. Native trees and shrubs provide considerable protection, particularly beside roads in the central and northern Mallee. However, they are seldom retained or planted in the large paddocks that prevail in the region and competition with crops for soil moisture is tendered as one explanation for this.

The government promotes conservation tillage practices (those in which a vegetative mulch is maintained on the surface) by educating farmers, by lending them government machinery such as rodweeders, blade ploughs, and seeding equipment to allow them to gain experience in the use of that machinery as part of normal farm management, and by establishing a number of field trials. It is estimated that about half of the Mallee farmers have now adopted some form of conservation tillage in the last 6 years. Many others do not have the necessary implements for trash-retention farming, and this has slowed its adoption.

Erosion control on public lands

To avoid erosion of the areas of public land licensed for grazing, lessees must either remove stock or adjust the level of stocking according to seasonal conditions. Strict rabbit control is also necessary. Quantitative data for land west of the Millewa settlement, from plots monitored between 1968 and 1980, indicate that management for animal production, vegetation maintenance, and erosion control should aim at a variable stocking rate that never completely defoliates the ground cover. When allied with strict rabbit control, this rate averaged 0.13 sheep per hectare over the 12-year period.

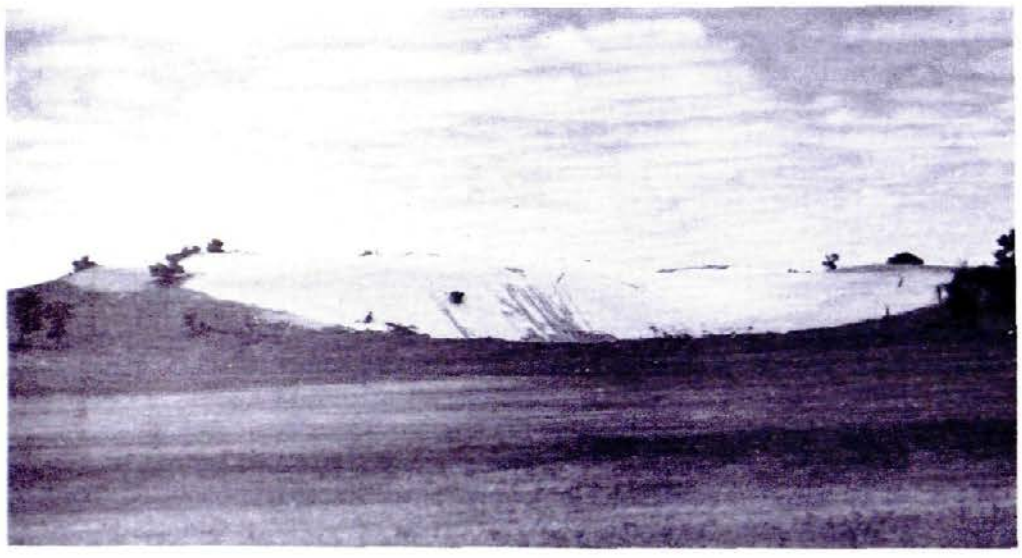
The large areas of land in the far north-west, the Sunset Country, and the Hattah--Kulkyne and Wyperfeld parks that are still eroding were subject to overgrazing by rabbits and domestic stock from late last century.

Most of the obvious on-site physical effects of annual wind erosion on cropping soils are readily obliterated by tillage. However, erosion of exposed dunes and some of the plains on public land has progressed relatively unabated for many decades. Such erosion requires a major input of resources for reclamation to be effective. Even so, the original landform and vegetation communities are unlikely to be restored.

Reclamation of eroding dunes generally requires several steps: re-shaping with earth-moving equipment, to reduce wind funnel effects and to provide access for machinery used for sowing seed and rabbit control; the application of seed and fertilizer; and fencing to exclude herbivores, including kangaroos. An example of the magnitude of the work required in the Mallee area is provided in a portion of the Hattah--Kulkyne National Park, where up to 480 ha are in need of reclamation work. It is estimated that this would cost $400 per ha.

Stabilization of an area usually involves the introduction of an alien plant species that has particularly suitable properties for the purpose. Evening primrose was used to stabilize dunes within the Hattah--Kulkyne park, but has now become established there as a weed. Ryecorn is now used exclusively as a primary stabilizing agent as it does not persist beyond about 3 years, by which time native plants have become established.

In some situations the native mallee vegetation has been re-established without the use of ryecorn; however, wind erosion continues here even after about 20 years probably because of the low density of the vegetation.



Reclamation of exposed dunes requires a major input of resources to be effective.

Wildfire

Fire is a natural component of most Australian ecosystems. The indigenous vegetation is variously adapted to it, and most plants are capable of successful regeneration afterwards. Some plant species depend on it for their long-term survival. The natural regime of fire was modified by Aborigines and later by European settlers.

Aborigines lit fires to flush out animals and to induce fresh vegetative growth that attracted the kangaroos and other grazing animals that they hunted for food. These burns generally produced a patchy mosaic of various age classes in the vegetation. European settlers, however, used fires to clear the native vegetation in preparation for agriculture, and pastoralists used them to remove dry grass and encourage green shoots for livestock. Thus, although they may occur with a similar frequency to that before settlement, they are now more extensive.

Prevention and suppression have increased in importance in the community in recent times, particularly since the devastating fires of 1939 and 1983. The suppression policy of the Department of Conservation, Forests and Lands is to control all wildfires as soon as practicable, as these pose

a threat to both private and public assets. On private land they threaten life, crops, livestock, and buildings. On public land they can adversely affect flora and fauna, downgrade landscape values, and place the fragile desert environment at risk from wind erosion. Fire, however, is not necessarily bad, and fire management can have an important place in flora and fauna management.

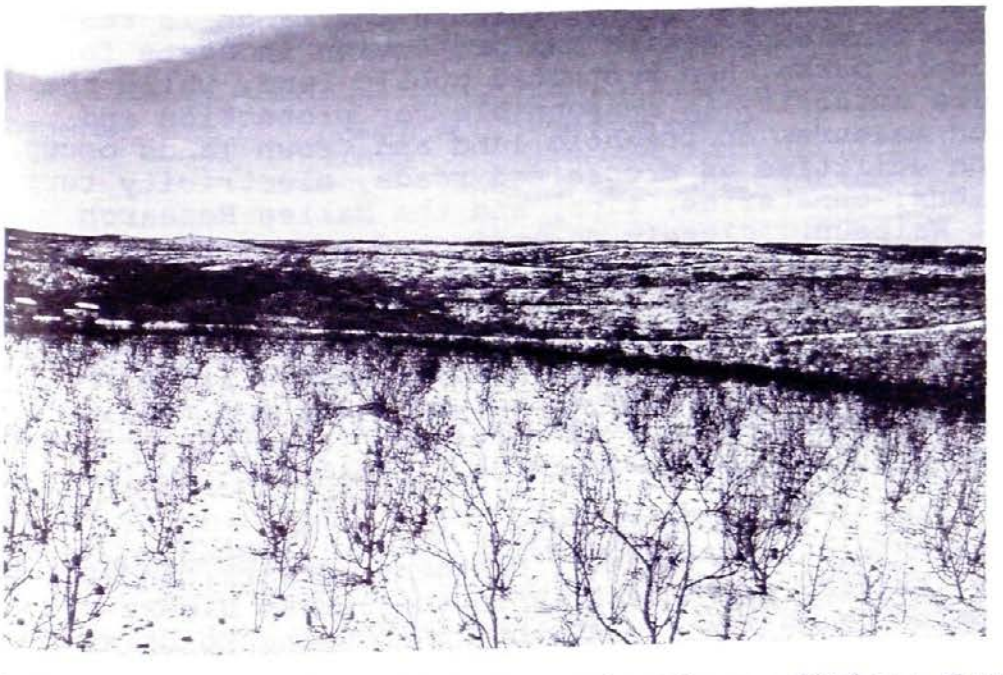
Fire and the Mallee environment

The semi-arid climate of the study area, with its typically hot dry summers, significantly adds to the fire hazard. Lightning during dry summer storms remains a significant cause in the Sunset Country and Big Desert; along the Murray River, carelessness with camp-fires is a source of numerous small ones.

The fuels in mallee vegetation consist of all the above-ground vegetation. Litter accumulates slowly under mallee, taking some 15 to 20 years after one intense fire to become sufficient to support another. Seasonal conditions are also important, however, and good growing conditions in a recently burnt area may produce sufficient grass in 1 year to carry another fire.

Fires burn rapidly under the influence of the strong winds, high temperatures, and low humidities characteristic of the region. The strong winds may sweep the flames from clump to clump, and carry burning bark and leaves downwind to start new outbreaks.

In the Big Desert, the mallee-heath, scrub-mallee, heath, form dense, continuous, and highly flammable fuels in which fires burn fiercely, consuming all the low vegetation and killing the aerial parts of the taller mallees. Under natural conditions the soil surface usually remains stable



Fires burn rapidly under the climatic conditions found in the Mallee.

afterwards because of the presence of lichen. Disturbance of that surface by hard-hooved animals or machinery, however, leaves it susceptible to erosion after a fire.

Eucalypts can regenerate through seed; however, an adaptive mechanism has also enabled them to produce new foliage from epicormic shoots produced by dormant buds under the bark. Most local eucalypts develop woody swellings - known as lignotubers - at or just below ground level, which carry numerous dormant buds and are sites of regeneration after the removal of stresses, such as insect attack, shade, disease, or fire. The lignotuber is rarely damaged by fire; it can become quite large and in some mature mallee species may produce up to 70 above-ground shoots 6 months later. The number of stems can diminish to 20 or 30 after 7 years and to less than 10 by 100 years.

The riverine forests and woodlands of red gum and black box are less fire-resistant than the mallees. Even mild fires can defoliate or kill red gum. After defoliation the crowns may re-establish from epicormic shoots. However, where fuel quantities are high, and fires consequently hotter, most red gum trees are killed. Such large accumulations of heavy fuel can occur when flood-waters heap branches and other debris against the trees.

Cypress pine and belah are easily killed by fire and, compounding this loss, grazing by rabbits, kangaroos, and stock will destroy their regeneration.

Frequency, intensity, pattern, and seasonality of fires all have important implications in floral and faunal diversity in an area. This is discussed in some detail in Chapters 7 and 8 - Vegetation and Fauna respectively.

Fire suppression

The Department of Conservation, Forests and Lands is responsible for fire suppression and protection in State forests, national parks, and protected public land, while the Country Fire Authority is responsible for protection and suppression measures on freehold land and Crown lands occupied by such utilities as proclaimed roads, electricity terminal stations, cemeteries, tips, and the Mallee Research Station at Walpeup. Closely co-ordinated arrangements for mutual co-operation exist between the two agencies.

In the riverine forests fuels are mostly grasses, which can be reduced by grazing. Wildfires seldom become large in these areas, most of which are close to towns and readily accessible, allowing rapid first attack. Those in accumulations of heavy fuel, however, can be difficult to extinguish.

The flat terrain, absence of a fire-tower network, and the relatively low population density in the larger blocks of land dominated by mallee and heaths can combine to delay detection of a fire, which has thus often become well established by the initial attack stage. After thunderstorms, aircraft are used to detect any fires started by lightning

strikes. Poor access in the Big Desert and Sunset Country causes considerable delays in transporting resources to a fire and, once there, work is hampered by the sandy terrain and extremely limited water supply.

Multiple fires resulting from lightning strikes are common and the spread pattern of large desert fires is extremely irregular, largely due to wind changes. Table 18 indicates the total area burnt by wildfires between 1977 and the 1986/87 fire season, while Table 19 indicates their sources

Table 18

WILDFIRES ON PUBLIC LAND (1977--87)

Year	Number of fires	Area of public land burnt (ha)
1986/87	35	9 024.4
1985/86	39	6 843.3
1984/85	21	87 306.3
1983/84	6	17.1
1982/83	10	28 952.8
1981/82	12	4 131.6
1980/81	33	282 593.3
1979/80	21	239.8
1978/79	17	189.3
1977/78	35	3 076.2
Total	229	422 374.1

Table 19

SOURCES OF WILDFIRES AND VEGETATION TYPES BURNT ON PUBLIC LAND (1977--87)

Fire source	Number of fires	Vegetation type (ha)			
		Red gum/ box	Mallee	Other	Total
Lightning	46	10.1	405 917.6	1 246.0	407 173.7
Match/cigarette (accidental)	24	43.5	131.5	42.3	217.3
Camp-fire (escape)	83	300.4	0.1	1.6	302.1
Burning off (escape)	18	31.2	8 668.0	2 068.5	10 767.7
Deliberate (malicious)	33	61.8	533.2	168.5	763.5
Other	25	4.3	3 003.8	141.7	3149.8
Total:	229	451.3	418 254.2	3 668.6	422 374.1

and the vegetation types burnt. Map 11 plots the extent of wildfires and fuel-reduction burns in the Mallee dune-fields since 1971.

Both fixed-wing aircraft and helicopters are used in desert outbreaks for reconnaissance, direction of the fire-fighting effort, fire-retardant bombing, and the transport of personnel and supplies. Bulldozers equipped with root rakes are ideal for fireline construction. Aircraft and earth-moving equipment used in fire-fighting operations are mainly provided by private contractors.

Fire protection

Fuel-reduction burning is a technique used in most forest types for lowering the intensity of wildfires so they can be controlled. It relies upon burning the litter in autumn or spring so that a wildfire in summer has little fuel to support it, thus reducing its rate of spread and intensity. However, so far the technique has not been extensively used in the semi-arid zone of the State. In the Conservation Strategy for Victoria, the government has stated that fuel-reduction burning in publicly owned mallee woodlands and mallee heathlands will be limited to local small-scale burning.

The major emphasis of the protection work on public land within the study area is the construction and maintenance of fire-breaks. Substantial breaks have been established on the boundaries of all of the larger blocks of public land. Their effectiveness has been increased by fuel-reduction burns of up to a kilometre in depth from the fire-breaks. Such burns have also been used to subdivide the larger blocks, particularly the Big Desert. These internal burns

The construction and maintenance of strategic fire-breaks is an important aspect of protecting land, property, and people from wildfire.

have been carried out beside tracks and within large untracked areas using aerial-ignition techniques.

No broad-scale fuel-reduction burning is undertaken in mallee areas, however. There, it has much the same effect as a wildfire, consuming most of the lower vegetation and killing the aerial parts of the taller mallees. The result provides a barrier to a recurrence of a wildfire for up to 15 years. Although sufficient grass may grow in a wet season to support a grass fire within a year or so, this burns at ground level, where it is more readily controlled and spotting is reduced. This is particularly important on the boundaries between public and private land, where many fires are fought, and next to tracks that form strategic fire-breaks.

The highest priorities for fire-prevention activities are granted to those areas that receive the greatest visitor use and to biological reserves including the national, State, and regional parks and flora and fauna reserves. Other operations include the maintenance and improvement of access and water points, public education, and the enforcement of fire laws.

Fire as a management tool

Fire may also be used as a tool for the management of fauna and flora. The fire regimes imposed by Aborigines and natural causes, which prevailed prior to settlement, have been modified by fire-suppression activities and the clearing of large areas for agriculture.

The exclusion or too frequent occurrence of fire in some areas of mallee may have some long-term deleterious effect, as a mosaic of age classes produced by burnt areas may be necessary for the survival of some species. Recent widespread fires (see Map 11 and the Landsat image on the front cover), however, have resulted in a predominance of early post-fire stages in mallee, with the later stages and areas of long-unburnt mallee being under-represented or scarce.

The Wathe Wildlife Reserve, for example, has not been burnt for many years: it contains substantial areas of 'old' mallee, which are favoured by species such as malleefowl, and supports the only known population of an endangered legless lizard. The reserve is connected to the nearby Wyperfeld National Park by a narrow corridor of public land, but for purposes of fire protection is essentially isolated by agricultural clearing.

Fuel quantities are very high in this reserve but probably stable (deposition of fuel being in equilibrium with decomposer organisms), as in most mature communities. There is some potential, however, for a single wildfire to burn the whole of the reserve and decrease its values for wildlife in the short term. In the event of a complete burn, the isolation of the block may retard its successful post-fire recolonization by some species. As a precaution against a complete burn, some protection works may be necessary in or adjacent to the reserve.

Salinity

Salinity has been recognized by the government as the single greatest threat facing Victoria's environment. The study area contains some of the worst-affected land in the State.

'Salinity' refers to the presence of salts in soil or water. These salts differ in the relative proportions of their components from place to place, but they generally contain ions of sodium, potassium, calcium, magnesium, chloride, carbonate, bicarbonate, nitrate, and/or sulphate.

If their concentration becomes too high, most plants can no longer survive, animals drinking the water will become ill and die (see Table 9), and aquatic ecosystems become degraded.

Salts in the soil or groundwater can be derived from a number of sources - from sea-water that was trapped in the sediments during the periods of marine transgression, from the weathering of rocks, from air-borne salt, and from streams flowing into the area.

Salinity, where it causes problems, is linked inextricably to groundwater behaviour. The balance between groundwater and surface water is very finely tuned and even a small increase in the amount of water filtering into the soil from the surface can cause the groundwater level to rise significantly. As it approaches the surface, salt is concentrated by evaporation. This increase in salt levels can damage vegetation by preventing plant germination and growth, or killing it, thereby reducing agricultural production and changing the nature of native vegetation. The loss of plants exposes the soil to wind erosion. Salt can also damage water-using appliances, pipes, and metal tanks and cause the loss of wildlife habitat and the amenity of recreational areas.

Extensive clearing of trees and the introduction of large-scale irrigation are the main factors that have contributed to the rise in groundwater levels. In irrigation areas, dissolved salts in the irrigation water can also gradually accumulate in the soil and shallow groundwaters.

Dryland salting

The Mallee suffers from two main forms of dryland salting. One occurs when the saline water table approaches the soil surface, and the salt is concentrated by evaporation; the other results from exposure of inherently saline subsoils when erosion removes non-saline topsoils (termed 'salt scalding' - as described previously under soil deterioration).

A report to the Parliamentary Salinity Committee in 1983 estimated that all of the naturally occurring saline clays and human-induced salt scalds in Victoria occur in the Mallee. This is indicated in Table 20 which also shows the extent of naturally occurring salt pans and induced saline seepage in the Mallee compared with the State totals.

Table 20

EXTENT OF DRYLAND SALTING
Estimates for the Mallee and the State (ha)

	Form of salting[1]			
	Salt pans and salt flats	Saline seepage	Saline clays	Salt scalds
Victoria	100 000	90 000	62 000	60 000
Mallee	88 000	9 000	62 000	60 000
	natural	human-induced	natural	human-induced

Note:
1. Definitions of the forms of salting are provided in the Glossary - Appendix I.

Saline regional groundwater is contained in the Parilla Sand, which underlies much of the study area and acts as a relatively unconfined aquifer generally 40 to 60 metres thick. Naturally occurring saline pans occupied about 88 000 ha or 2% of the study area at the time of settlement. Groundwater pressures have risen as a consequence of removal of the perennial vegetation, and groundwater now discharges at the soil surface over approximately 3% of the total landscape. Salt-affected areas are thought to be expanding at an annual rate that averages about 2%, increasing in abnormally wet years.

Saline depressions are a natural feature of the Mallee.

The Mallee is prone to salting as potential evaporation from the soil greatly exceeds rainfall, and most of the area has internal drainage. Consequently, much of the salt that has entered the region through rainfall has been retained in the soils. In wetter years, rain soaking into the soil 'leaches' salts down through the soil profile away from the root zone of plants.

Groundwater recharge has been influenced by the clearing of native vegetation, irrigation, the earthen channels and reservoirs of the water supply systems, and, to a lesser extent, the use of evaporation basins to dispose of drainage water. The dominant vegetation over most of the area before clearing comprised mallee eucalypts. These are deep-rooted and perennial and consequently very little of the natural rainfall would have reached the groundwater. Since clearing and the introduction of shallower-rooted annuals such as wheat and medic pasture, significant amounts of rain-water have entered the groundwater system. Long fallows accentuate this accession because of the absence of transpiring vegetation.

About 90% of the secondary (human-induced) salinization in the Mallee has been brought about by a general increase in the height of the regional water table. Regional groundwater can be identified by its high salinity (25 000--35 000 mg TDS per L) and moderate acidity (pH<4) and differs markedly from local seeps, which have much lower salinity and are almost neutral in reaction.

Particularly where sand dunes have been cleared for agriculture, local groundwater systems associated with clay subsoils that have low permeability produce salinity at the foot of some of the dunes. Water seeping from the earthen channels of the stock and domestic system also picks up salt as it moves through the sand, causing salting near the channels. While their immediate effects are observed at or near

Aeriel view of saline groundwater seepage.

the recharge area or water source, both may also be contributing to the regional groundwater. Seepage-salting occurs mainly in the eastern half of the study area.

In these situations, the salinity of the seepage water ranges between 1200 and 1300 mg TDS per L, causing death to traditional agricultural cereal and grass species. This allows sea barley grass and other salt-tolerant grasses to establish. Landholders can replace these non-productive plants with improved pastures of species such as lucerne (*Medicago sativa*) and tall wheatgrass (*Agropyron elongatum*). Salt-tolerant *Eucalyptus* species can effectively utilize the excess water, and if planted can lead to contraction of the salt-affected area.

Where regional groundwater, with salinities in excess of 30 000 mg TDS per L, intersects the land surface, the usual agricultural plants will not germinate. Favourable seasons may allow certain grass and weed species to grow temporarily, otherwise saltbushes, in particular succulent samphire species, are the only inhabitants of regional salt pans. Their success, however, depends on the depth to the groundwater.

The present extent of secondary salting resulting from seepage for the whole of the Mallee is about 9000 ha, or about 0.4% of the total settled land. In some areas, however, this represents up to 20% of the most productive land. Some of the worst-affected sites occur on broad flat areas where the regional water table is already close to the surface, such as south-east of Lascelles, east of Rainbow, north of Danyo, and around Manangatang and Ouyen. The Manangatang--Piangil district shows an accelerated annual rate of salting of up to 8% in certain parts.

The Department of Conservation, Forests and Lands has plotted the known extent of dryland salinity in the State, and Figure 26 indicates the extent and severity for the Mallee. The salinity classes referred to in the figure are listed in Table 21, which shows the plant species regarded as indicators of the degree of salinity for the purposes of field surveys.

Soil salinity is usually measured by the concentration of salts in the solution extracted from a soil sample that is saturated with water. As well as being expressed as the content of total dissolved solids (TDS), salinity is also expressed as the degree of electrical conductivity of the sample - a more readily measured value in the field.

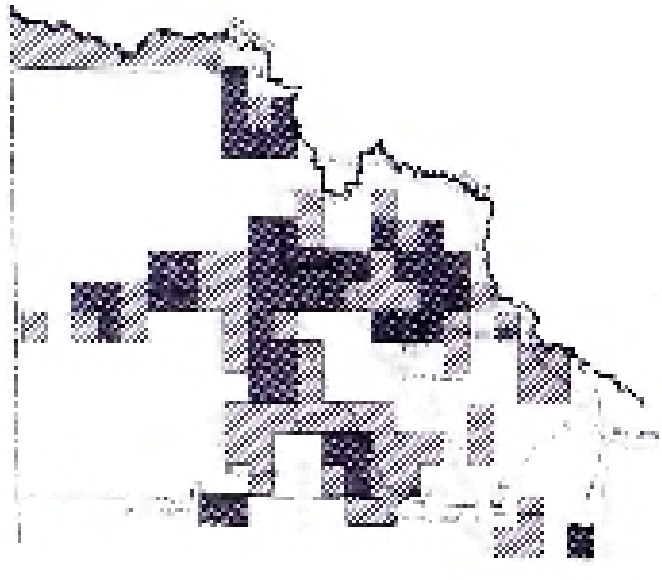
Electrical conductivity is measured for a range of soil samples - from within the plant root zone - and expressed as microsiemens per cm at a temperature of 25°C (abbreviated as 'EC units'). The approximate relationship between EC units and TDS may be given as: EC x 0.6 = (TDS).

Effects of dryland salting

Based on 1984 estimates, dryland salting within the study area has to date caused the capital value of land to decline

Figure 26

DRYLAND SALINITY



KEY

The degree of dryland salinity is indicated for each gri
rectangle as:

▓	High:	more than 50 ha of Class S3 salinit and/or more than 400 ha of Class S salinity
▒	Moderate:	5 to 50 ha of Class S3 salinity and, 50 to 400 ha of Class S2 salinity
	Low:	less than 5 ha of Class S3 salinity less than 50 ha of Class S2 salinit

Notes:

1. The grid rectangles conform with the 7'30" grid of t 1:25 000 series topographic maps prepared by the Div sion of Survey and Mapping - Department of Property Services. In the Mallee, they are equivalent to abo 15 500 ha.

2. The salinity classes referred to are described in Te 21.

Source: Land Protection Division - Department of Conser tion, Forests and Lands 1986

Table 21

DRYLAND SALINITY CLASSES

Class		Indicator agricultural plant species
S0	Non-saline	Salt-sensitive pasture and crop species present
S1	Slightly saline	Reduced productivity of pastures and crops
		Strawberry clover present, no other clovers
		Sea barley grass abundant
S2	Moderately saline	Salt-tolerant species dominant; no clovers present
		Facultative halophytes common
		Some bare ground
S3	Severely saline	Only salt-tolerant species present
		Obligate halophytes present
		Large areas of bare ground, with obvious salt encrustment

Source: Land Protection Division - Department of Conservation, Forests and Lands, 1986

by more than $2 million. The annual loss in productivity is estimated to be $0.4 million. If present trends continue, some districts, such as those around Manangatang and Piangil, can expect the affected area to double in size over the next 10 years.

The decline in water quality on freehold and public land is an additional cost. Salinization of the River Murray is of particular concern not only for the study area but for the States of New South Wales and South Australia, and this is further discussed in relation to salting in irrigation areas.

Parts of the Big Desert and the Sunset Country, and of the naturally saline evaporative basin plains, would be susceptible to further salinization if clearing of the native vegetation took place.

Salinity control

Studies to identify the lands affected and at risk from salting are being conducted by the government. A transect

of deep bores has been drilled between Manangatang and Ouyen and further bores are planned in critical areas such as Mittyack, Chinkapook in the Tyrrell depression, and Rainbow.

These will be used to monitor the behaviour of the regional groundwater system. Information gained during wet years will be valuable for defining local recharge areas and will improve effectiveness in targeting remedial strategies and setting priorities for those with the highest recharge rates. The decisions will take account of position in the landscape, farming system, and phase of rotation. Fallowing of sand dunes may well be a major source of recharge. Control must be tackled on a regional basis and it unlikely that the farmers actually affected by salinity can achieve anything of significance on their own properties.

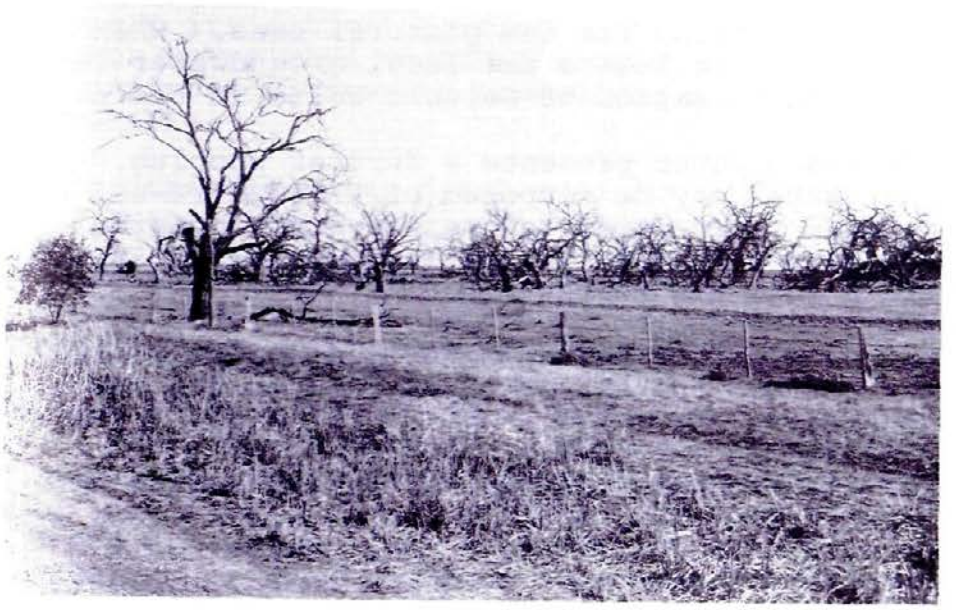
Over a period of several years, lucerne crops can reduce the moisture content of these dune soils that are giving rise to seepage salting - enough to prevent movement of the soil moisture. Spring- or summer-active perennial lucerne and winter-active medics appear to be the appropriate mixture to ensure continued pasture growth and the maximum use of water. The replacement of annuals with perennial pasture would mean a shift from the traditional cropping enterprises of most Mallee farms.

Smaller-scale control measures have an effect only where local seepage is an important contributor to the affected site. A number of land management options, including the planting of trees or lucerne, are available to increase the use of soil water, and therefore reduce groundwater recharge.

Preventative work - such as fencing and the planting of deep-rooted perennial and salt-tolerant species - has proved effective in controlling dune and channel seepage. Tree-planting is generally recommended for channel-seepage problems on relatively small areas or where shade and shelter for stock are lacking. Conversely, where sufficient shade and shelter exist, the sowing of tall wheatgrass is recommended, especially if the seepage problem extends over a large area. This grass is comparatively inexpensive to establish in a farming situation, and can provide useful strategic grazing.

Channel seepage could be reduced by replacing the existing earthen channel system, or at least the worst-affected sections, with pipes or concrete aqueducts.

Establishment of a continuous vegetative cover to reduce surface run-off and erosion is an important factor in reclaiming bare saline soils. The mulching effect of the plant cover reduces surface evaporation and hence salt accumulation at the soil surface. Tall wheatgrass and Australian salt marshgrass (*Puccinellia* spp.) can be used successfully as primary stabilizers on moderately saline areas. As the soils become less saline, lucerne and ryegrass can be established to help reduce the water table further. Perennial pastures are appropriate for the areas of local recharge.



Salting in the irrigated lands of the Mallee causes tree death and loss of productivity.

Salting in irrigation areas

Irrigation areas in the Mallee include some of the most productive lands in Australia. They support a wide range of agricultural and horticultural pursuits. However, salting is of major concern to horticultural producers along the Murray River, particularly in lower-rainfall years when the salt content of irrigation water increases through evaporation and less salt is leached out of the soil surface. Heavy soils are the most susceptible.

Irrigation has changed the natural hydraulic equilibrium between groundwater and surface water and has directly caused the raising of groundwater levels, thus 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.

In the Mildura settlement, salting due to rising water levels and mobilization of soil salts became a problem only 10 years after the commencement of irrigation. Excess irrigation water, combined with increased infiltration due to the removal of native tree cover, percolated down to form a groundwater mound perched on an impervious sedimentary layer, the Blanchetown Clay.

Salinity in Lake Charm of about 3000 EC units is of concern to the few people still irrigating from the lake. The other Kerang wetlands that form part of the water-distribution system also have slowly rising salinity levels, which concerns irrigators in the Tresco, Swan Hill, and Woorinen areas.

To overcome the problems of raised groundwater levels, most of the irrigation districts are drained either by a system

of sub-surface 'tile' drains for the vine and horticultural areas or by surface drains for the pastoral ones. When drainage is effective it lowers the local groundwater level and reduces the concentration of soluble salts in the soil.

Disposal of drainage water presents a further problem. Saline drainage water may be disposed of through re-use on the land, disposal to evaporation basins, and discharge to surface drainage systems - which, in northern Victoria, all ultimately drain into the Murray River.

Several large-scale public saline-water disposal schemes operate in the Mallee, and all of these involve the use of evaporation basins.

The Barr Creek catchment to the east of Kerang drains about 64 000 ha of irrigated land, most of which suffers from a raised water table of high salinity. The creek itself ultimately runs into the Murray River and is the largest point-source input of salt for the river's entire Victorian length.

The amount of salt discharged from Barr Creek to the Murray is partially controlled by the Lake Tutchewop diversion/ evaporation scheme constructed in 1968 and located at the downstream end of Barr Creek. This prevents 15% of the flow and salt load from entering the Murray. Works commenced in 1981 to extend the scheme by the inclusion of a series of natural depressions further to the west, known as the Mineral Reserve Basins (MRB). Completion of the MRB would have increased the diversion of Barr Creek flow and salt loads to about 24%. However, in December 1986, following considerable public concern over the project, the government decided to defer the completion of the MRB Scheme indefinitely.

Another proposal, to pipe Barr Creek water to Lake Tyrrell, has been shown to be expensive in relation to the benefits to River Murray water-users and other approaches to the problem have been pursued.

A Barr Creek Catchment Salinity Management Plan has recently been drawn up by the local community, which the government adopted in 1987 and committed $2 million to. In essence, the Plan is to reduce run-off to the Barr Creek drainage system, thus making the operation of the existing Lake Tutchewop scheme more efficient. Its key elements are whole-farm plans, landforming, on-farm re-use schemes, works on Rural Water Commission channels to reduce leakage and outfalls, and tree-planting along some 10% of the length of those channels. The plan is to be reviewed 2 years after commencement of works. A further 5 years would be necessary to complete it.

Salinity on irrigated pasture land has become less of a problem since the application of the technology of laser grading from the late 1970s. This process utilizes the high level of accuracy available through laser technology to determine level lines and to improve precision in grading the land surface so that water will flow evenly across it,

thereby improving the efficiency of water use. Some 40% of the Boort irrigation district is now laser graded, and, although not always on ideal slopes, has shown some improvement in terms of lowered accessions of water to the groundwater table.

Saline drainage water discharged from intensively irrigated lands such as near Nangiloc and Colignan is detained in drainage basins, from where it is either diverted to inland evaporation basins like Lake Iraak, Bullock Swamp, and Karadoc Swamp or released to the Murray River at rates and times that are not critical to the quality of river water.

Between Mildura and Merbein, the highly saline groundwater table formerly intruded into the Murray River in sufficient quantity to significantly raise Murray River salinity. In 1979, the Rural Water Commission installed the Mildura--Merbein Groundwater Interception Scheme, which now largely controls this input. The Scheme comprises 17 groundwater pumps situated along the river; these intercept saline groundwater before it reaches the river and pump it to a holding basin - Lake Ranfurly near Mildura - from where it is transferred to evaporation basins at Wargan, 13 km away.

Further upstream, at Lambert Island, a naturally occurring salt intrusion of similar magnitude, and covering a 10-km stretch of the river, is under investigation for possible interception and disposal.

Small trial plantations of a few hectares have been established using Broken Hill red gum and swamp yate to utilize waste water, including saline drainage water. It is expected that such woodlots will be of increasing importance for local waste-water-disposal areas in the future.

Various 'pipeline to the sea' schemes have been evaluated over the past 10 years and, in every case, have been found to be grossly uneconomic. Desalinization has a very high capital cost per tonne of salt removed and is also uneconomic. Deep aquifer injection is seldom feasible for the disposal of large quantities of drainage water.

The government recently released a draft strategy for managing the salinity of land and water resources - 'Salt Action' - which details the options available to it and action it proposes. The strategy suggests that evaporative basins are viable options - where appropriate, and subject to careful evaluation of environmental effects. Long-term solutions include reducing recharge and accession to the groundwater by planting trees, and other plants that require large volumes of water, in the recharge zones and adopting more efficient means of watering irrigation areas.

In its recommendations in 1977, the Council noted that the depressions and natural lakes used for the disposal of drainage water have considerable nature conservation value because they provide habitat for water-birds and waders. For example, Lake Tutchewop is noted for the migratory waders found there from time to time, while the Cardross Lakes often attract large numbers of water-birds.

As the salt content of these lakes increases over time, however, their value as habitat will fall until they become lifeless bodies of brine. Nevertheless, the salt usually builds up slowly and the lakes would be expected to provide useful habitat for some years. The public lands used for saline-water-disposal purposes are indicated on Map 8 as O195--O220.

Drainage Water

Drainage systems are an integral part of any irrigation scheme: removal of excess water from irrigated land is essential to maintain peak agricultural production. In the early development of such schemes, drainage was not provided concurrently with the supply works and salinity or water-logging problems soon became apparent in the more intensively developed ones.

In many of the irrigation areas in northern Victoria, the groundwater is very close to the surface and is highly saline. Because of the significant rise in groundwater levels since European settlement, due mainly to the removal of tree cover and the increased percolation of water from irrigation, accession to the groundwater is faster than outflow and in many cases drainage is now required principally as a ground-water-control measure.

The irrigation areas around Kerang, Boort, and, to a lesser extent, Swan Hill support mainly pastoral enterprises and either have no drainage or are served by surface drains. The drains, being lower than both the supply channels and the irrigated land, regularly intercept the groundwater table, which around Kerang is only about 1 m below the surface.

The disposal of drainage water can be a critical problem.

North-west of Swan Hill, the irrigated properties along the Murray River chiefly produce vine and citrus fruits. This type of agriculture requires a low water table and, to this end, subsurface drainage has been installed, using tile-drains and slotted plastic pipe, for example.

Groundwater in the Murray Basin moves generally north-west, discharging into the numerous saline lakes in the northern parts of the Mallee and into the Murray River. At the same time, accession of drainage water from irrigated land causes 'mounds' in the regional groundwater table, which disrupts the movement of the groundwater and thereby aggravates salinity problems.

In both cases, the disposal of drainage water then becomes a critical problem. Reasonable-quality drainage water can be re-used for irrigation, either as it is or 'shandied' with better-quality water, or discharged into the system for use further downstream. Drainage-water re-use schemes have become popular in recent years.

If water quality is poor then other disposal methods become necessary, as described in the previous section on salinity.

Flooding

Floods are a natural and inevitable phenomenon in which the stream and its associated floodplain form an integrated system for the carriage of heavy water flows. Many wetlands depend on seasonal flooding for their continued health and existence.

Flooding, however, is hazardous to life, health, and property and can have a serious effect on agricultural land use, particularly if areas are inundated for long periods of time.

In the Mallee the main problem is damage to crops and irrigated pasture. The terrain is generally flat and the flood-waters, although usually shallow, spread out over a wide area. It is relatively easy for landholders to protect their crops by constructing low levee banks. Levee banks in the past, however, have been constructed indiscriminately, cutting off important floodways and places where water can be stored temporarily until the flood recedes.

Levee banks channel the waters into unnaturally confined floodways and the water accelerates downstream, causing many unintended problems:

- As new levee banks are constructed, existing banks must be raised.
- As levee banks are raised in height, the risk of failure increases, and the consequences of failure become more serious.
- Flooding problems are transferred to downstream areas - this is particularly evident in the Loddon and Avoca River systems.

- Conflict arises within the community between groups on opposite sides of a river or floodway and between upstream and downstream landholders.

- Consequences such as erosion (and subsequent siltation downstream), alteration of the natural flooding patterns of wetlands, and destruction of habitat all degrade the environment of the floodplain.

The *Drainage of Land Act* (1975), and subsequent amendments, was designed to overcome these problems by setting down principles of free flow as a basis for preventing or resolving disputes, by establishing drainage authorities to administer the Act, and by empowering these authorities to prepare floodplain-management strategies. The Rural Water Commission - the drainage authority for the Mallee - is involved in a continuing program of floodplain-management studies in conjunction with local municipalities, as summarized below.

Loddon River

The Loddon River, which runs along the eastern boundary of the study area, is a braided stream occupying a wide floodplain. 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 in the State.

A number of major breakouts to the west of the Loddon would, under natural conditions, have flooded wide areas of the floodplain. Upstream of Kerang, levee banks along the western side of the river and along the main flood paths confine the spread of water from moderate-sized floods.

Levee-bank systems developed downstream of Kerang will hold against floods with a periodicity of about once in 20 years.

Kerang floods in 1909.

For bigger ones, the levee banks have a high risk of failure and a large area of rural land around the Kerang Lakes between Kerang and Fish Point is subject to flooding. The Rural Water Commission is currently preparing floodplain-management strategies for the lower Loddon region. Information collected to date includes data on flooding problems, frequencies, and flow rates, maps of flood-prone areas, and a strategy for the development of the floodplain. A master plan for the Loddon River between Serpentine and Kerang is also in preparation.

Avoca River

The character of the Avoca River changes downstream of Charlton from a reasonably well-defined course, where flooding is confined to a relatively narrow floodplain, to a divergent stream where the main course has a very limited capacity and flood-waters spread out over a wide area. The major effects of flooding are damage to roads and loss of agricultural production, particularly through damage to crops. Total damage caused in 1983 by a flood with a return period of between 30 and 45 years was estimated to be $2.32 million.

At Charlton, the Avoca River has a flood-carrying capacity of more than 30 000 ML per day, but this reduces to about 200 ML per day downstream of the off-take of Mosquito Creek. Between these two points flood flows break out of the Avoca over a wide front into the effluent streams of Tyrrell, Lalbert, and Back Creeks to the west and Mosquito Creek and the Avoca flood course to the east.

Inappropriate locations for private levee banks, water-supply channels, and roadways together with excessive weed growth, natural siltation, and land grading for agriculture have all aggravated the natural flooding characteristics.

An Avoca Floodplain Management Study in 1985 defined flooding problems, mapped prone areas, and suggested an approach to mitigation of the problems. The main thrust of the suggested strategy was to correct the imbalance in the distribution of regional flood flows. Levee banks along the west side of the River near Glenloth were found to be sending most of the flow to the east, where it ends up in Lake Bael Bael and The Marshes, instead of Lake Lalbert.

The current Avoca Flood Mitigation Study is investigating the proposal to correct the imbalance in regional flood distribution, as well as investigating other levee-bank systems along Lalbert Creek and the Avoca flood course.

Murray River

Flooding along the Murray River is extremely complex, due mainly to the huge size of its catchment and the effects of tributary inflows and effluent systems. Major floods occurred in 1870, 1917, 1931, 1956, 1974, 1975, and 1981.

A comprehensive investigation of the Murray's flooding characteristics was undertaken by consultants in 1986 as a

co-operative project between the Victorian, New South Wales, and Commonwealth governments. The Murray River Floodplain Management Study recommended a 7-year program of detailed flood investigations, with a range of priorities. The high-priority measures, as they affect the study area, include recommendations for:

- a regional hydraulic study in the vicinity of Swan Hill (Murrabit to Speewa Island)
- the implementation of certain strategies and land use/building controls at Koondrook, Swan Hill, Nyah, Robinvale, and Mildura
- the introduction of a new interstate levees agreement
- the continued implementation of the Rural Water Commission's previously adopted floodplain-management strategy for Mildura
- certain long-term measures at Pental Island and Tyntynder flats

This study included mapping of the extents of past major floods at 1:100 000 scale and the cataloguing of the nature and extent of existing and proposed works in the floodplain. The information is presented as a Floodplain Atlas.

In some locations, levees have been constructed to protect specific areas on the floodplain, and may lead to the reduction or exclusion of seasonal flooding from some wetlands or billabongs. This has occurred to a small extent in the south-west of the study area.

BIOLOGICAL HAZARDS

Human interests and activities are diverse and it is inevitable that these will overlap to some degree with the activities of other organisms. When conflict arises, the other organism becomes a hazard.

While pest plants and animals are best known for the losses they cause in agricultural land, they also have considerable impact on public land. Work required to control pest species on public land may conflict with some of the aims of management by destroying native flora and fauna or damaging their habitat, disturbing archaeological artefacts, or compromising other conservation values. Not all of the local pest plants and animals are proclaimed as noxious weeds or vermin under the provisions of the *Vermin and Noxious Weeds Act* 1958.

Pest control is a major expense associated with the management of public land. In particular, land that has been or is used for agricultural pursuits is usually affected by some pest species. Control of these pests is often the first step in reclaiming the land for nature conservation purposes, and the subsequent maintenance of that control is usually an ongoing expense.

Noxious Weeds

The largest group of noxious weeds in Victoria consists of introduced species, which often have little significance in their country of origin but thrive in disturbed Australian habitats. Of the 103 plant species in the State that have been proclaimed as noxious weeds, a survey in 1980 revealed that 55 occur herein the study area. These are listed in Appendix XXII along with an indication of the sites of main infestation of each species.

Many of the weeds have limited distribution, although they can be locally dense and cause problems at particular sites. Their impact varies throughout the region according to soil type, land use and management practices, and variation in rainfall.

Disturbance of the soil is the main factor that influences the invasion by weeds in the Mallee. Deep-rooted perennial plants (skeleton-weed, silver-leaf nightshade, and hard-heads) are serious weeds in the lighter Mallee soils because of their ability to survive prolonged dry conditions and continued cultivation. Once established, such plants are superior competitors for water and nutrients. In heavier soils in the south of the region, shallow-rooted weeds such as wild garlic can be a problem. The heavy alluvial soils associated with the rivers and creeks encourage the growth of a wide range of annual, biennial, and perennial weeds (box-thorn, Paterson's curse, spiny emex, and dodder).

On recreation areas, weeds may be aesthetically displeasing, cause discomfort through the presence of prickles or thorns, or have poisonous properties. In other areas of public land they compete with native plants and are aesthetically undesirable, but measures to control them may be incompatible with the conservation of native species. Weeds often spread between private and public land.

Weeds at the edges of public land

The noxious annual weeds are characterized by a group of burry and prickly plants - Bathurst burr, caltrop, spiny burr-grass, spiny emex, Californian burr, noogoora burr, saffron thistle, and stemless thistle. These plants are prevalent on much of the public and some private land in the study area, including roadsides, bushland reserves, and land held under grazing leases or licences. Many are characterized by successive germinations and the ability to flower and fruit under adverse conditions.

Boxthorn poses a major problem in the irrigated dairying and fruit and vegetable-growing areas, where it crowds and shades pasture, blocks access to dams and water channels, and damages fences. It also provides harbour for vermin and has become widespread on public land adjacent to the horticultural areas.

Camel thorn is a deep-rooted perennial legume. Heavy infestations occur in urban areas at Merbein and Swan Hill. It is difficult to control in urban areas because the recom-

mended herbicides are a hazard to horticultural and garden plants.

Golden dodder can parasitize a wide range of commercial crops, native plants, and other pest plants. It attacks commercially grown lucerne in parts of New South Wales and South Australia, and has been found on self-sown lucerne close to commercially grown stands in the study area. Patches of golden dodder are scattered along the full length of the River Murray here. Access to these infestations is often difficult.

Horehound is the most widespread of the noxious weeds in this area, which has the heaviest infestation in the State. It will grow on poor soils and is often one of the first plants to colonize overgrazed or eroded sites. This weed is a major problem in national, State, and regional parks. It is a common contaminant of wool and therefore is less important in the agricultural lands of the Millewa, where the emphasis is on cropping. The only means of controlling it would appear to be biological.

Khaki weed creates a serious problem in New South Wales, but in the Mallee it occurs mainly in urban parks, playing fields, and nature strips.

Spiny rush - a salt tolerant plant - which grows along channel banks, water storages, and saline basins. It can prevent stock obtaining access to water and provides excellent harbour for rabbits.

Significant weeds of horticultural land

Caltrop, spiny emex, and spiny-burr grass are becoming serious problem weeds on horticultural, agricultural, and public land. Their burrs contaminate dried fruit, and the industry is experiencing increasing resistance to the presence of the burrs in marketed products. The spiny burred fruit of spiny emex and caltrop also damage the feet of animals. Spiny burr grass is a major contaminant of wool and is vigorously avoided by shearers and abattoir workers.

Significant weeds of agricultural land

Approximately 30 000 ha of dryland cropping areas in the Mallee have become infested with hardheads, and a major eradication program is under way. Infestations may reduce grain yields by up to 95%. Hardheads are also widespread as a noxious weed of irrigated horticulture and pastures. They are difficult to eradicate in all situations.

Silver-leaf nightshade competes with grain crops causing substantial reduction in yields. The main infestations are at Lascelles and Carwarp West. A containment plan involving co-operation between the Department of Conservation Forests and Lands and affected landholders is helping to reduce the area of infestation.

Skeleton-weed is another of the most widespread weeds in the area. It not only reduces wheat yields but increases farm-

machinery maintenance costs. Biological control proved effective in controlling the plant in the past; however, a broad-leafed form of it that remains unaffected by the present biological control is now spreading rapidly.

Wild garlic occupies small areas on both private and public land, where it is mainly confined to roadsides and channels. This erect, strong-smelling perennial is potentially the most serious noxious weed of the grain industry, as the bulbils are the same size and shape as wheat grains and impart a strong odour to the harvested grain.

Wild garlic is potentially a serious noxious weed for the grain industry.

Another group of annual weeds, but not declared noxious, comprises the exotic species that have spread from agricultural land, invading the native vegetation in the partly cleared and grazed areas. Representative species are barley brass, *Bromus* spp., and the medics.

Landholders are responsible, under legislation, for the control of noxious weeds both on their properties and on the half-width of road adjoining their respective properties.

In many cases weed control is an aspect of normal agricultural land management, and may include grazing, topdressing, pasture improvement, mowing, and ploughing. In other cases, the application of hormone-like herbicides or biological control may be used to supplement management practices.

Vermin

The study area is very sensitive to damage by pest animals. In fact, its fragile soils and semi-arid environment make it one of the most sensitive regions in the State. The large areas of public land provide habitat for many species of vermin and these pose problems in land management.

Rabbits, mice, and plague locusts cause considerable losses to grain crops, pastures, and horticultural crops.

Some pest animals constitute a threat to human and animal health because they are potential vectors of disease such as rabies, swine fever, foot and mouth disease, Ross River fever, and Murray Valley encephalitis. They are also potential carriers of diseases that could decimate native animal populations, and some prey on native species.

Rabbits (*Oryctolagus cuniculus*)

European rabbits are the most numerous and damaging vermin and are widespread throughout the region. Historically, they have had a major impact on its ecology and economy. Some districts still show evidence of damage caused by the rabbit plagues that were common before the introduction of myxomatosis.

On public land, rabbits cause severe damage to native grasses and herbs, ringbark shrubs and trees, and nip the growing tips of seedlings. Their intensive grazing prevents the re-establishment of native flora such as *Callitris*. These areas then provide ideal conditions for colonization by invasive weeds such as horehound, boxthorn, onion weed, and Paterson's curse, which in turn provide harbour for rabbits and mice and crowd out desirable native flora.

The aggressive grazing habit of rabbits spoils or destroys the food source for many native grazing animals, and removes or alters the habitat of many of the smaller ground-dwelling animals. This can place the survival of some native animals at risk. Continuous overgrazing by rabbits also increases the erosion hazard.

Control of rabbits on public land is essential to the continued viability of reference areas, parks, flora and fauna, wildlife, and bushland reserves and for the protection of

Rabbits are the most numerous and damaging vermin in the Mallee - rabbit burrows.

the conservation values of the public land in general. Appendix XXIII describes the work required to achieve a satisfactory level of rabbit control in part of the Hattah--Kulkyne National Park. Initial knockdown and fencing cost almost $72.50 per hectare and ongoing maintenance more than $4.80 per hectare. This indicates the community cost that would be incurred should complete control of this species be required.

Myxomatosis has been a valuable biological control agent, especially in association with poisoning, fumigation, the ripping of warrens, and the destruction of harbouring vegetation. Estimated kills of up to 95% have been obtained, although myxomatosis has become much less effective in recent years. Fewer infected rabbits have been observed, and a substantial build-up of the rabbit population has occurred in some areas.

Rabbit-control programs are being carried out throughout the study area on both public and private land, with large-scale operations undertaken on public land at Morkalla, in the Sunset Country, and in Hattah--Kulkyne National Park.

In the dryland farming areas rabbits usually find shelter in the remnant stands of native vegetation and roadsides and, in the past, their control has necessitated the removal or damage of this vegetation in these areas. Pressure fumigators now provide a means for control of rabbits without recourse to the removal of vegetation.

On public land, rabbits tend to inhabit sandy ridges in open woodlands or treeless areas. Much of this country was covered with woodlands of *Callitris*, *Casuarina*, and *Hakea* prior to European settlement, but these species, particularly the first two, were removed by post-cutters, fire, the drought of the 1940s, and insect pests. Not only do rabbits appear to favour this habitat, they also exert severe pressure on it by their continual grazing and subsequent removal of any regenerating native trees. This problem continues on such areas, especially in the Sunset Country, Pine Plains, and the far north-west of the study area. The saltbush--blue-bush plains of the far north-west harbour large numbers of rabbits, and the vast areas involved mean that the control is expensive.

The control of vermin and noxious weeds is a condition of the licence for the use of public land for grazing. In some grazing blocks the cost of an adequate level of control of rabbits would probably exceed the income derived from the grazing of stock.

Foxes and feral cats and dogs

Red fox *(Vulpes vulpes)* is a widespread and common species throughout the study area. Although most frequently seen in, or near to, agricultural land, these animals also occur within the larger blocks of public land.

Studies have shown that mammals are the primary source of food for foxes, with rabbits the single most important prey.

They also eat other introduced mammals and a wide range of native ones (such as western grey kangaroo, echidna, common brushtail possum, and silky desert mouse), and birds, reptiles, amphibians, and invertebrates.

The research has clearly indicated that they are not major predators of sheep; although they may occasionally take young lambs, they prefer to feed on carrion and the afterbirth of lambing. Some graziers dispute this and claim that foxes attack live sheep, especially lambs. Foxes occasionally attack poultry on farmlets close to urban areas.

A study of the potential for foxes to act as hosts for rabies is in progress. The current work includes investigations of population density, movement, and control techniques. The bonus on fox scalps was lifted in 1980.

Feral cats (*Felis catus*) are also widespread throughout public and private land in the study area. It is estimated that their density in the Hattah--Kulkyne National Park, for instance, ranges between 0.74 and 2.4 cats per sq. km in winter and summer respectively.

In semi-arid environments, mammals are the main source of food for feral cats and in the Mallee comprise 87% of their food, almost three-quarters of which is rabbit. Native mammals, a wide range of reptiles, and the larger ground-feeding species of bird such as galah, Australian magpie, and various parrots are also taken.

Feral dogs (*Canis familiaris*) are widespread in the public land here, but are seldom sighted. The population includes both dogs and hybrids between dogs and dingoes. It is unlikely that any pure-bred dingoes still occur in the area, although they were certainly present, and common, at the time of European settlement.

Like foxes and cats, feral dogs take a wide variety of prey, but tend more to take the larger species of mammals such as western grey kangaroo, common brushtail possum, and echidna.

Wild dogs are of concern to graziers on land that adjoins the Big Desert, who at times, suffer significant losses of sheep. Trapping and poisoning operations are carried out in these areas when necessary.

Analysis of the diets of foxes, cats, and dogs reveal that all are opportunistic predators. Although introduced mammals, particularly rabbits, play an important part in their diets, they prey on a wide range of native wildlife.

The relative proportions of introduced and native species taken depend on the habitat occupied by the predator. In open woodland, or close to the edge of natural vegetation, introduced mammals are likely to be taken most frequently; while in the extensive tracts of mallee scrub, native fauna will comprise the greater proportion of prey species.

There is little direct evidence to show what effect feral predators have on the dynamics of wildlife populations.

Heavy predation by foxes on the nests of Murray River tortoise (*Emydara macquarri*), however, has resulted in a bias in the age structure of the tortoise due to the low level of recruitment of juveniles into the population.

The availability of an abundant prey (rabbit) may also be to the detriment of native fauna in that it maintains an artificially high population density of predators. An increase in rabbit numbers is often followed by an increase in the numbers of foxes and cats. The impact on native fauna is twofold: the greater density of predators results in a greater cropping of 'secondary' prey such as the native mammals; and when rabbit populations crash, perhaps after a myxamytosis or poisoning program, a large number of predators - previously dependent on rabbits - turn to the secondary prey for the bulk of their diet.

Even a low level of predation on native wildlife may be severely detrimental for some species. It compounds the problems they experience through the loss or degradation of habitat.

Fallen timber and clumps of vegetation that rabbits, cats, and foxes may use for shelter are often important habitat for native species such as snakes, geckos, and goannas. The destruction of such refuges, which is an integral part of vermin control, can have a heavy impact on resident native wildlife. Indeed, this has apparently already led to the decline or extinction of a number of ground-dwelling birds, small mammals, and some reptiles.

Other mammals

Hares (*Lepus capensis*) are not considered to be significant pests in the region, although they sometimes cause damage to young fruit trees in irrigation areas. They may also pose a threat to natural regeneration or to young plantations of native species.

Feral goats (*Capra hircus*) have been observed on public land in 30 parishes in the northern public land blocks of the

Large herds of up to 100 goats are common in some areas of the Mallee.

study area. They roam extensively and often enter adjoining private land. The population has not been properly assessed, but appears to comprise at least 2000 goats; herds of up to 100 are common.

Goats are heavy and non-specific grazers. Their close grazing habit causes considerable damage to native vegetation, particularly following fire when they graze shoots and seedlings on the tops of sand ridges. These areas are then prone to wind erosion.

Control of goats is undertaken by affected private landholders, and in national parks by the Department of Conservation, Forests and Lands.

Feral pigs (*Sus scrofa*) occur in colonies along the length of the River Murray downstream of Swan Hill. They appear to be nomadic, crossing the Murray to and from New South Wales, almost at random. This movement may be due to pressure from hunters and the availability of suitable food and habitat.

Pigs damage grain and grape crops. Some lamb losses have also been attributed to predation by feral pigs. Their trampling and feeding habits destroy ground cover and the habitat of native fauna and damage pastures. However, the biggest threat from wild pigs is their potential role as vectors of diseases such as anthrax, brucellosis, hydatids, leptopirosis, and pork measles, as well as foot and mouth disease and Aujeskys disease.

Feral pigs are controlled by trapping, shooting, and poisoning. This has only a temporary effect, as treated areas are regularly re-infested from across the River Murray.

The House mouse (*Mus musculus*) occurs widely throughout the study area on both private and public land. It was recorded in 87% of the sites on public land surveyed recently by the Department of Conservation, Forests and Lands (see Chapter 8 - Fauna).

Normally the mouse population is low and presents no serious problems. Periodically, however, it builds up to plague proportions, usually on private land, when a mild winter follows a better-than-average grain crop with good summer rains. In plague proportions, mice cause damage amounting to several million dollars to grain, fruit and vegetable crops, fodder, groceries, machinery, household goods, and electrical wiring and appliances. The 1979/80 plague was estimated to have caused $30 million damage.

Recent CSIRO research has established the population dynamics of mouse-plague development and has introduced a predatory rematode that can prevent that development. Poisoning can effectively prevent them eating planted vegetable seed.

Birds and fish

Sparrows (*Passer domesticus* and *P. montancis*) and starlings (*Sturnus vulgaris*) are common in the region around townships

and irrigated fruit and vegetable crops. They cause considerable damage to grape, stone-fruit, berry, and some vegetable crops. No control work, other than the removal of the boxthorn bushes that provide harbour for sparrows, is undertaken by the government.

Carp (*Cyprinus carpio*) were first recorded for this region at Lake Hawthorn, near Mildura, in the 1960s and have spread rapidly through the River Murray system. They are now common in almost all permanent waters in the study area. The species was formally declared a noxious fish in 1962, and since that time control has been attempted using chemical and removal methods. Recent research using Spring *Viraemia* virus as a biological control, while at first promising, has been abandoned because of problems in determining its effect on native aquatic fauna, the low temperature at which it is effective, and the high probability of resistant hybrid stock developing.

It has long been considered that carp greatly increase water turbidity, destroy aquatic vegetation, and adversely effect native fish and other aquatic fauna. Recent investigations have shown that such effects are not as great as at first believed. The carp will remain an established part of the aquatic fauna, as no practical means of eradication are available. It will, however, continue to be declared a noxious fish.

Marron (*Cherax tenuimanus*) is a large freshwater crayfish native to Western Australia. It has an established reputation as a popular food item, with specimens reaching 40 cm in length and weighing more than 1.5 kg. For this reason, it is regarded as more suited for aquaculture than the indigenous yabbie (*Cherax destructor*). As a result of deliberate and accidental releases, marron has expanded its range in Western Australia, and is now also found in other States.

Concern has been expressed that marron, if commercially grown in Victoria, may escape and establish themselves in the wild. Such feral populations may be damaging to the local aquatic biota, and are potential sources for disease organisms not currently present in the waterways of the State. Marron therefore has been declared a noxious and prohibited fish in Victoria. It is probably already present here, albeit in small numbers. Eradication of any existing populations will occur as they are identified.

Other pest species

Australian plague locusts (*Chortoicetes terminifera*) usually breed in New South Wales and southern Queensland, where they are a recurrent pest. Plagues are less frequent in Victoria, but flying swarms that escape spraying by the Australian Plague Locust Commission enter the State about once every 5--8 years from the breeding grounds further north, and considerable damage can occur.

Significant invasions by locust swarms occurred in the summers of: 1869--73, 1875, 1934, 1946, 1950, 1953, 1971--73,

and 1984. The damage they inflict is greatest in the Millewa area, but can extend as far south as Wycheproof and the Wimmera. In the 1984 plague, they caused losses costing $1.2 m in the Mallee - $1 m to ripening crops and $200 000 to horticultural and other irrigated crops.

Locusts breed to a small extent in north-western Victoria, from over-wintering eggs laid during the pre-plague autumn build up, but the numbers are usually too small to be significant. Bare scalded areas in open country are favoured egg-laying sites. Plague locusts on public land are destroyed when possible at the banding (pre-flying) stage of growth.

European wasps (*Vespula germanica*) are predatory scavenging insects that are usually confined to urban areas. In this region they have been recorded at Mildura, Swan Hill, and Sea Lake. Wasps prefer to nest in habitated areas where they can scavenge for food. All food and drink consumed outdoors should be closely examined, as wasps in cans of beverage or on food will sting repeatedly and can cause painful and serious injury.

To date no wasps have been found on public land in the study area, but they could be transported to parks, picnic areas, and camping sites on food. They could threaten the bee industry, as they have been known to attack hives.

Honey bees (*Apis mellifera*) turned feral may displace the native fauna from tree hollows or become the carriers of disease. During dry seasons they have become nuisances around campsites in their search for water. Further information about honey bees is provided in Chapter 12 - Primary Production.

Cereal cyst nematode (*Heterodena avenae*) readily infests cereal crops on most soil types of the Mallee, but particularly the loams or sandy clay loams such as the calcareous earths. It lives in the soil and damages the roots of young plants.

Nearly a million hectares of cropping land in the study area are believed to be infested by the nematode, causing losses in yields valued at nearly $20 m per year. Since the early 1980s a soil bio-assay 'Sironem' has been available to predict the potential damage from nematodes in the following season. With this information farmers can decide on management strategies, which include the use of resistant varieties, crops that are not be affected, and nematicides.

Native wildlife

Emus and kangaroos create problems by damaging fences and by eating fodder and crops, especially those that adjoin public land. Permits may be issued for their destruction, but the object of the permit is to enable farmers to disturb them rather than destroy all of the animals causing concern.

On public land, the populations of these species sometimes reach high numbers and the onset of adverse conditions such

Emus may create problems by eating fodder and crops.

as drought results in many deaths. Excessive populations on public land have at times required control to reduce grazing pressure on the native vegetation. This has been attempted on the populations of western grey kangaroos in the Hattah--Kulkyne National Park, for instance.

Other native birds occasionally cause localized problems in the study area. Galahs, sulphur-crested cockatoos, long-billed corellas, ravens, and rosellas may damage horticultural crops, principally grapes, almonds, and cereals. In some cases, the Department of Conservation Forests and Lands issues permits for their destruction. Possums are often a nuisance in towns.

Public land grazing

Grazing of domestic stock on public land may produce several effects that reduce the land's potential for a number of future uses, especially those involving nature conservation and recreation. It reduces the diversity of the native vegetation, and usually introduces exotic weed species. Grazing pressure from stock and rabbits is at least partly responsible for the lack of regeneration in the *Callitris* and *Casuarina* stands and the loss of salt pan vegetation that occur in many of the grazing areas. These changes to the vegetation, and trampling by stock, also lower the value of the land as wildlife habitat. The extent of public land affected by grazing is indicated on Map 12 and further discussed in other chapters, particularly Chapter 7 - Vegetation.

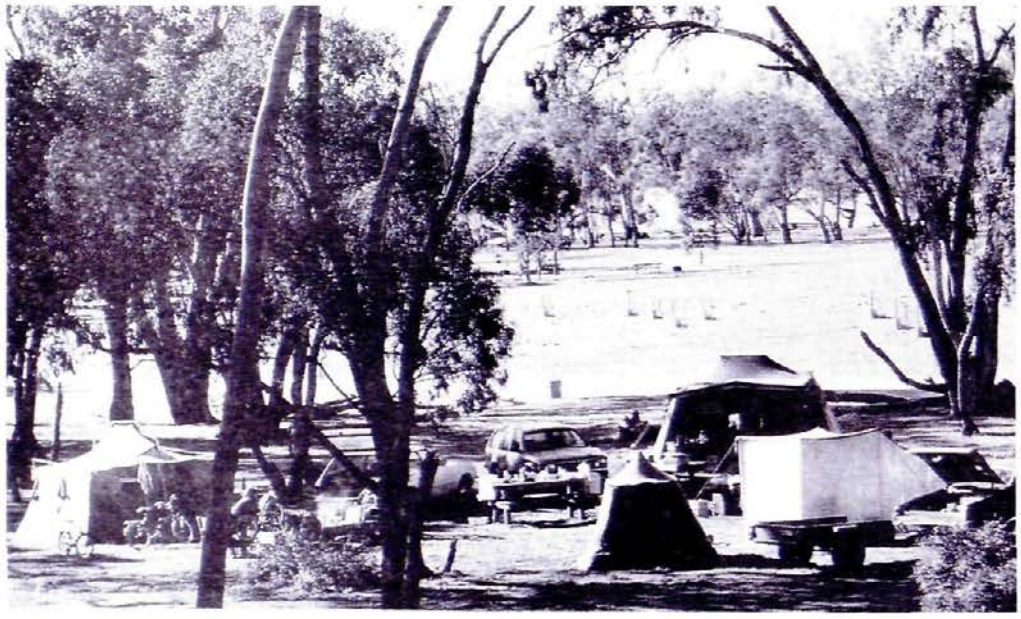
One of the Council's consultants that investigated the agricultural use of public land in the Mallee area noted that 'grazing by sheep, even at low levels, is deleterious to all mallee vegetation types. Grazed areas are immediately obvious by the poor condition of the understorey. In naturally grassy areas, there is a preponderance of introduced pasture species and other weeds, a marked decline of palatable native species - especially the normally diverse herb flora - an increase in unpalatable ones, and increased soil

disturbance. In non-grassy understoreys, the understorey is unnaturally open, species poor, and there are large areas of bare ground.'

The impact of grazing on native flora can be reduced by careful management - based on controlling stock numbers according to the condition of the vegetation and on providing sufficient watering points.

Recreation as a Land-use Hazard

Outdoor recreation in general is an acceptable primary or secondary use of much of the public land, and the various activities differ in their impact on the land. Generally, any activity pursued at a low level of intensity poses little threat to the environment. As intensity increases, however, conflicts and problems can arise. There is always the problem of recreation damaging the environment it seeks to use.



As recreation intensity increases, conflicts and problems can arise.

In some areas - where the vegetation and soils are sensitive to damage, where water quality may be affected, and where the natural environment or special features are being preserved - some controls on the levels or patterns of recreational use may be imposed.

The nature of much of the public land in the north-west means that recreational use of the area creates special problems for recreation management. The woodlands and semi-arid plant communities present few barriers to vehicle-based recreationists. While this enables people to explore and enjoy the many different environments in the region, unrestricted access can create major difficulties and impacts, and has done so.

Vehicle use in the Sunset Country and Big Desert is scattered, but a significant amount of this activity is concentrat-

Uncontrolled vehicle access can create erosion problems.

ed where tracks cross the higher sand dune areas and where visitors are attracted by the prospect of a view across the deserts. This concentration of vehicle use results in destruction of vegetation on the dune and the development of severe wind erosion or blow-outs. Stabilization of these areas in the Mallee environment presents its own difficulties, and tracks throughout the sand country remain evident for a great many years.

Uncontrolled tracking by broombush-cutters and apiarists is also leading to a proliferation of tracks through the mallee scrub and heathlands. Multiple tracks along the floodplains of the Murray River are largely produced by recreational traffic.

The use of vehicles also results, around the many lakes and lunettes in the north-west, in localized destruction of vegetation and the cracking or scarring of the surface of these areas. As well as the visual intrusion, this scarring by vehicle wheels opens the surface crust to wind erosion and modifies water flows when the lakes contain water.

Recreation along the Murray River

A major and growing problem along the Murray River is presented by the proliferation of dispersed mooring points for houseboats adjacent to the public land water-frontage reserve. Bank erosion, sub-standard mooring and sanitation facilities, the installation of power and telephone lines, the construction of illegal slipways, and concentrations of litter are all common problems leading to degradation of the frontage and the reduction of public access.

Deterioration of camp-sites and the accumulation of litter around them makes the river-banks both visually unpleasant and hazardous to health. Feral pigs and scavenging native animals add to the problem by disturbing buried rubbish.

Activities on land adjacent to the frontage have often encroached on public land with illegal clearing, buildings, storage areas, jetties, boat moorings, and rubbish. Furthermore, a number of huts have been constructed illegally on the reserve, which effectively gave exclusive use to portion of the frontage to the occupiers. Many of these huts have since been removed.

The visual amenity of the river-bank is also impaired by the proliferation of pumpsheds and pipelines providing water for irrigation and domestic purposes, and by sand-extraction activities.

Few developed recreational facilities such as toilet blocks (except at caravan parks) are available on public land, because of the cost inherent in their establishment and maintenance and because the periodic floods that inundate large areas can restrict access and damage the facilities.

References

ACIL Australia Pty Ltd (1983). 'Causes, Extent, and Effects of Salinity in Victoria.' Report to the Parliamentary Salinity Committee. (Government Printer: Melbourne).

Burt, T.J. (1982). Problems associated with camping along the Murray River. *Unpublished Report, Department of Conservation, Forests and Lands, Horsham, Victoria.*

Coman, B.J. (1973). The diet of the red fox, *Vulpes vulpes* (L), in Victoria. *Australian Journal of Zoology*, 21, 391--401.

Government of Victoria (1987). 'Salt Action. Victoria's Strategy for Managing the Salinity of Land and Water Resources.' (Government Printer: Melbourne.)

Jones, E., Coman, B.J. (1981, 1982). Ecology of the feral cat, *Felis catus* (L) in south-eastern Australia. 1. Diet. III. Home ranges and population ecology in semi-arid north-west Victoria. *Australian Wildlife Research*, 8, 537--47; 9, 409--20.

Lane, D., Riches, K., Combellack, H. (1980). A survey of the distribution of the noxious weeds in Victoria. *Unpublished Report, Department of Crown Lands and Survey, Victoria.*

Parsons, W.T. (1986). 'Noxious Weeds of Victoria.' (Inkata Press: Melbourne.)

Rolls, E.C. (1969). 'They All Ran Wild: the Story of Pests on the Lands in Australia.' (Angus and Robertson: Sydney.)

Thompson, M.B. (1983). Populations of the Murray River tortoise, *Emydura* (Chelodina): the effect of egg predation by the red fox (*Vulpes vulpes*). *Australian Wildlife Research*, 10, 363--71.

APPENDICES

Appendix I

GLOSSARY

Aeolian material	-	any wind-transported material; includes loess (known locally as parna) - silt or clay-sized particles that are transported in suspension as dust; and sand that moves by saltation
Alluvial	-	pertaining to or composed of alluvium, or deposited by a stream or running water
Anabranch	-	a diverging branch flowing out of a main stream and rejoining it further downstream
Biome	-	a major regional ecological community of plants and animals extending over large areas
Bryozoan	-	an invertebrate of the phylum Bryozoa and characterized chiefly by colonial growth and a calcareous skeleton; stratigraphic range is Ordovician to present
Calcareous	-	containing calcium carbonate: when applied to a rock, implies up to 50%
Calcrete	-	any material hardened by enrichment with calcium carbonate
Coarse soil material	-	refers to soil particle diameter; sands are coarse - their particle size range is from 2mm to 0.02mm (see also fine soil material)
Compaction (of soils)	-	increase in the density of soil as a result of applied loads or pressure from, for example, cropping machinery or domestic grazing stock; impedes root growth and tends to reduce crop yield
Confined aquifer	-	an aquifer bounded above and below by beds of distinctly lower permeability than that of the aquifer itself
Copi	-	see gypsite
Deflation	-	removal of loose material by wind
Disturbance	-	in reference to native vegetation refers to the alteration of the frequency of occurrence of species from the natural situation
Dolomite	-	limestone rock with more than 15% magnesium carbonate

Appendix I (continued...)

Dry saline land (saline clay)	-	land without a water table, naturally saline in the subsoil or throughout, and with uniform heavy soils or duplex soils in areas with less than 300 mm average annual rainfall
Duplex soil	-	soils with profiles showing marked texture change between the two upper horizons, the subsoil being much more clayey than the topsoil
Ecology	-	the scientific study of the relationships of living organisms with each other and with their environment
Ecosystem	-	a community of organisms and the environment in which they live
Efflorescence	-	one or several minerals, generally soluble salts, precipitated as a surface incrustation on a rock by evaporation of water
Effluent	-	a surface stream that flows out of a lake, or a stream or branch that flows out of a larger stream
Facultative (halophyte)	-	plants able to grow in moderately saline conditions; they can also grow in non-saline conditions, however
Fallowing	-	the practice of leaving the soil free of crops and weeds for a period of time (usually not longer than 6 months) in order to conserve soil moisture by reducing transpiration losses
Ferruginous	-	pertaining to or containing iron: said of a rock having a rusty colour due to the presence of ferric oxide; the quantity of iron does not have to be large, nor do all red rocks derive their colour from iron (ferruginize)
Fine soil material	-	this refers to the average diameter of individual soil particles; clay particles are fine - their size range is from 0.002 mm (2 microns) down (see also coarse soil material)
Fluvial	-	the results of river action (fluviatile)
Glauconite	-	characteristically bright green mica
Gypsite	-	an earthy variety of gypsum containing dirt and sand; found only in more arid regions as an efflorescent deposit; known locally as copi

Appendix I (continued...)

Gypsum - hydrous calcium sulphate, $CaSO_4.2H_2O$

Halite - common salt - sodium chloride

Heavy soils - refers to the ease of workability of the soil under cultivation; heavy soils are clay-dominated, while light soils are predominantly sandy

Horizon - a layer in the soil profile with morphological characteristics and properties that differ from those of layers below and/or above it

Indigenous - originating in a particular region

Infiltration - the entry of water into the soil surface

Invertebrate - a type of animal not having a backbone, such as a butterfly or a yabby

Lacustrine - pertaining to, produced by, or formed in a lake

Laterite - indurated, iron-rich material that hardens on exposure and is associated with a deeply weathered profile

Light soils - see heavy soils

Lime - salts containing calcium; the most common form is calcium carbonate; calcium oxide and calcium hydroxide are also lime

Loess - see aeolian material

Lunette - one of the broad, low, smooth, crescent mounds or ridges of clay loam or silty clay bordering the leeward (eastern) shore of almost every lake and swamp in the plains of northern Victoria

Marl - applies to a soft deposit consisting chiefly of a mixture of clay and calcium carbonate in varying proportions

Obligative (halophyte) - plants that require saline conditions to grow

Palaeosol - ancient or relict soil type - its morphology is not entirely explicable in terms of its present environment

Paralic - term applied to sediments that are deposited on the landward side of the coast on areas, such as lagoons, that are subject to periodic marine inundation (providing a

Appendix I (continued...)

		'mix' of marine and terrestrial sediments)
Pedal	-	containing peds (natural soil aggregates)
Permeability	-	the rate of movement of water through the soil profile
Profile	-	a soil profile is the face of the soil exposed in a vertical section, from the surface down to the parent material
Rhizone	-	prostrate or underground rootlike stem that produces both roots and shoots
Quartz	-	common form of crystalline silica (silicon oxide); quartzose - comprising principally quartz sand
Saline seepage	-	land that has a water table, and has become saline as a result of land-use changes since European settlement
Salt flat	-	land with a water table not at the surface, naturally saline in the subsoil or throughout, and carrying salt-tolerant plants
Salt pan	-	land with a water table intermittently at the surface and naturally too salty throughout to support plant growth (shown as 'salt lakes' on many maps)
Scald	-	land where erosion of soil from the surface has revealed a naturally saline or sodic horizon and is largely bare of vegetation
Sclerophyllous	-	refers to the thickening of the walls of the leaf tissues of plants as an adaptation to reduce water loss (leathery leaved)
Seral	-	progression of natural vegetation from the first established plant communities to the climax under a particular climatic regime
Siliceous	-	said of a rock containing abundant silica, especially free silica (SiO_2), the chemically resistant dioxide of silicon (silicify = harden by enrichment with silica)
Sodic	-	containing greater than 5% exchangeable sodium in the subsoil horizon/s
Strandline	-	in this study area a former shoreline now elevated above sea level

Appendix I (continued...)

Swale	-	in this study area the trough-like depression between dunes
Tectonic	-	relating to the processes that tend to build up the various features of the Earth's crust
Texture	-	the texture of a soil horizon reflects the proportions of the sand, fine sand, silt, and clay-size particles of which it is composed
Thigmothermic	-	an organism that absorbs heat from its environment (as distinct from heliothermic animals, which absorb body heat by basking in the sun)
Xerophilous (of plants)	-	adapted to extremely dry conditions

Appendix II

HISTORIC SITES

The firm of Andrew C. Ward and Associates was commissioned by the Council in 1986 to undertake a study of sites on public land related to the European exploration and settlement of the Mallee. The following list summarizes those sites the consultant identified.

The sites are referenced to the relevant National Topographic Map Series 1:100 000 mapsheets, the names of which would also indicate the general region of the Mallee in which the sites are located. The list includes the level of significance that the consultant afforded each site.

Significance is ranked as follows:

A Important at the State level
B Important at the regional level
C Important at the local level
D Of interest at the local level
E Also of interest at the local level, but less than D

Mapsheet/site	Ranking
Albacutya	
Rainbow cemetery	C
Bellbird	
Bellbird bore-site	C
Lehmann farmhouse	C
lime-burning kilns ?	C
rock holes	A
rock holes bore-site	C
Birchip	
Birchip SRWSC office	C
Birchip former court house	C
Pioneer woman memorial	C
Sea Lake hall	C
Sea Lake court house	C
Willangie East school site	D
Woomelang railway station	A
Woomelang school	C
former Woomelang court house	C
Danyo	
Cowangie - sign	C
Cowangie - water reserve	C
Danyo weighbridge	C
Murrayville railway station	A
Murrayville court house	C
public bores	A
sheep pens	C
Hopetoun	
Beulah West hall	C
experimental orchard	C
gypsum mine site	C
Hopetoun town water supply	C
Hopetoun school	B
Kenmare school	B
Kenmare cemetery	C
Nypo school	C
Wyperfeld National Park	
- whim	C
- grave	D
- Wonga hut	C
Yarriambiack Creek reservoir (i)	B
Yarriambiack Creek reservoir (ii)	B
Lalbert	
Cannie Ridge pumping station	C

Appendix II (continued...)

Mapsheet/site	Ranking
Lindsay	
Karween railway station	C
Meringur hall	C
Meringur town water supply	B
Meringur land office	C
Millewa pumping station site	B
Morkalla railway station site	C
Kerang	
Budgerum cemetery	C
Budgerum public tank	B
Budgerum weir	C
former Budgerum East school	C
Cranes Lake saltworks	C
Dingwall school	C
Kunat school site	E
Lake Meran hall	C
Lake Meran school site	E
Mystic Park war memorial	C
former Quambatook weir	D
Spencer's Lake saltworks	C
Mildura	
Irymple railway station	A
Kings Billabong pumping station	B
Merbein brickworks	C
Merbein cemetery	C
Merbein pumping station	B
Merbein main channel	C
Nicholls Point pumping station	B
Psyche Bend pumping station	A
Redcliffs main pumping station	C
Redcliffs A re-lift pumping station	A
Redcliffs old urban pump	A
Redcliffs C re-lift pumping station	A
Sturt memorial	C
Yelta railway causeway	C
Yelta railway roadbridge	C
Nowingi	
Brighton tank	C
Congereel tank	C
Gypsum washing plant	C
Gypsum mine	C
Gypsum mine site	C
Hattah railway station	B
Hattah railway station water tower	A
Hattah--Kulkyne National Park:	
- Mahon homestead site	D
- Brighton's block	D
- Mahon grave	C
- Brighton's bridge	C
- 'Florence Annie' wreck	C
- pumping station	A
- regulator	A
McArthur's tank	A
Millewa South railway	A
Nowingi tank	A
Spectacle Lake:	
- tramway formation	E
- hut ruin	C
- camping site	C
- saltworks	B
track formation	C
Trinita log tank	A
Nyah	
'Alewein' wreck	C
'Kookaburra' wreck	?
Nyah cemetery	C
Nyah pumping station	B
Tyntynder channel flume (i)	B
Tyntynder channel flume (ii)	A
Tyntynder channel flume (iii)	A
Ouyen	
Bugge's tank	C
Dennying channel	C
Dering pumping station	A
Fox's tank	D
Hullards tank	B
Hullards tank	A
Patchewollock railway station	A
'Pine Plains' run:	
- bridge site	B
public bores	A
public tank	C
Walpeup pumping station	C
Robinvale	
bench mark	C
Coreena Bend pumping station site	C
Coreena Bend pumping station offtake	C
Coreena Bend main channel	C
Coreena Bend pumping station	C
Murray River bridge	C
Robinvale embankment	C
Robinvale town water supply	C
Robinvale town water supply (windmill)	A
Robinvale railway station loco depot site	B
Robinvale main pumping station - stack site	C
Robinvale A re-lift pumping station	C

Appendix II (continued...)

Mapsheet/site	Ranking
Robinvale B re-lift pumping station	C
Robinvale C re-lift pumping station	C
Robinvale D re-lift pumping station	C
Robinvale E re-lift pumping station	C
Robinvale F re-lift pumping station	C
Robinvale main channel	C
Sunset	
Dry Lakes tank	C
gypsum mine site	C
gypsum washing plant	C
gypsum mine	A
Last Hope tank	C
Millewa South railway	A
Swan Hill	
Lake Boga town water supply	C
Lake Boga:	
- flying-boat repair depot	A
Lake Boga railway station	B?
Lake Boga pump memorial	B
Long Lake pumping station site	C
Tresco main pumping station site	?
Tyrrell	
Eureka pumping station	C
Lake Tyrell saltworks (i)	C
Lake Tyrell saltworks (ii)	C
Manangatang railway station	A
Underbool	
Boinka cemetery	C
'Pine Plains' homestead	A
- Everard's grave	D
- Carter's tank	C
- Conga Wonga tanks	C
Pink Lakes State Park:	
- ruin	E
- farming equipment	E
- tramway formation	B
- salt stock-pile (i)	C
- salt stock-pile (ii)	C
public bore No. 91	B
public bores	A
Torrita public hall	A
Underbool railway station	B
Wedderburn	
former Barraport school	C
Barraport West re-lift pumping station	A
Weimby	
bench march	C
'Hero' wreck	A
Koorkab	E
602-mile tree	C
Natya railway station	D
Natya hall	C
Yungera railway station site	C
Wentworth	
'Kablan' homestead	E
'Kulnine' homestead fence	C
Lock 9 school site	C
Lock-masters residence	B
Millewa main pumping station site	C
Millewa A pumping station	A
Millewa B pumping station site	C
Ned's Corner:	
- homestead site	D
'Secret' grave	C

Appendix III

PRIVATE WATER DIVERSIONS

Source	Irrigation			Domestic & stock		Total annual Volume (ML)
	No of author-ities	Area (ha)	Annual volume (ML)	No of author-ities	Annual volume (ML)	
Avoca River	60	971.5	3 334.4	1	2.2	3 336.6
Lake Albacutya	0	0.0	0.0	1	2.2	2.2
Lake Bael Bael	1	1.6	11.8	1	2.2	14.0
Lake Boga	1	2.0	11.1	46	118.8	129.9
Lake Charm	1	1.6	11.8	1	2.2	14.0
Lake Cullulleraine	9	34.9	245.2	9	19.8	265.0
Lake Kangaroo	0	0.0	0.0	15	50.6	50.6
Lake Lalbert	0	0.0	0.0	1	2.2	2.2
Lake Leaghur	1	2.5	15.0	0	0.0	15.0
Lake Lookout	1	102.8	316.0	0	0.0	316.0
Lake Meering	7	236.6	1 425.4	1	2.2	1 427.6
Lindsay Creek	5	1 014.6	9 295.0	3	6.6	9 301.6
Loddon River	0	0.0	0.0	4	8.8	8.8
Margooya Lagoon	1	1.2	13.0	0	0.0	13.0
Mosquito Creek	6	87.3	308.3	0	0.0	308.3
Narcooyia Creek	13	415.4	3 742.5	3	6.6	3 749.1
Sand Hill Lake	5	40.9	149.0	0	0.0	149.0
Wallpolla Creek	0	0.0	0.0	1	2.2	2.2
Murray River						
Murray Zone 7	24	1 354.5	8 133.5	14	30.8	8 164.3
Murray Zone 8a	138	4 064.4	34 322.1	39	105.6	34 427.7
Murray Zone 9	214	4 147.0	37 412.5	64	143.0	37 555.5
Murray Zone 10	207	6 041.9	54 433.7	24	154.3	54 588.0
Murray Zone 11	179	1 814.2	16 419.8	21	83.6	16 503.4
Little Murray	37	1 040.0	6 249.4	8	17.6	6 267.0
Euston Lock	0	0.0	0.0	2	4.4	4.4
Totals:	910	21 374.9	175 849.5	259	765.9	176 615.4

Appendix IV

URBAN WATER SUPPLIES

Town	Population	Annual supply (ML)	Comments
Towns supplied from Wimmera--Mallee Domestic and Stock System			
Berriwillock	201	80	All of these urban districts are operated by the Rural Water Commission. They are all controlled from the Rural Water Commission's Swan Hill centre with the exception of Rainbow, which is controlled from the Horsham centre.
Chillingollah	26	5	
Beulah	300	110	
Birchip	945	320	
Chinkapook	45	20	
Culgoa	194	60	
Hopetoun	950	300	
Lalbert	135	25	
Lascelles	65	30	
Manangatang	420	80	
Nandaly	90	20	
Nullawill	85	30	
Ouyen	1 600	450	
Patchewollock	100	40	
Quambatook	430	100	
Rainbow	698	200	
Sea Lake	986	420	
Speed	65	20	
Tempy	65	30	
Ultima	220	30	
Waitchie	10	5	
Walpeup	215	60	
Woomelang	297	130	
Woorinen	400	80	
Yaapeet	50	30	
Other towns supplied in the study area			
Swan Hill	9 400	3 588	Swan Hill Water Board from the Murray River
Lake Boga	520	160	
Robinvale	2 000	No data	Robinvale Water Board from the Murray River
Mildura	25 000	10 530	Sunraysia Water Board from the Murray River
Irymple	2 300	No data	
Merbein	2 000	719	
Red Cliffs	2 700	644	
Underbool	300	130	Walpeup Shire Council from RWC channel for Underbool and from bores for Murrayville and Cowangie
Murrayville	330	153	
Cowangie	50	5	
Nyah	400	122	Rural Water Commission controlled from the Swan Hill centre
Nyah West	350	156	
Piangil	250	53	
Carwarp	25	5	Rural Water Commission controlled from the Mildura centre
Werrimull	140	53	
Meringur	70	15	

Appendix V

WATER BODIES OVER 50 ML IN CAPACITY

Name	Capacity (ML)	Area (ha)	Name	Capacity (ML)	Area (ha)
Agnes	-	202.5	Lockie	1 292	142.0
Albacutya	212 790	5 844.0	Long	9 225	125.0
Arawak	615	40.5	Lookout	1 599	64.8
Bael Bael	8 300	435.0	Mannaor	148	63.0
Bambill storage	180	3.3	Meering	6 150	203.0
Bitterang	886	72.9	Middle	2 645	174.0
Boga	36 710	907.0	Mournpall	2 214	243.0
Brambruk	-	48.6	Murphys	3 454	227.0
Brockie	344	28.4	Parupa	74	8.1
Bulla	738	40.5	Pelican	584	38.5
Cantala	1 230	101.0			
Cardross and Red Cliffs basins	6 600	450.0	Ranfurly	2 624	268.0
Carpul	1 230	101.0	Reedy	3 790	204.0
Charm	21 970	528.0	Roonki	344	28.4
Coorong	14 760	810.0	Ross	123	20.3
Cullens	14 957	616.0	Round	492	20.3
Cullulleraine	2 460	40.5	Round	431	14.2
Duck	3 198	352.0	Sandhills	2 706	89.1
Gilmours	1 624	42.9	Spectacle	1 230	70.9
Green	5 166	284.0	Tchum Lake South	800	52.0
Hattah	1 476	60.8	Third	3 690	234.0
Hawthorn	4 151	198.0	Timberoo	111	6.1
Heywoods	1 181	64.8	Timboram	10 180	2 060.0
Hindmarsh	479 700	14 500.0	Tobacco	246	10.1
Iraak	2 460	81.0	Tutchewop	19 975	775.0
Kangaroo	34 360	982.0	Wahpool	-	2 025.0
Kelly	2 260	201.0	Wallace	8 659	178.0
Konardin	1 476	122.0	Walpeup	191	-
Kramen	221	24.3	Wandella	1 230	81.0
Lalbert	9 251	750.0	Wargan basins	13 750	1 144.0
Lascelles	-	24.3	Werrebean	-	-
Leaghur	1 119	52.7	William	2 700	108.0
Little	554	55.0	Wonga	123	20.3
Little Charm	541	40.5	Yando	984	81.0
Little Meering	295	50.0	Yellwell	738	81.0
			Yerang	787	64.8

Note: Weir pools on the Murray River are not included.

Appendix VI

PLANT SPECIES OF THE MALLEE AREA

KEY:

* Introduced species
Status in Victoria (d,v,e,r,x)
The symbols refer to the status of those plants considered rare or threatened in Victoria. An explanation of the symbols and a description of each species are provided in Appendix VIII.

Botanical name	Common name	Status in Victoria
GYMNOSPERMS		
CUPRESSACEAE		
Callitris columellaris	White cypress pine	d
Callitris preissii	Slender cypress pine	
Callitris verrucosa	Scrub cypress pine	
FERNS AND FERN ALLIES		
ADIANTACEAE		
Cheilanthes austrotenuifolia	Rock fern	
Cheilanthes lasiophylla	Woolly cloak-fern	r
Cheilanthes sieberi	Fern	
AZOLLACEAE		
Azolla filiculoides	Pacific azolla	
Azolla pinnata	Ferny azolla	
DENNSTAEDTIACEAE		
Hypolepis rugosula	Ruddy ground-fern	
MARSILEACEAE		
Marsilea angustifolia	Narrow-leaf nardoo	
Marsilea drummondii	Common nardoo	
Marsilea hirsuta	Short-fruit nardoo	
Pilularia novae-hollandiae	Austral pillwort	
OPHIOGLOSSACEAE		
Ophioglossum lusitanicum	Austral adder's-tongue	
Ophioglossum polyphyllum	Adder's-tongue	v
MONOCOTYLEDONS		
ALISMATACEAE		
Damasonium minus	Star-fruit	
AMARYLLIDACEAE		
Calostemma purpureum	Garland lily	r
Crinum flaccidum	Murray lily	v
**Nothoscordum inodorum*	Fragrant false-garlic	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
CENTROLEPIDACEAE		
Centrolepis cephaloformis	Cushion centrolepis	
Centrolepis polygyna	Wiry centrolepis	
Centrolepis strigosa	Hairy centrolepis	
CYPERACEAE		
Bulboschoenus medianus	Marsh club-rush	
Carex appressa	Tall sedge	
Carex bichenoviana	Sedge	
Carex breviculmis	Sedge	
Carex inversa	Sedge	
Carex tereticaulis	Sedge	
Cyperus bifax	Flat-sedge	
Cyperus concinnus	Flat-sedge	v
Cyperus difformis	Variable flat-sedge	
**Cyperus eragrostis*	Drain flat-sedge	
Cyperus exaltatus	Tall flat-sedge	
Cyperus flaccidus	Flat-sedge	v
Cyperus gunnii	Flecked flat-sedge	
Cyperus gymnocaulos	Spiny flat-sedge	
**Cyperus hamulosus*	Flat-sedge	
Cyperus lhotskyanus	Flat-sedge	
Cyperus nervulosus	Flat-sedge	e
Cyperus pygmaeus	Flat-sedge	v
Cyperus rigidellus	Flat-sedge	e
Cyperus rotundus	Nut-grass	
Cyperus squarrosus	Bearded flat-sedge	v
Cyperus victoriensis	Flat-sedge	
Eleocharis acuta	Common spike-rush	
Eleocharis pallens	Pale spike-rush	v
Eleocharis pusilla	Small spike-rush	
Eleocharis sphacelata	Tall spike-rush	
Fimbristylis aestivalis	Summer fringe-rush	
Fimbristylis velata	Veiled fringe-rush	
Gahnia lanigera	Desert saw-sedge	
Isolepis australiensis	Club-rush	
Isolepis cernua	Nodding club-rush	
Isolepis hookeriana	Club-rush	
Isolepis marginata	Club-rush	
Isolepis nodosa	Knobby club-rush	
Isolepis platycarpa	Club-rush	
Lepidosperma carphoides	Black rapier-sedge	
Lepidosperma longitudinale	Pithy sword-sedge	
Lepidosperma viscidum	Sticky sword-sedge	
Lipocarpha microcephala	Button rush	
Schoenoplectus erectus	Soft club-rush	
Schoenoplectus pungens	Club-rush	
Schoenoplectus validus	River club-rush	
Schoenus apogon	Common bog-rush	
Schoenus breviculmis	Matted bog-rush	
Schoenus brevifolius	Zig-zag bog-rush	
Schoenus nanus	Tiny bog-rush	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
CYPERACEAE (continued...)		
Schoenus racemosus	Bog-rush	r
Schoenus subaphyllus	Desert bog-rush	
GRAMINEAE		
**Agropyron repens*	English couch	
Agropyron scabrum	Common wheat-grass	
Agrostis aemula	Blown-grass	
Agrostis avenacea	Common blown-grass	
**Aira caryophyllea*	Silvery hair-grass	
**Alopecurus aequalis*	Orange fox-tail	
Alopecurus geniculatus	Marsh fox-tail	
Amphibromus neesii	Swamp wallaby-grass	
Amphibromus nervosus	Wallaby-grass	
Amphipogon caricinus	Long grey-beard grass	
Amphipogon strictus	Grey-beard grass	
Aristida behriana	Brush wire-grass	
Aristida browniana	Wire-grass	v
Aristida contorta	Sand wire-grass	
**Avellinia michelii*	Avellinia	
**Avena barbata*	Bearded oat	
**Avena fatua*	Wild oat	
**Avena sativa*	Oat	
**Avena sterilis*	Sterile oat	
Bothriochloa macra	Red-leg grass	
**Brachypodium distachyon*	False brome	
**Briza minor*	Lesser quaking-grass	
Bromus arenarius	Sand brome	
**Bromus catharticus*	Prairie grass	
**Bromus diandrus*	Great brome	
**Bromus hordeaceus*	Soft brome	
**Bromus lanceolatus*	Mediterranean brome	
**Bromus madritensis*	Compact brome	
**Bromus rubens*	Red brome	
**Bromus stamineus*	Brome	
**Bromus sterilis*	Barren brome	
**Cenchrus ciliaris*	Black buffel-grass	
**Cenchrus echinatus*	Bur-grass	
**Cenchrus longispinus*	Bur-grass	
**Chloris gayana*	Rhodes grass	
Chloris truncata	Windmill grass	
Chloris virgata	Feather finger-grass	
Cymbopogon obtectus	Silky-heads	v
Cynodon dactylon	Couch	
Dactyloctenium radulans	Finger grass	r
Danthonia caespitosa	Common wallaby-grass	
Danthonia carphoides	Short wallaby-grass	
Danthonia duttoniana	Brown-back wallaby-grass	
Danthonia eriantha	Wallaby-grass	
Danthonia geniculata	Kneed wallaby-grass	
Danthonia linkii	Wallaby-grass	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
GRAMINEAE (continued...)		
Danthonia longifolia	Long-leaf wallaby-grass	
Danthonia pilosa	Velvet wallaby-grass	
Danthonia setacea	Bristly wallaby-grass	
Deyeuxia quadriseta	Reed bent-grass	
Dichelachne crinita	Long-hair plume-grass	
Digitaria ammophila	Silky umbrella grass	v
**Digitaria sanguinalis*	Summer-grass	
Diplachne fusca	Brown beetle-grass	r
Diplachne parviflora	Beetle-grass	
Distichlis distichophylla	Australian salt-grass	
**Echinochloa colonum*	Awnless barnyard grass	
**Echinochloa crus-galli*	Common barnyard grass	
**Echinochloa utilis*	Barnyard grass	
**Ehrharta calycina*	Perennial veldt grass	
**Ehrharta longiflora*	Annual veldt grass	
Enneapogon avenaceus	Bottle-washers	
Enneapogon nigricans	Nigger-heads	
Enteropogon acicularis	Spider grass	
Eragrostis australasica	Cane grass	v
Eragrostis brownii	Common love-grass	
**Eragrostis cilianensis*	Stink grass	
Eragrostis dielsii	Mallee love-grass	
Eragrostis elongata	Close-headed love-grass	
Eragrostis falcata	Love-grass	r
Eragrostis lacunaria	Purple love-grass	
Eragrostis molybdea	Love-grass	r
Eragrostis parviflora	Weeping love-grass	
Eragrostis setifolia	Bristly love-grass	
Eragrostis tenellula	Delicate love-grass	
Eriochloa pseudacrotrichia	Early spring grass	
Eulalia fulva	Silky browntop	
Festuca littoralis	Coast fescue	
Hemarthria uncinata	Mat grass	
**Holcus mollis*	Creeping fog	
**Hordeum geniculatum*	Mediterranean barley-grass	
**Hordeum glaucum*	Barley-grass	
**Hordeum leporinum*	Barley-grass	
**Hordeum marinum*	Sea barley	
**Hordeum secalinum*	Meadow barley	
**Hordeum vulgare*	Barley	
**Lagurus ovatus*	Hare's tail	
**Lamarckia aurea*	Golden-top	
**Lolium perenne*	Perennial rye-grass	
**Lolium rigidum*	Wimmera rye-grass	
**Lophochloa cristata*	Annual cat's-tail	
**Lophochloa pumila*	Tiny bristle-grass	
**Monerma cylindrica*	Common barb-grass	
Neurachne alopecuroidea	Fox-tail mulga grass	
**Oryzopsis miliacea*	Rice millet	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
GRAMINEAE (continued...)		
Panicum decompositum	Australian millet	r
Panicum effusum	Hairy panic	
Panicum prolutum	Rigid panic	
**Parapholis incurva*	Coast barb-grass	
**Parapholis strigosa*	Slender barb-grass	
Paspalidium constrictum	Panic	
Paspalidium jubiflorum	Warrego summer-grass	
**Paspalum dilatatum*	Paspalum	
Paspalum distichum	Water couch	
**Pennisetum clandestinum*	Kikuya	
**Pennisetum macrourum*	African feather-grass	
**Pennisetum villosum*	Feathertop	
**Pentaschistis airoides*	False hair-grass	
**Periballia minuta*	Small hair-grass	
**Phalaris aquatica*	Toowoomba canary-grass	
**Phalaris canariensis*	Canary-grass	
**Phalaris minor*	Lesser canary-grass	
**Phalaris paradoxa*	Paradoxical canary-grass	
Phragmites australis	Common reed	
**Poa annua*	Annual meadow-grass	
**Poa bulbosa*	Bulbous meadow-grass	
Poa clelandii	Tussock-grass	
Poa drummondiana	Knotted poa	r
Poa fax	Scaly poa	
Poa fordeana	Forde poa	
Poa labillardieri	Tussock-grass	
Poa sieberiana	Tussock-grass	
**Polypogon maritimus*	Coast beard-grass	
**Polypogon monspeliensis*	Annual beard-grass	
Pseudoraphis spinescens	Spiny mud grass	
Puccinellia stricta	Australian saltmarsh-grass	
**Schismus barbatus*	Arabian grass	
**Secale cereale*	Rye	
**Setaria glauca*	Pale pigeon-grass	
**Setaria verticillata*	Whorled pigeon-grass	
**Sorghum halepense*	Johnson grass	
Sporobolus caroli	Yakka grass	r
Sporobolus mitchellii	Short rat-tail grass	
Sporobolus virginicus	Salt couch	
**Stenotaphrum secundatum*	Buffalo grass	
Stipa acrociliata	Graceful spear-grass	
Stipa aristiglumis	Plump spear-grass	
Stipa drummondii	Cottony spear-grass	
Stipa elegantissima	Feather spear-grass	
Stipa eremophila	Desert spear-grass	
Stipa scabra	Spear-grass	
Stipa hemipogon	Half-bearded spear-grass	r
Stipa macalpinei	Annual spear-grass	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
GRAMINEAE (continued...)		
Stipa mollis	Spear-grass	
Stipa nitida	Balcarra grass	
Stipa nulla-nulla	Club spear-grass	v
Stipa pilata	Prickly spear-grass	v
Stipa platychaeta	Flat-awned spear-grass	
Stipa semibarbata	Fibrous spear-grass	
Stipa setacea	Corkscrew spear-grass	r
Stipa tuckeri	Spear-grass	e
Themeda australis	Kangaroo grass	
Tragus australianus	Small burr-grass	r
Triodia irritans	Common porcupine grass	
Triodia scariosa	Porcupine grass	
Triraphis mollis	Needle grass	r
Trisetum spicatum	Bristle-grass	
**Triticum aestivum*	Wheat	
**Vulpia bromoides*	Squirrel-tail fescue	
**Vulpia ciliata*	Fringed fescue	
**Vulpia megalura*	Fox-tail fescue	
**Vulpia membranacea*	Dune fescue	
**Vulpia muralis*	Fescue	
**Vulpia myuros*	Rat's-tail	
HYDROCHARITACEAE		
Hydrilla verticillata	Hydrilla	
Ottelia ovalifolia	Swamp lily	
Vallisneria gigantea	Eel-weed	
HYPOXIDACEAE		
Hypoxis hookeri	Tiny star	
Hypoxis hygrometrica	Golden weather-glass	
IRIDACEAE		
**Gynandriris setifolia*	Thread iris	
**Homeria collina*	Cape tulip	
**Homeria miniata*	Two-leaf cape tulip	
**Romulea rosea*	Common onion-grass	
**Sisyrinchium iridifolium*	Striped rush-leaf	
JUNCACEAE		
**Juncus acutus*	Sharp rush	
Juncus aridicola	Rush	
**Juncus articulatus*	Jointed rush	
Juncus bufonius	Toad rush	
Juncus caespiticius	Grassy rush	
**Juncus capitatus*	Capitate rush	
Juncus filicaulis	Thread rush	
Juncus flavidus	Rush	
Juncus holoschoenus	Joint-leaf rush	
Juncus ingens	Giant rush	
Juncus pallidus	Pale rush	
Juncus radula	Hoary rush	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
JUNCACEAE (continued...)		
Juncus subsecundus	Finger rush	
Juncus usitatus	Rush	
Juncus vaginatus	Clustered rush	
JUNCAGINACEAE		
Triglochin calcitrapa	Spurred arrow-grass	
Triglochin centrocarpa	Dwarf arrow-grass	
Triglochin hexagona	Six-point arrow-grass	v
Triglochin minutisssima	Tiny arrow-grass	
Triglochin procera	Water-ribbons	
Triglochin striata	Streaked arrow-grass	
LEMNACEAE		
Lemna minor	Common duckweed	
Spirodela oligorrhiza	Thin duckweed	
Wolffia australiana	Tiny duckweed	
LILIACEAE		
Arthropodium minus	Small vanilla-lily	
**Asparagus asparagoides*	Smilax asparagus	
**Asparagus officinalis*	Asparagus	
**Asphodelus fistulosus*	Onion weed	
Bulbine bulbosa	Bulbine lily	
Bulbine semibarbata	Leek lily	
Caesia lateriflora	Sand lily	r
Dianella laevis	Pale flax-lily	
Dianella revoluta	Black-anther flax-lily	
Dichopogon fimbriatus	Nodding chocolate-lily	
Laxmannia sessiliflora	Dwarf wire-lily	
Lomandra collina	Pale mat-rush	
Lomandra effusa	Scented mat-rush	
Lomandra juncea	Desert mat-rush	
Lomandra leucocephala	Woolly mat-rush	
Lomandra micrantha	Small-flower mat-rush	
Thysanotus baueri	Mallee fringe-lily	
Thysanotus juncifolius	Rush fringe-lily	
Thysanotus patersonii	Twining fringe-lily	
Tricoryne elatior	Yellow rush-lily	
Wurmbea dioica	Early nancy	
Xanthorrhoea minor	Small grass-tree	
Xanthorrhoea semiplana	Grass-tree	r
NAJADACEAE		
Najas tenuifolia	Water nymph	
ORCHIDACEAE		
Caladenia catenata	Pink fingers	
Caladenia deformis	Bluebeard caladenia	
Caladenia dilatata	Green-comb spider-orchid	
Caladenia filamentosa	Daddy long-legs	
Caladenia leptochila	Narrow-lip spider-orchid	v

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
ORCHIDACEAE (continued...)		
Calochilus campestris	Copper beard-orchid	
Calochilus robertsonii	Purplish beard-orchid	
Diuris palustris	Swamp diuris	v
Lyperanthus nigricans	Red-beaks	
Microtis unifolia	Common onion-orchid	
Orthoceras strictum	Horned orchid	
Prasophyllum elatum	Tall leek-orchid	
Prasophyllum fuscum	Tawny leek-orchid	r
Prasophyllum nigricans	Mallee midge-orchid	
Prasophyllum odoratum	Sweet leek-orchid	
Prasophyllum rufum	Dark midge-orchid	
Pterostylis alata	Striped greenhood	
Pterostylis biseta	Rusty-hood	
Pterostylis boormanii	Boorman's greenhood	r
Pterostylis cycnocephala	Swan greenhood	
Pterostylis hamata	Scaly greenhood	r
Pterostylis longifolia	Tall greenhood	
Pterostylis mutica	Midget greenhood	
Pterostylis nana	Dwarf greenhood	
Pterostylis plumosa	Bearded greenhood	
Pterostylis rufa	Rusty-hood	
Pterostylis scabra	Greenhood	
Pterostylis vittata	Banded greenhood	
Thelymitra antennifera	Rabbit-ears	
Thelymitra canaliculata	Azure sun-orchid	v
Thelymitra nuda	Plain sun-orchid	
PHILYDRACEAE		
Philydrum lanuginosum	Woolly waterlily	r
POTAMOGETONACEAE		
Potamogeton crispus	Curly pondweed	
Potamogeton ochreatus	Blunt pondweed	
Potamogeton pectinatus	Fennel pondweed	
Potamogeton perfoliatus	Perfoliate pondweed	
Potamogeton tricarinatus	Floating pondweed	
RESTIONACEAE		
Hypolaena fastigiata	Tassel rope-rush	
Lepidobolus drapetocoleus	Scale-shedder	
TYPHACEAE		
Typha domingensis	Bulrush	
Typha orientalis	Bulrush	
ZANNICHELLIACEAE		
Lepilaena bilocularis	Small-fruited water-mat	
Lepilaena cylindrocarpa	Long-fruited water-mat	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
	DICOTYLEDONS	
AIZOACEAE		
**Aptenia cordifolia*	Heart-leaf ice-plant	
**Carpobrotus aequilaterus*	Angled pigface	
Carpobrotus modestus	Inland pigface	
Carpobrotus rossii	Karkalla	
Disphyma clavellatum	Rounded noon-flower	
**Galenia pubescens*	Galenia	
**Glinus lotoides*	Hairy carpet-weed	
**Glinus oppositifolius*	Slender carpet-weed	
**Mesembryanthemum aitonis*	Angled ice-plant	
**Mesembryanthemum crystallinum*	Common ice-plant	
**Mesembryanthemum nodiflorum*	Ice-plant	
**Psilocaulon tenue*	Wiry noon-flower	
Sarcozona praecox	Sarcozona	
Tetragonia eremaea	Annual spinach	r
Tetragonia tetragonioides	New Zealand spinach	
AMARANTHACEAE		
Alternanthera denticulata	Lesser joyweed	
Alternanthera nodiflora	Common joyweed	
**Alternanthera pungens*	Khaki weed	
**Amaranthus albus*	Stiff tumbleweed	
**Amaranthus caudatus*	Love-lies-bleeding	
Amaranthus grandiflorus	Large-flower amaranth	
Amaranthus macrocarpus	Amaranth	v
**Amaranthus viridis*	Green amaranth	
Ptilotus atriplicifolius	Silver-tails	
Ptilotus erubescens	Hairy-tails	e
Ptilotus exaltatus	Lamb-tails	
Ptilotus nobilis	Yellow-tails	e
Ptilotus polystachyus	Long-tails	e
Ptilotus seminudus	Rabbit-tails	
Ptilotus spathulatus	Pussy-tails	
ANACARDIACEAE		
**Schinus molle*	Pepper-tree	
ARALIACEAE		
**Hedera helix*	Ivy	
ASCLEPIADACEAE		
**Asclepias fruticosa*	Swan plant	
Leichardtia australis	Austral doubah	v
Rhyncharrhena linearis	Purple pentatrope	v
BORAGINACEAE		
**Amsinckia calycina*	Hairy fiddle-neck	
**Amsinckia intermedia*	Common fiddle-neck	
**Amsinckia lycopsoides*	Bugloss fiddle-neck	
Cynoglossum australe	Australian hound's-tongue	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
BORAGINACEAE (continued...)		
Cynoglossum suaveolens	Sweet hound's-tongue	
**Echium plantagineum*	Paterson's curse	
Halgania cyanea	Rough halgania	
Halgania lavandulacea	Lavender halgania	
Heliotropium asperrimum	Rough heliotrope	v
Heliotropium curassavicum	Smooth heliotrope	
**Heliotropium europaeum*	Common heliotrope	
**Heliotropium supinum*	Creeping heliotrope	
**Lithospermum arvense*	Corn gromwell	
Myosotis australis	Austral forget-me-not	
Omphalolappula concava	Burr stickseed	
Plagiobothrys elachanthus	Hairy forget-me-not	
Plagiobothrys plurisepalus	White rochelia	
CACTACEAE		
**Opuntia robusta*	Wheel pear	
**Opuntia stricta*	Common prickly-pear	
CAESALPINIACEAE		
Cassia artemisioides	Silver cassia	x
Cassia nemophila	Desert cassia	
CALLITRICHACEAE		
Callitriche sonderi	Matted water starwort	
CAMPANULACEAE		
Wahlenbergia communis	Tufted bluebell	
Wahlenbergia fluminalis	River bluebell	
Wahlenbergia gracilenta	Annual bluebell	
Wahlenbergia litticola	Bluebell	
Wahlenbergia quadrifida	Bluebell	
Wahlenbergia stricta	Tall bluebell	
Wahlenbergia tadgellii	Bluebell	
Wahlenbergia tumudifructa	Bluebell	
CARYOPHYLLACEAE		
**Arenaria leptoclados*	Lesser thyme-leaved sandwort	
**Cerastium glomeratum*	Common mouse-ear chickweed	
Gypsophila australis	Austral chalkwort	
**Herniaria hirsuta*	Herniaria	
**Petrorhagia velutina*	Hairy pink	
**Polycarpon tetraphyllum*	Four-leaved allseed	
Sagina apetala	Common pearlwort	
Sagina procumbens	Spreading pearlwort	
Scleranthus minusculus	Cushion knawel	
**Silene apetala*	Catchfly	
**Silene conica*	Striated catchfly	
**Silene gallica*	French catchfly	
**Silene longicaulis*	Portuguese catchfly	
**Silene nocturna*	Mediterranean catchfly	
**Silene vulgaris*	Bladder campion	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
CARYOPHYLLACEAE (continued...)		
Spergularia diandra	Lesser sand-spurrey	
Spergularia media	Coast sand-spurrey	
**Spergularia rubra*	Red sand-spurrey	
Stellaria caespitosa	Starwort	
Stellaria filiformis	Thread starwort	
**Stellaria media*	Chickweed	
Stellaria multiflora	Rayless starwort	
**Stellaria pallida*	Lesser starwort	
Stellaria palustris	Swamp starwort	
**Vaccaria pyramidata*	Cow soapwort	
CASUARINACEAE		
Casuarina cristata	Belah	
Casuarina luehmannii	Buloke	
Casuarina muelleriana	Slaty she-oak	
Casuarina obesa	Swamp she-oak	e
Casuarina paludosa	Scrub she-oak	
Casuarina pusilla	Dwarf she-oak	
Casuarina stricta	Drooping she-oak	
CERATOPHYLLACEAE		
Ceratophyllum demersum	Common hornwort	
CHENOPODIACEAE		
Atriplex acutibractea	Saltbush	
Atriplex angulata	Angular saltbush	v
Atriplex australasica	Saltbush	
Atriplex eardleyae	Eardley's saltbush	
Atriplex inflata	Saltbush	
Atriplex leptocarpa	Slender-fruit saltbush	
Atriplex limbata	Spreading saltbush	
Atriplex lindleyi	Baldoo	
Atriplex muelleri	Saltbush	
Atriplex nummularia	Old-man saltbush	
Atriplex paludosa	Marsh saltbush	
Atriplex papillata	Saltbush	
**Atriplex patula*	Common orache	
Atriplex pseudocampanulata	Saltbush	
Atriplex pumilio	Mat saltbush	
Atriplex rhagodioides	Silver saltbush	v
Atriplex semibaccata	Berry saltbush	
Atriplex spongiosa	Pop saltbush	
Atriplex stipitata	Kidney saltbush	v
Atriplex suberecta	Sprawling saltbush	
Atriplex vesicaria	Bladder saltbush	
Babbagia acroptera	Babbagia	
**Bassia hyssopifolia*	Saltbush	
**Chenopodium album*	Fat hen	
Chenopodium carinatum	Kneeled goosefoot	
Chenopodium cristatum	Crested goosefoot	
Chenopodium curvispicatum	Goosefoot	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
CHENOPODIACEAE (continued...)		
Chenopodium desertorum	Frosted goosefoot	
Chenopodium glaucum	Glaucous goosefoot	
**Chenopodium murale*	Sowbane	
Chenopodium nitrariaceum	Nitre goosefoot	
Chenopodium pumilio	Clammy goosefoot	
Dissocarpus biflorus	Twin-flower saltbush	r
Dissocarpus paradoxa	Hard-head saltbush	
Dysphania glomulifera	Globular pigweed	
Dysphania simulans	Pigweed	e
Einadia hastata	Saloop saltbush	
Einadia nutans	Nodding saltbush	
Enchylaena tomentosa	Ruby saltbush	
Halosarcia flabelliformis	Samphire	e
Halosarcia halocnemoides	Grey glasswort	
Halosarcia indica	Brown-head glasswort	
Halosarcia lylei	Wiry glasswort	r
Halosarcia nitida	Glasswort	
Halosarcia pergranulata	Black-seeded glasswort	
Halosarcia pruinosa	Glasswort	
Halosarcia pterygosperma	Glasswort	
Hemichroa diandra	Mallee hemichroa	e
Maireana aphylla	Leafless bluebush	r
Maireana appressa	Bluebush	
Maireana brevifolia	Short-leaf bluebush	
Maireana cheelii	Chariot blue-bush	v
Maireana decalvans	Common blue-bush	
Maireana enchylaenoides	Wingless blue-bush	
Maireana erioclada	Rosy blue-bush	
Maireana excavata	Bottle blue-bush	
Maireana humillima	Dwarf blue-bush	r
Maireana lobiflora	Lobed blue-bush	v
Maireana oppositifolia	Heathy blue-bush	
Maireana pentagona	Slender blue-bush	
Maireana pentatropis	Erect blue-bush	
Maireana pyramidata	Shrubby blue-bush	
Maireana radiata	Radiant blue-bush	
Maireana rohrlachii	Rohrlach's blue-bush	r
Maireana sclerolaenoides	Woolly-fruit bassia	
Maireana sedifolia	Hoary blue-bush	
Maireana trichoptera	blue-bush	
Maireana triptera	Three-winged blue-bush	r
Maireana turbinata	Satiny blue-bush	
Malacocera tricornis	Goat head	r
Neobassia proceriflora	Soda-bush	r
Pachycornia triandra	Desert glasswort	r
Rhagodia crassifolia	Fleshy saltbush	
Rhagodia spinescens	Hedge saltbush	
Rhagodia ulicina	Spiny goosefoot	r
Salsola kali	Prickly saltbush	
Sarcocornia blackiana	Thick-head glasswort	
Sarcocornia quinqueflora	Beaded glasswort	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
CHENOPODIACEAE (continued...)		
Scleroblitum atriplicinum	Starry goosefoot	
Sclerochlamys brachyptera	Hairy bassia	
Sclerolaena convexula	Tall copperburr	v
Sclerolaena decurrens	Saltbush	
Sclerolaena diacantha	Horned saltbush	
Sclerolaena divaricata	Tangled saltbush	
Sclerolaena intricata	Saltbush	
Sclerolaena muricata	Five-spined saltbush	
Sclerolaena obliquicuspis	Oblique-spined saltbush	
Sclerolaena parviflora	Small-flower saltbush	
Sclerolaena patenticuspis	Spear-fruit saltbush	
Sclerolaena ramsayae	Ramsay's saltbush	
Sclerolaena tricuspis	Three-spined saltbush	
Sclerolaena uniflora	Two-spined saltbush	r
Sclerolaena ventricosa	Salt copperburr	v
Sclerostegia moniliformis	Ruby glasswort	r
Sclerostegia tenuis	Slender glasswort	
Stelligera endecaspinis	Starfruit bassia	
Suaeda australis	Austral sea-blite	
**Suaeda* sp. aff. *linifolia*	Sea-blite	
Threlkeldia diffusa	Coast bonefruit	
Threlkeldia salsuginosa	Bonefruit	
COMPOSITAE		
**Achillea millefolium*	Milfoil	
**Acroptilon repens*	Creeping knapwood	
Actinobole uliginosum	Flannel cudweed	
Angianthus brachypappus	Spreading angianthus	v
Angianthus tomentosus	Hairy angianthus	
**Arctotheca calendula*	Cape weed	
**Aster subulatus*	Aster-weed	
Asteridea athrixioides	Wirewort	
**Bidens pilosa*	Cobbler's-pegs	
Blennospora drummondii	Dwarf beauty-heads	
Brachycome basaltica	Swamp daisy	
Brachycome ciliaris	Variable daisy	
Brachycome debilis	Weak daisy	v
Brachycome exilis	Slender daisy	v
Brachycome goniocarpa	Dwarf daisy	
Brachycome heterodonta	Lobe-seed daisy	
Brachycome leptocarpa	Downy daisy	
Brachycome lineariloba	Hard-head daisy	
Brachycome perpusilla	Rayless daisy	
**Calendula arvensis*	Field marigold	
Calocephalus citreus	Lemon beauty-heads	
Calocephalus sonderi	Pale beauty-heads	
Calotis anthemoides	Cut-leaf burr-daisy	
Calotis cuneifolia	Blue burr-daisy	
Calotis cymbacantha	Burr-daisy	
Calotis erinacea	Tangled burr-daisy	
Calotis hispidula	Hairy burr-daisy	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
COMPOSITAE (continued...)		
Calotis lappulacea	Yellow burr-daisy	
Calotis scabiosifolia	Rough burr-daisy	
Calotis scapigera	Tufted burr-daisy	
**Carduus nutans*	Musk thistle	
**Carduus pycnocephalus*	Slender thistle	
**Carduus tenuiflorus*	Thistle	
**Carthamus lanatus*	Saffron thistle	
Cassinia arcuata	Drooping cassinia	
Cassinia uncata	Sticky cassinia	
**Centaurea calcitrapa*	Star thistle	
**Centaurea melitensis*	Malta thistle	
Centipeda cunninghamii	Common sneezeweed	
Centipeda minima	Spreading sneezeweed	
Centipeda thespidioides	Desert sneezeweed	r
Ceratogyne obionoides	Wingwort	
**Chondrilla juncea*	Skeleton weed	
**Chrysanthemoides monilifera*	Boneseed	
Chthonocephalus pseudevax	Groundheads	
**Cichorium intybus*	Chicory	
**Cirsium acarna*	Soldier thistle	
**Cirsium vulgare*	Spear thistle	
**Conyza bonariensis*	Tall fleabane	
Cotula australis	Common cotula	
**Cotula bipinnata*	Ferny cotula	
Cotula coronopifolia	Water buttons	
Craspedia chrysantha	Golden billy-buttons	
Craspedia glauca	Common billy-buttons	
Craspedia pleiocephala	Soft billy-buttons	
Cratystylis conocephala	Blue-bush daisy	x
**Crepis foetida*	Stinking hawksbeard	
Cymbonotus lawsonianus	Bear's-ears	r
Cymbonotus preissianus	Austral bear's-ears	
**Dittrichia graveolens*	Stinkweed	
Eclipta platyglossa	Yellow twin-heads	
Elachanthus glaber	Elachanth	r
Elachanthus pusillus	Elachanth	
Epaltes australis	Spreading nut-heads	
Epaltes cunninghamii	Tall nut-heads	
Epaltes tatei	Small nut-heads	v
Eriochlamys behrii	Woolly mantle	
Gnaphalium indutum	Tiny cudweed	
Gnaphalium involucratum	Cudweed	
Gnaphalium polycaulon	Indian cudweed	
Gnaphalium sphaericum	Common cudweed	
Gnephosis burkittii	Gnephosis	v
Gnephosis skirrophora	Woolly gnephosis	v
Gnephosis tenuissima	Gnephosis	
Haeckeria ozothamnoides	Cottony haeckeria	
Haeckeria pholidota	Scaly haeckeria	
**Hedypnois cretica*	Cretan hedypnois	
Helichrysum apiculatum	Common everlasting	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
COMPOSITAE (continued...)		
Helichrysum baxteri	White everlasting	
Helichrysum bilobum	Rough everlasting	
Helichrysum blandowskianum	Woolly everlasting	
Helichrysum bracteatum	Golden everlasting	
Helichrysum catadromum	Ridged everlasting	
Helichrysum leucopsideum	Satin everlasting	
Helichrysum obtusifolium	Blunt everlasting	
Helichrysum scorpioides	Button everlasting	
Helichrysum semipapposum	Clustered everlasting	
Helichrysum tepperi	Delicate everlasting	
Helipterum anthemoides	Chamomile sunray	
Helipterum australe	Common sunray	
Helipterum corymbiflorum	Paper sunray	
Helipterum cotula	Mayweed sunray	
Helipterum demissum	Moss sunray	
Helipterum hyalospermum	Dwarf sunray	
Helipterum jessenii	Orange sunray	
Helipterum laeve	Smooth sunray	
Helipterum molle	Soft sunray	v
Helipterum moschatum	Musk sunray	
Helipterum polygalifolium	Milkwort sunray	
Helipterum pygmaeum	Pygmy sunray	
Helipterum strictum	Sunray	
Helipterum stuartianum	Flowery sunray	
Helipterum tietkensii	Sunray	
**Hypochoeris glabra*	Smooth cat's ear	
**Hypochoeris radicata*	Cat's ear	
Isoetopsis graminifolia	Grass cushion	
**Iva axillaris*	Poverty weed	
Ixiolaena chloroleuca	Ixiolaena	e
Ixiolaena leptolepis	Plover daisy	
Ixiolaena tomentosa	Woolly ixiolaena	v
Kippistia suaedifolia	Fleshy minuria	v
**Lactuca saligna*	Willow-leaf lettuce	
**Lactuca serriola*	Prickly lettuce	
**Leontodon taraxacoides*	Hairy hawkbit	
Leptorhynchos panaetioides	Woolly buttons	r
Leptorhynchos squamatus	Scaly buttons	
Leptorhynchos tetrachaetus	Beauty buttons	
Leptorhynchos waitzia	Button immortelle	v
Microseris scapigera	Yam-daisy	
Millotia macrocarpa	Large-fruited millotia	
Millotia myosotidifolia	Broad-leaf millotia	
Millotia tenuifolia	Soft millotia	
Minuria cunninghamii	Bush minuria	
Minuria denticulata	Woolly minuria	r
Minuria intergerrima	Smooth minuria	r
Minuria leptophylla	Minnie daisy	
Myriocephalus rhizocephalus	Woolly-heads	
Myriocephalus stuartii	Poached-eggs daisy	
Olearia brachyphylla	Short-leaf daisy-bush	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
COMPOSITAE (continued...)		
Olearia ciliata	Fringed daisy-bush	
Olearia decurrens	Daisy-bush	
Olearia lanuginosa	Woolly daisy-bush	
Olearia lepidophylla	Club-moss daisy-bush	
Olearia magniflora	Splendid daisy-bush	
Olearia muelleri	Mueller daisy-bush	
Olearia passerinoides	Daisy-bush	r
Olearia picridifolia	Rasp daisy-bush	v
Olearia pimeleoides	Pimelea daisy-bush	
Olearia ramulosa	Twiggy daisy-bush	
Olearia rudis	Azure daisy-bush	
Olearia subspicata	Spiked daisy-bush	v
Olearia teretifolia	Cypress daisy-bush	
**Onopordum acaulon*	Stemless onopordon	
**Osteospermum clandestinum*	Tripteris	
**Picris echioides*	Ox-tongue	
**Picris hieracioides*	Hawkweed picris	
Podolepis arachnoidea	Cottony podolepis	x
Podolepis canescens	Grey podolepis	v
Podolepis capillaris	Wiry podolepis	
Podolepis jaceoides	Showy podolepis	
Podolepis rugata	Pleated podolepis	
Podotheca angustifolia	Sticky longheads	
Pogonolepis muelleriana	Stiff cup-flower	
Pseudognaphalium luteo-album	Jersey cudweed	
**Reichardia tingitana*	Reichardia	
Rutidosis helichrysoides	Grey wrinklewort	v
**Schkuhria pinnata*	Schkuhria	
**Scolymus hispanicus*	Golden thistle	
**Scorzonera laciniata*	Scorzonera	
Senecio behrianus	Stiff groundsel	x
Senecio cunninghamii	Branching groundsel	
Senecio glomeratus	Annual fireweed	
Senecio glossanthus	Slender groundsel	
Senecio gregorii	Fleshy groundsel	
Senecio hispidulus	Rough fireweed	
Senecio lautus	Variable groundsel	
Senecio linearifolius	Fireweed groundsel	
Senecio magnificus	Tall yelllow-top	r
Senecio minimus	Shrubby fireweed	
Senecio platylepis	Toothed groundsel	
Senecio quadridentatus	Cotton fireweed	
Senecio runcinifolius	Tall groundsel	
Senecio sp. aff. *apargiaefolius*	Groundsel	
Senecio tenuiflorus	Groundsel	
**Silybum marianum*	Variegated thistle	
Sonchus hydrophilus	Sow thistle	
**Sonchus asper*	Rough sow thistle	
**Sonchus oleraceus*	Sow thistle	
Stuartina hamata	Cudweed	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
COMPOSITAE (continued...)		
Stuartina muelleri	Spoon cudweed	
**Taraxacum officinale*	Dandelion	
Toxanthes muelleri	Common bow-flower	
Toxanthes perpusilla	Tiny bow-flower	
**Tragopogon porrifolius*	Salsify	
**Vellereophyton dealbatum*	White-cudweed	
**Verbesina encelioides*	Crownbeard	
Vittadinia australasica	New Holland daisy	
Vittadinia blackii	Western New Holland daisy	v
Vittadinia cervicularis	New Holland daisy	
Vittadinia condyloides	New Holland daisy	
Vittadinia cuneata	Woolly New Holland daisy	
Vittadinia dissecta	New Holland daisy	
Vittadinia gracilis	New Holland daisy	
Vittadinia megacephala	Giant New Holland daisy	v
Vittadinia pterochaeta	New Holland daisy	e
Waitzia acuminata	Orange immortelle	
**Xanthium orientale*	Californian burr	
**Xanthium pungens*	Noogoora burr	
**Xanthium spinosum*	Bathurst burr	
CONVOLVULACEAE		
**Convolvulus arvensis*	Common bindweed	
Convolvulus erubescens	Pink bindweed	
Cressa cretica	Rosinweed	
Dichondra repens	Kidney-weed	
Wilsonia rotundifolia	Round-leaf wilsonia	
CRASSULACEAE		
Crassula colorata	Dense crassula	
**Crassula decumbens*	Spreading crassula	
Crassula exserta	Large-fruited crassula	
Crassula helmsii	Swamp crassula	
Crassula pedicellosa	Stalked crassula	
Crassula peduncularis	Purple crassula	
Crassula sieberiana	Sieber crassula	
CRUCIFERAE		
Alyssum linifolium	Flax-leaf alyssum	
Arabidella nasturtium	Yellow cress	
Arabidella trisecta	Shrubby cress	
**Brassica tournefortii*	Mediterranean turnip	
**Camelina sativa*	False flax	
**Capsella bursa-pastoris*	Shepherd's purse	
Cardamine tenuifolia	Slender bitter-cress	
**Cardaria draba*	Hoary cress	
**Carrichtera annua*	Ward's weed	
**Coronopus didymus*	Lesser swine's-cress	
**Diplotaxis muralis*	Wall rocket	
**Diplotaxis tenuifolia*	Sand rocket	
**Eruca sativa*	Bladder eruca	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
CRUCIFERAE (continued...)		
Geococcus pusillus	Earth cress	
Harmsiodoxa blennodioides	May smocks	
Harmsiodoxa brevipes	Short cress	
Hymenolobus procumbens	Oval purse	
**Lepidium africanum*	Common pepper-cress	
Lepidium fasciculatum	Bundled pepper-cress	
Lepidium leptopetalum	Slender pepper-cress	
Lepidium monoplocoides	Winged pepper-cress	e
Lepidium papillosum	Warty pepper-cress	
Lepidium phlebopetalum	Veined pepper-cress	v
Lepidium pseudohyssopifolium	Pepper-cress	
Lepidium pseudopapillosum	Pepper-cress	e
Lepidium pseudotasmanicum	Pepper-cress	
**Matthiola longipetala*	Two-horned stock	
Menkea australis	Fairy spectacles	
Pachymitus cardaminoides	Sand cress	
Phlegmatospermum eremaeum	Phlegmatospermum	v
**Raphanus raphanistrum*	Wild radish	
**Rapistrum rugosum*	Giant mustard	
Rorippa eustylis	Bitter-cress	
Rorippa laciniata	Jagged bitter-cress	
Rorippa palustris	Marsh yellow-cress	
**Sinapis alba*	White mustard	
**Sinapis arvensis*	Charlock	
**Sisymbrium erysimoides*	Smooth mustard	
**Sisymbrium irio*	London mustard	
**Sisymbrium orientale*	Indian hedge mustard	
Stenopetalum lineare	Narrow thread-petal	
Stenopetalum sphaerocarpum	Pea thread-petal	
Stenopetalum velutinum	Velvet thread-petal	v
CUCURBITACEAE		
**Citrullus colocynthis*	Colocynth	
**Citrullus lanatus*	Wild melon	
**Cucumis myriocarpus*	Paddy melon	
**Ecballium elaterium*	Squirting cucumber	
Mukia micrantha	Mallee cucumber	
CUSCUTACEAE		
Cuscuta australis	Australian dodder	
Cuscuta tasmanica	Golden dodder	
DILLENIACEAE		
Hibbertia riparia	Erect guinea-flower	
Hibbertia sericea	Silky guinea-flower	
Hibbertia stricta	Guinea-flower	
Hibbertia virgata	Twiggy guinea-flower	
DROSERACEAE		
Drosera glanduligera	Scarlet sundew	
Drosera indica	Indian sundew	v

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
DROSERACEAE (continued...)		
Drosera macrantha	Sundew	
Drosera whittakeri	Scented sundew	
ELATINACEAE		
Elatine gratioloides	Waterwort	
EPACRIDACEAE		
Acrotriche affinis	Ridged ground-berry	
Astroloma conostephioides	Flame heath	
Astroloma humifusum	Cranberry heath	
Brachyloma daphnoides	Daphne heath	
Brachyloma ericoides	Brush heath	
Leucopogon clelandii	Cleland's beard-heath	
Leucopogon cordifolius	Heart-leaf beard-heath	
Leucopogon costatus	Twiggy beard-heath	
Leucopogon rufus	Ruddy beard-heath	
Leucopogon woodsii	Nodding beard-heath	
Styphelia exarrhena	Desert styphelia	r
EUPHORBIACEAE		
Adriana hookeri	Mallee bitter-bush	
Bertya mitchellii	Mitchell bertya	
Beyeria leschenaultii	Pale turpentine bush	
Beyeria opaca	Dark turpentine bush	
Chamaesyce drummondii	Flat spurge	
Euphorbia parvicaruncula	Rough-seeded spurge	e
**Euphorbia peplus*	Petty spurge	
Euphorbia planiticola	Desert spurge	e
Euphorbia tannensis	Spurge	e
**Euphorbia terracina*	Terracina spurge	
Phyllanthus lacunarius	Lagoon spurge	v
Poranthera microphylla	Small poranthera	
**Ricinus communis*	Castor oil plant	
FRANKENIACEAE		
Frankenia angustipetala	Sea-heath	
Frankenia crispa	Hoary sea-heath	r
Frankenia foliosa	Leafy sea-heath	
Frankenia gracilis	Slender sea-heath	r
Frankenia pauciflora	Southern sea-heath	
Frankenia pulverulanta	Mediterranean sea-heath	
Frankenia sessilis	Small-leaf sea-heath	
FUMARIACEAE		
**Fumaria capreolata*	Ramping fumitory	
**Fumaria densiflora*	Fumitory	
**Fumaria parviflora*	Fumitory	
GENTIANACEAE		
**Centaurium erythraea*	Common centaury	
Centaurium spicatum	Spike centaury	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
GENTIANACEAE (continued...)		
**Centaurium tenuiflorum*	Centaury	
Sebaea ovata	Yellow sebaea	
GERANIACEAE		
**Erodium botrys*	Big heron's bill	
**Erodium cicutarium*	Common heron's-bill	
Erodium crinitum	Blue heron's-bill	
**Erodium malacoides*	Oval heron's-bill	
**Erodium moschatum*	Musky heron's-bill	
Geranium potentilloides	Cinquefoil	
Geranium retrorsum	Grassland crane's-bill	
Geranium solanderi	Austral crane's-bill	
Pelargonium australe	Austral stork's-bill	
GOODENIACEAE		
Dampiera lanceolata	Grooved dampiera	
Dampiera marifolia	Velvet dampiera	
Dampiera rosmarinifolia	Rosemary dampiera	
Goodenia affinis	Goodenia	
Goodenia geniculata	Bent goodenia	
Goodenia glauca	Pale goodenia	
Goodenia gracilis	Slender goodenia	
Goodenia heteromera	Spreading goodenia	
Goodenia pinnatifida	Cut-leaf goodenia	
Goodenia pusilliflora	Small-leaf goodenia	
Goodenia robusta	Woolly goodenia	
Goodenia subintegra	Silky goodenia	
Goodenia varia	Sticky goodenia	
Scaevola aemula	Fairy fan-flower	
Scaevola depauperata	Skeleton fan-flower	e
Scaevola spinescens	Prickly fan-flower	d
Velleia arguta	Velleia	r
Velleia connata	Cup velleia	
GYROSTEMONACEAE		
Codonocarpus cotinifolius	Bell-fruit tree	
Gyrostemon australasicus	Wheel fruit	
HALORAGACEAE		
Glischrocaryon behrii	Golden pennants	
Gonocarpus tetragynus	Common raspwort	
Haloragis aspera	Rough raspwort	
Haloragis heterophylla	Varied raspwort	
Haloragis odontocarpa	Toothed raspwort	
Myriophyllum porcatum	Ridged water-milfoil	r
Myriophyllum propinquum	Common water-milfoil	
Myriophyllum verrucosum	Red water-milfoil	
HYPERICACEAE		
Hypericum gramineum	Small St. John's wort	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
LABIATAE		
Ajuga australis	Austral bugle	
**Lamium amplexicaule*	Henbit dead-nettle	
**Marrubium vulgare*	Horehound	
Mentha australis	River mint	
Mentha diemenica	Slender mint	
**Mentha pulegium*	Pennyroyal	
Mentha satureoides	Creeping mint	
Prostanthera aspalathoides	Scarlet mint-bush	
Prostanthera microphylla	Small-leaf mint-bush	
**Salvia verbenaca*	Wild sage	
Teucrium racemosum	Grey germander	
Teucrium sessiliflorum	Camel bush	
Westringia eremicola	Slender westringia	
Westringia rigida	Stiff westringia	
LAURACEAE		
Cassytha glabella	Slender dodder-laurel	
Cassytha melantha	Coarse dodder-laurel	
Cassytha pubescens	Downy dodder-laurel	
LINACEAE		
Linum marginale	Native flax	
LOBELIACEAE		
Lobelia gibbosa	Tall lobelia	
Lobelia pratioides	Poison lobelia	
Pratia concolor	Poison pratia	
LOGANIACEAE		
Logania linifolia	Flax-leaf logania	
Logania nuda	Bare logania	
Mitrasacme paradoxa	Wiry mitrewort	
LORANTHACEAE		
Amyema linophyllum	Buloke mistletoe	v
Amyema miquelii	Box mistletoe	
Amyema miraculosum	Fleshy mistletoe	
Amyema pendulum	Drooping mistletoe	
Amyema preissii	Wire-leaf mistletoe	
Lysiana exocarpi	Harlequin mistletoe	
LYTHRACEAE		
Ammannia multiflora	Jerry-jerry	v
Lythrum hyssopifolia	Small loosestrife	
MALVACEAE		
Abutilon fraseri	Dwarf lantern-flower	e
Abutilon otocarpum	Desert lantern	v
Abutilon oxycarpum	Straggly lantern-bush	v
Abutilon theophrasti	Chingma	
**Hibiscus trionum*	Bladder ketmia	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
MALVACEAE (continued...)		
Lavatera plebeia	Australian hollyhock	
Lawrencia berthae	Showy lawrencia	v
Lawrencia glomerata	Clustered lawrencia	
**Malva nicaeensis*	Mallow of Nice	
**Malva parviflora*	Small-flowered mallow	
**Modiola caroliniana*	Carolina mallow	
Radyera farragei	Desert rose mallow	v
Selenothamnus squamatus	Thorny selenothamnus	
Sida ammophila	Sand sida	v
Sida corrugata	Variable sida	
Sida fibulifera	Pin sida	v
Sida intricata	Twiggy sida	
**Sida leprosa*	Alkali sida	
**Sida rhombifolia*	Common sida	
Sida trichopoda	Narrow-leaf sida	
MENYANTHACEAE		
Nymphoides crenata	Wavy marshwort	
MIMOSACEAE		
Acacia acanthoclada	Harrow wattle	
Acacia acinacea	Gold-dust wattle	
Acacia bivenosa	Small cooba	
Acacia brachybotrya	Grey mulga	
Acacia calamifolia	Wallowa	
Acacia colletioides	Wait-a-while	r
Acacia glandulicarpa	Hairy-pod wattle	v
Acacia gunnii	Ploughshare wattle	
Acacia hakeoides	Hakea wattle	
Acacia havilandii	Needle wattle	e
Acacia lineata	Streaked wattle	r
Acacia loderi	Nealie	v
Acacia melanoxylon	Blackwood	
Acacia melvillei	Wattle	v
Acacia microcarpa	Manna wattle	
Acacia montana	Mallee wattle	
Acacia myrtifolia	Myrtle wattle	
Acacia notabilis	Wattle	v
Acacia nyssophylla	Wattle	
Acacia osswaldii	Umbrella wattle	d
Acacia pycnantha	Golden wattle	
Acacia rigens	Nealie	
Acacia salicina	Willow wattle	
**Acacia saligna*	Golden-wreath wattle	
Acacia sclerophylla	Hard-leaf wattle	
Acacia spinescens	Spiny wattle	
Acacia stenophylla	Eumong	
Acacia trineura	Three-nerve wattle	v
Acacia victoriae	Bramble wattle	
Acacia wilhelmiana	Dwarf nealie	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
MYOPORACEAE		
Eremophila bignoniiflora	Bignonia emu-bush	e
Eremophila crassifolia	Thick-leaf emu-grass	
Eremophila divaricata	Spreading emu-grass	
Eremophila glabra	Common emu-bush	
Eremophila longifolia	Berrigan	
Eremophila maculata	Spotted emu-bush	r
Eremophila oppositifolia	Twin-leaf emu-bush	v
Eremophila polyclada	Twiggy emu-bush	v
Eremophila scoparia	Silvery emu-bush	v
Eremophila sturtii	Narrow-leaf emu-bush	e
Myoporum deserti	Turkey-bush	d
Myoporum montanum	Waterbush	r
Myoporum parvifolium	Creeping myoporum	
Myoporum platycarpum	Sugarwood	
MYRTACEAE		
Baeckea behrii	Broom baeckea	
Baeckea crassifolia	Desert baeckea	
Baeckea ericaea	Mat baeckea	
Callistemon brachyandrus	Prickly bottlebrush	r
Callistemon macropunctatus	Scarlet bottlebrush	
Calytrix alpestris	Snow myrtle	
Calytrix tetragona	Common fringe-myrtle	
Eucalyptus baxteri	Brown stringybark	
Eucalyptus behriana	Bull mallee	
Eucalyptus calycogona	Red mallee	
Eucalyptus camaldulensis	River red gum	
**Eucalyptus cladocalyx*	Sugar gum	
Eucalyptus cyanophylla	Blue mallee	r
Eucalyptus dumosa	Dumosa mallee	
Eucalyptus foecunda	Slender-leaf mallee	
Eucalyptus gracilis	White mallee	
Eucalyptus incrassata	Yellow mallee	
Eucalyptus largiflorens	Black box	
Eucalyptus leucoxylon	Yellow gum	
Eucalyptus melliodora	Yellow box	
Eucalyptus microcarpa	Grey box	
Eucalyptus oleosa	Acorn (oil) mallee	
Eucalyptus porosa	Black mallee box	
Eucalyptus socialis	Grey mallee	
Eucalyptus viridis	Green mallee	
Kunzea pomifera	Muntries	
Leptospermum coriaceum	Green tea-tree	
Leptospermum myrsinoides	Heath tea-tree	
Melaleuca acuminata	Creamy honey-myrtle	
Melaleuca decussata	Totem-poles	
Melaleuca halmaturorum	Salt paper-bark	d
Melaleuca lanceolata	Moonah	
Melaleuca neglecta	Mallee honey-myrtle	
Melaleuca uncinata	Broom honey-myrtle (broombush)	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
MYRTACEAE (continued...)		
Melaleuca wilsonii	Violet honey-myrtle	
Micromyrtus ciliata	Heath-myrtle	
NYCTAGINACEAE		
Boerhavia diffusa	Tah-vine	
OLEACEAE		
Jasminum lineare	Desert jasmine	v
*Olea europaea	Olive	
ONAGRACEAE		
Epilobium billardierianum	Robust willow-herb	
Epilobium hirtigerum	Hairy willow-herb	
Ludwigia peploides	Clove-strip	
**Oenothera erythrosepala*	Evening primrose	
**Oenothera rosea*	Rose evening primrose	
**Oenothera stricta*	Common evening primrose	
OROBANCHACEAE		
Orobanche australiana	Australian broomrape	
**Orobanche minor*	Lesser broomrape	
OXALIDACEAE		
Oxalis corniculata sp. agg.	Yellow wood-sorrel	
**Oxalis hirta*	Hairy wood-sorrel	
Oxalis perennans	Wood-sorrel	
**Oxalis pes-caprae*	Soursob	
Oxalis radicosa	Wood-sorrel	
PAPAVERACEAE		
**Hypecoum pendulum*		
Papaver aculeatum	Bristle poppy	
**Papaver dubium*	Long-headed poppy	
**Papaver hybridum*	Rough poppy	
**Papaver somniferum*	Opium poppy	
PAPILIONACEAE		
**Alhagi pseudalhagi*	Camel thorn	
Aotus ericoides	Common aotus	
Bossiaea walkeri	Cactus bossiaea	v
Daviesia arenaria	Bitter-pea	
Daviesia benthamii	Broom bitter-pea	
Daviesia brevifolia	Leafless bitter-pea	
Daviesia virgata	Bitter-pea	
Dillwynia hispida	Red parrot-pea	
Dillwynia sericea	Showy parrot-pea	
Dillwynia uncinata	Silky parrot-pea	r
Eutaxia microphylla	Common eutaxia	
Eutaxia microphylla var. *diffusa*	Spreading eutaxia	
Glycine canescens	Silky glycine	e

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
PAPILIONACEAE (continued...)		
Glycine clandestina	Twining glycine	
Glycyrrhiza acanthocarpa	Southern liquorice	
Kennedia prostrata	Running postman	
Lotus australis	Austral trefoil	
Lotus cruentus	Red bird's-foot trefoil	d
**Medicago laciniata*	Cut-leaf medic	
**Medicago minima*	Little medic	
**Medicago polymorpha*	Burr medic	
**Medicago sativa*	Lucerne	
**Medicago scutellata*	Snail medic	
**Medicago truncatula*	Barrel medic	
**Melilotus alba*	Bokhara clover	
**Melilotus indica*	Sweet melilotus	
Phyllota pleurandroides	Heathy phyllota	
Phyllota remota	Slender phyllota	r
Psoralea australasica	Psoralea	e
Psoralea cinerea	Hoary psoralea	e
Psoralea eriantha	Woolly psoralea	
Psoralea pallida	Psoralea	
Psoralea patens	Spreading psoralea	e
Psoralea tenax	Tough psoralea	e
Pultenaea acerosa	Bristly bush-pea	v
Pultenaea densifolia	Dense bush-pea	r
Pultenaea prostrata	Silky bush-pea	
Pultenaea tenuifolia	Slender bush-pea	
Swainsona greyana	Hairy Darling pea	v
Swainsona laxa	Yellow swainson-pea	v
Swainsona microphylla	Small-leaf swainson-pea	
Swainsona murrayana	Murray swainson-pea	e
Swainsona oroboides	Variable swainson-pea	
Swainsona phacoides	Dwarf swainson-pea	v
Swainsona plagiotropis	Red swainson-pea	e
Swainsona procumbens	Broughton pea	
Swainsona stipularis	Swainson-pea	v
Swainsona swainsonioides	Downy swainson-pea	e
Templetonia egena	Rough templetonia	d
Templetonia stenophylla	Leafy templetonia	d
Templetonia sulcata	Flat templtonia	
**Trifolium angustifolium*	Narrow-leaf clover	
**Trifolium arvense*	Hare's foot clover	
**Trifolium campestre*	Hop clover	
**Trifolium fragiferum*	Strawberry clover	
**Trifolium glomeratum*	Cluster clover	
**Trifolium repens*	White clover	
**Trifolium subterraneum*	Subterranean clover	
**Trifolium suffocatum*	Suffocated clover	
**Trifolium tomentosum*	Woolly clover	
Trigonella suavissima	Sweet fenugreek	r
**Vicia monantha*	One-flower vetch	
**Vicia sativa*	Common vetch	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
PITTOSPORACEAE		
Billardiera cymosa	Sweet apple-berry	
Bursaria spinosa	Sweet bursaria	
Pittosporum phillyreoides	Weeping pittosporum	
PLANTAGINACEAE		
**Plantago arenaria*	Plantain	
**Plantago coronopus*	Buck's-horn plantain	
Plantago cunninghamii	Plantain	
Plantago drummondii	Dark plantain	
**Plantago lanceolata*	Ribwort	
Plantago turrifera	Plantain	
PLUMBAGINACEAE		
Limonium australe	Yellow sea-lavender	
**Limonium lobatum*	Winged sea-lavender	
POLYGALACEAE		
Comesperma calymega	Blue-spike milkwort	
Comesperma scoparium	Broom milkwort	v
POLYGONACEAE		
**Emex australis*	Spiny emex	
**Emex spinosa*	Emex	
Muehlenbeckia cunninghamii	Tangled lignum	
Muehlenbeckia diclina	Twiggy lignum	
Muehlenbeckia horrida	Spiny lignum	r
**Polygonum aviculare*	Prostrate knotweed	
Polygonum hydropiper	Water-pepper	
**Polygonum lanigerum*	Woolly knotweed	
Polygonum lapathifolium	Pale knotweed	
Polygonum minus	Slender knotweed	
**Polygonum patulum*	Knotweed	
Polygonum plebeium	Small knotweed	
Polygonum prostratum	Creeping knotweed	
**Rumex acetosella* sp. agg.	Sheep sorrel	
Rumex bidens	Mud dock	
Rumex brownii	Slender dock	
**Rumex conglomeratus*	Clustered dock	
**Rumex crispus*	Curled dock	
Rumex crystallinus	Glistening dock	
Rumex dumosus	Wiry dock	
PORTULACACEAE		
Calandrinia calyptrata	Pink purslane	
**Calandrinia caulescens*	Purple purslane	
Calandrinia corrigioloides	Strap purslane	
Calandrinia eremaea	Small purslane	
Calandrinia granulifera	Pigmy purslane	
Calandrinia volubilis	Twining purslane	r
**Claytonia perfoliata*	Claytonia	
Portulaca oleracea	Common purslane	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
PRIMULACEAE		
**Anagallis arvensis*	Pimpernel	
Asterolinon linum-stellatum	Asterolinon	
PROTEACEAE		
Adenanthos terminalis	Gland flower	
Banksia marginata	Silver banksia	
Banksia ornata	Desert banksia	
Conospermum patens	Slender smoke-bush	
Grevillea glabella	Grevillea	
Grevillea huegelii	Comb grevillea	
Grevillea ilicifolia	Holly grevillea	
Grevillea lavandulacea	Lavender grevillea	
Grevillea pterosperma	Desert grevillea	
Hakea leucoptera	Silver needlewood	d
Hakea muelleriana	Desert hakea	
Hakea repullulans	Furze hakea	r
Hakea tephrosperma	Hooked needlewood	d
Isopogon ceratophyllus	Horny cone-bush	
Persoonia juniperina	Prickly geebung	
RANUNCULACEAE		
Clematis microphylla	Small-leaved clematis	
Myosurus minimus	Mouse-tail	
Ranunculus inundatus	River buttercup	
**Ranunculus muricatus*	Sharp buttercup	
Ranunculus pentandrus	Inland buttercup	
Ranunculus pumilio	Fan-leaf buttercup	
Ranunculus rivularis	Small river buttercup	
**Ranunculus scleratus*	Celery buttercup	
Ranunculus sessiliflorus	Annual buttercup	
Ranunculus trichophyllus	Water buttercup	
Ranunculus undosus	Buttercup	v
RESEDACEAE		
**Reseda alba*	White mignonette	
**Reseda luteola*	Weld	
RHAMNACEAE		
Cryptandra leucophracta	White cryptandra	
Cryptandra propinqua	Silky cryptandra	
Cryptandra tomentosa	Prickly cryptandra	
Spyridium eriocephalum	Heath spyridium	
Spyridium subochreatum	Velvet spyridium	
Spyridium tridentatum	Trident spyridium	x
ROSACEAE		
Aphanes australiana	Australian piert	
RUBIACEAE		
Asperula conferta	Common woodruff	
Asperula gemella	Twin-leaf bedstraw	v

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
RUBIACEAE (continued...)		
Asperula scoparia	Prickly woodruff	
**Galium aparine*	Cleavers	
Galium gaudichaudii	Rough bedstraw	
**Galium murale*	Small bedstraw	
**Galium tricornutum*	Rough corn bedstraw	
Opercularia scabrida	Stalked stinkweed	
Opercularia turpis	Twiggy stinkweed	
Opercularia varia	Variable stinkweed	
RUTACEAE		
Boronia caerulescens	Blue boronia	
Boronia inornata	Desert boronia	v
Correa reflexa	Common correa	
Eriostemon angustifolius	Narrow-leaf wax-flower	r
Eriostemon difformis	Small-leaf wax-flower	r
Eriostemon pungens	Prickly wax-flower	
Geijera parviflora	Wilga	e
Microcybe multiflora	Red microcybe	v
Microcybe pauciflora	Yellow microcybe	e
Phebalium bullatum	Desert phebalium	
Phebalium glandulosum	Phebalium	
Phebalium lowanense	Lowan phebalium	v
Phebalium stenophyllum	Narrow-leaf phebalium	
Zieria veronicea	Pink zieria	r
SALICACEAE		
**Salix babylonica*	Weeping willow	
SANTALACEAE		
Choretrum glomeratum	Common sour-bush	
Choretrum spicatum	Spiked sour-bush	r
Exocarpos aphyllus	Leafless ballart	
Exocarpos cupressiformis	Cherry ballart	
Exocarpos sparteus	Broom ballart	
Exocarpos strictus	Pale-fruit ballart	
Santalum acuminatum	Sweet quandong	v
Santalum lanceolatum	Northern sandalwood	e
Santalum murrayanum	Bitter quandong	
SAPINDACEAE		
Dodonaea bursariifolia	Small hop-bush	
Dodonaea hexandra	Hop-bush	r
Dodonaea stenozyga	Desert hop-bush	
Dodonaea viscosa	Akeake (sticky hop-bush)	
Heterodendrum oleifolium	Cattle-bush	d
SCROPHULARIACEAE		
**Bellardia trixago*	Bellardia	
Euphrasia collina	Purple eyebright	
Glossostigma drummondii	Desert mud-mat	
Glossostigma elatinoides	Small mud-mat	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
SCROPHULARIACEAE (continued...)		
Gratiola pedunculata	Stalked brooklime	
Gratiola pubescens	Brooklime	
Limosella australis	Austral mudwort	
Limosella curdieana	Large mudwort	
**Linaria pelisseriana*	Pelisser's toad-flax	
Mimulus gracilis	Slender monkey-flower	
Mimulus prostratus	Small monkey-flower	
Mimulus repens	Creeping monkey-flower	
Morgania glabra	Blue rod	
**Parentucellia latifolia*	Common parentucellia	
**Verbascum virgatum*	Twiggy mullein	
**Veronica catenata*	Pink water speedwell	
**Veronica peregrina*	Wandering speedwell	
Veronica sp. aff. *gracilis*	Thread speedwell	
**Zaluzianskya divaricata*	Spreading night-phlox	
SOLANACEAE		
Cyphanthera myosotidea	Small-leaf ray-flower	
**Datura inoxia*	Recurved thorn-apple	
**Datura stramonium*	Common thorn-apple	
Lycium australe	Australian box-thorn	
**Lycium barbarum*	Chinese box-thorn	
**Lycium ferocissimum*	African box-thorn	
**Nicotiana glauca*	Tree tobacco	
Nicotiana goodspeedii	Smooth-flower tobacco	r
Nicotiana velutina	Velvet tobacco	
**Physalis viscosa*	Sticky ground-cherry	
**Salpichroa origanifolia*	Pampas lily-of-the-valley	
**Solanum elaeagnifolium*	Silver-leaf nightshade	
Solanum esuriale	Quena	
Solanum lacunarium	Lagoon nightshade	v
**Solanum nigrum*	Black nightshade	
Solanum opacum	Nightshade	
**Solanum rostratum*	Buffalo burr	
Solanum simile	Oondoroo	
STACKHOUSIACEAE		
Stackhousia monogyna	Creamy stackhousia	
STERCULIACEAE		
Brachychiton populneus	Kurrajong	
Lasiopetalum baueri	Slender velvet-bush	
Lasiopetalum behrii	Pink velvet-bush	
STYLIDIACEAE		
Levenhookia dubia	Hairy stylewort	
Stylidium graminifolium	Grass trigger-plant	
THYMELAEACEAE		
Pimelea curviflora	Curved rice-flower	
Pimelea dichotoma	Diosma rice-flower	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
THYMELAEACEAE (continued...)		
Pimelea glauca	Smooth rice-flower	
Pimelea microcephala	Mallee rice-flower	
Pimelea octophylla	Woolly rice-flower	
Pimelea phylicoides	Heath rice-flower	
Pimelea serpyllifolia	Thyme rice-flower	
Pimelea simplex	Desert rice-flower	r
Pimelea stricta	Gaunt rice-flower	
Pimelea trichostachya	Annual rice-flower	
Pimelea williamsonii	Williamson's rice-flower	x
UMBELLIFERAE		
**Apium graveolens*	Celery	
**Conium maculatum*	Hemlock	
Daucus glochidiatus	Austral carrot	
Eryngium plantagineum	Long eryngium	v
**Foeniculum vulgare*	Fennel	
Hydrocotyle callicarpa	Small pennywort	
Hydrocotyle capillaris	Thread pennywort	
Hydrocotyle medicaginoides	Trefoil pennywort	
Hydrocotyle pilifera	Pennywort	
Hydrocotyle rugulosa	Pennywort	
Trachymene anisocarpa	Parsnip trachymene	
Trachymene cyanopetala	Purple trachymene	
Trachymene pilosa	Dwarf trachymene	
URTICACEAE		
Parietaria debilis	Shade pellitory	
**Urtica urens*	Small nettle	
VERBENACEAE		
**Phyla nodiflora*	Fog-fruit	
Verbena officinalis	Common verbena	
**Verbena supina*	Trailing verbena	
VIOLACEAE		
Hybanthus floribundus	Shrub violet	
VISCACEAE		
Ruppia maritima	Sea tassel	
ZYGOPHYLLACEAE		
Nitraria billardieri	Nitre-bush	
Tribulus terrestris	Caltrop	
Zygophyllum ammophilum	Sand twin-leaf	
Zygophyllum apiculatum	Pointed twin-leaf	
Zygophyllum aurantiacum	Shrubby twin-leaf	
Zygophyllum billardieri	Coast twin-leaf	
Zygophyllum compressum	Rabbit-ears twin-leaf	v
Zygophyllum crenatum	Notched twin-leaf	
Zygophyllum eremaeum	Climbing twin-leaf (native hop)	

Appendix VI (continued...)

Botanical name	Common name	Status in Victoria
ZYGOPHYLLACEAE (continued...)		
Zygophyllum glaucum	Pale twin-leaf	
Zygophyllum iodocarpum	Violet twin-leaf	
Zygophyllum ovatum	Dwarf twin-leaf	
OTHER TAXA		
Acacia sclerophylla var. *lissophylla*		
Chenopodium gaudichaudiana		
Neatostema apulans		
Pentzia suffruticosa		

Appendix VII

CHARACTER SPECIES OF THE PLANT COMMUNITIES

Key to Appendix VII

Each of the six regional assemblages of plant communities on public land in the Mallee area is represented on the following tables and indicated on Map 10.

The body of a table indicates the species that characterize each community and sub-community of plants comprising the regional assemblages.

The frequency of occurrence in any sub-community is indicated numerically as:

5	85--100%
4	70--84%
3	55--69%
2	40--54%
1	34--39%

For example, a value of '3' for *Callitris preissii* in the first sub-community of pine--buloke woodland (lunettes and ridges assemblage) indicates that between 55 and 69% of the survey quadrats in that sub-community contain *C. preissii*.

* indicates introduced species

Appendix VII (continued...)

Dune-fields of the Sunset Country

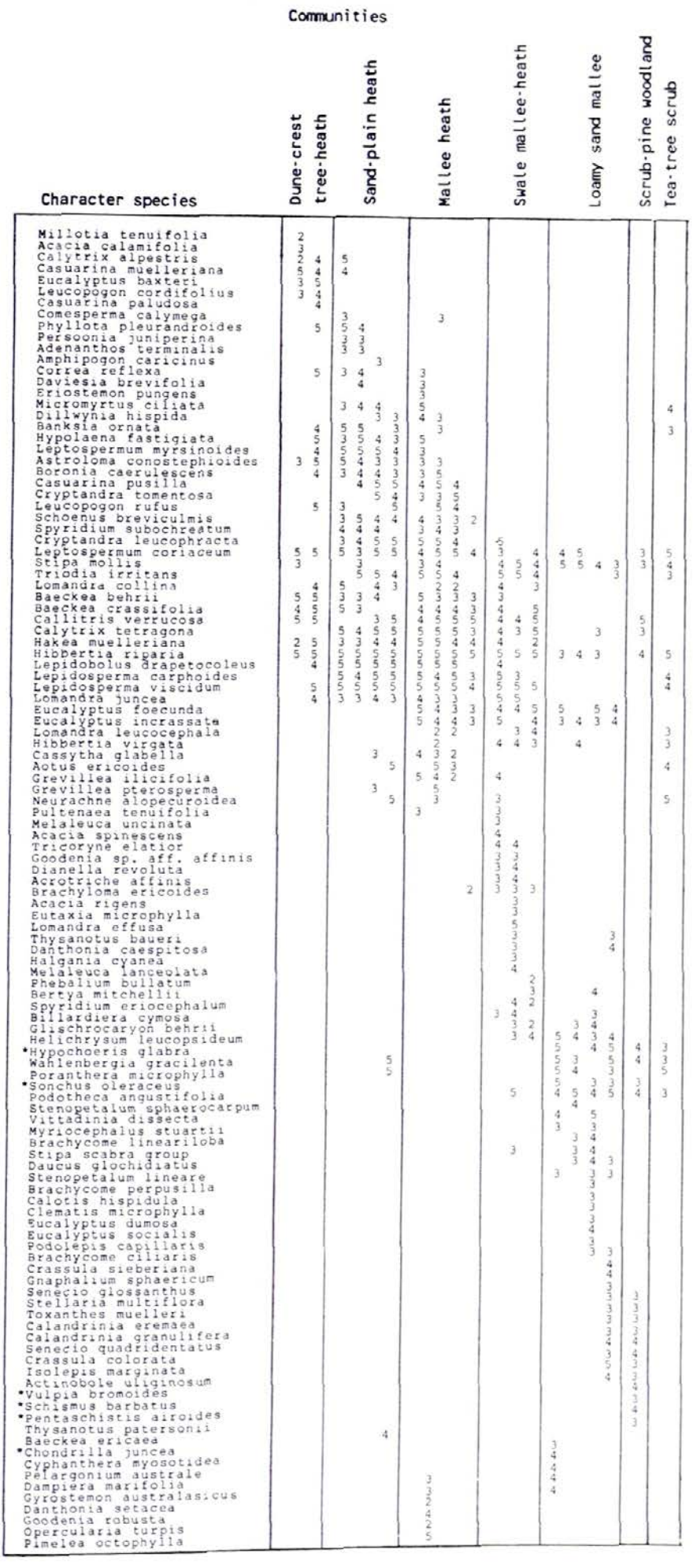
Communities

Deep-sand mallee | East-west dune mallee | Shallow-sand mallee | Chenopod mallee

Character species	Deep-sand mallee	East-west dune mallee	Shallow-sand mallee	Chenopod mallee
Haloragis odontocarpa	3			
Helipterum demissum	3			
Brachycome perpusilla	3			
Baeckea behrii	3			
Acacia bivenosa	3 3			
Glischrocaryon behrii	5 2			
Wahlenbergia gracilenta	3 4			
Scleranthus minusculus	2 3	3		
Leptospermum coriaceum	4 4	3		
Blennospora drummondii	3			
Plantago drummondii	2		4 3	
Pterostylis nana	2			
Stipa mollis	2	3		
Isolepis marginata	4			
Poranthera microphylla	5	2		
Crassula sieberiana	4		4	
Myriocephalus stuartii	3			
Thysanotus patersonii	3 3 5			
Trachymene cyanopetala	5 5 5			
Danthonia caespitosa	2 3 3			
Triglochin calcitrapa	4 4 5		4 2	
Eucalyptus incrassata	5 5 5	5 3		
Brachycome ciliaris	3		2	
Calotis erinacea	4 3			
Dodonaea bursariifolia	4			
Callitris verrucosa	3	4		
Gahnia lanigera		4		
Hibbertia riparia		3		
Lepidosperma viscidum		5		
Phebalium bullatum		3		
Schoenus subaphyllus		3		
Aotus ericoides		2		
Acacia rigens		2 3		
Goodenia varia		3		
Acacia wilhelmiana		4		
Olearia teretifolia		3		
Prostanthera microphylla		5	3	
Amphipogon caricinus		3		
*Brassica tournefortii	3	2	5	3 2
Helichrysum apiculatum		4 3 3		
Lomandra leucocephala		4	3	
Goodenia sp. aff. affinis		3 4 3	2	
Actinobole uliginosum	4 4 5	3 4 4	4 4 5 5 5	4
Calandrinia granulifera	5 5 5	3 5 4	2 5 5 5	
Daucus glochidiatus	4 5 3	2 3	4 2 5 4 5	3
Helichrysum leucopsideum	3	3 4	3 5 3	
Millotia tenuifolia	5 5 5	5 3 3	5 3 4 4 4	
Podolepis capillaris	3 4 5	5 3	2 4 3	3
Podotheca angustifolia	5 5 5	5 5 4	4 4 5 3 3	
Stenopetalum sphaerocarpum	4 5	3 4 3	3 3 5 2	
Toxanthes muelleri	4 3 3	2	3 2 5 2	
Triodia irritans	4 3 4	5 5 5	4 5 3 5 4	
*Hypochoeris glabra	5 5 5	3 5 5	5 5 4 5	4 3
Brachycome lineariloba	5 4 5	3 5 4	4 4 5 4	5 5
Helipterum pygmaeum	3 3 4		4 5 4	3 4
Calandrinia eremaea	5 5 4	4 5 5	4 5 5 5 5	5 3 2
Senecio glossanthus	4 3	5 4	4 3 5 5 4	3 4 2
Stenopetalum lineare	3 4	3 3	4 4 4 5 4	3 2 2 3
Stipa scabra group	2 5	4 3	2 4 5 4	4 3 2 2 3
Calotis hispidula	4 4	3 4	4 4 3	3 3
Crassula colorata	4 5 5	3 4 3	5 3 5 5 4	4 3 3
Eucalyptus dumosa		3 3 4	4 4 4 5	3 3 3
Eucalyptus foecunda	3	4 5 4	4 5	4
Sclerolaena parviflora		2	3 4 3 4 5	
Wittadinia dissecta	3		3 4 3 3 3	3
Thysanotus baueri	3	3	3 2 4	
Eucalyptus socialis		3	4 3 2	
Sclerolaena diacantha			2 3 5 3	5 5 5 5
Ptilotus spathulatus			3 4	3 3 3 3
Maireana pentatropis			4 3	4 4 4
Chenopodium desertorum			5 3	3 3 2
Eucalyptus gracilis			4	3 3
Eucalyptus oleosa				3 2 4 5
Senecio lautus				2
Oxalis perennans				3
Isoetopsis graminifolia				4
*Erodium cicutarium				2
Erodium crinitum				3
Einadia nutans				3
Eremophila glabra				2 2
Enchylaena tomentosa				3 2
*Medicago minima				2 3
Omphalolappula concava				3 2
*Sonchus oleraceus				3 4
Stipa elegantissima				2 2 2 2
Zygophyllum apiculatum				2 4 3
Olearia muelleri				4
Beyeria opaca				4
Cassia nemophila v.nemophila				3
Westringia rigida			4	3
Zygophyllum aurantiacum				2 3
Maireana erioclada				2
Gnaphalium sphaericum			3	
Grevillea huegelii			2	
Dianella revoluta			2	
Eutaxia microphylla			2	
Melaleuca lanceolata		2	3	
Lomandra effusa			3	
Waitzia acuminata	4	3	4	
Halgania cyanea		5	3	
Menkea australis	2		3 3	
Helichrysum tepperi	4			3
Stellaria filiformis			2	
Calotis sp. aff. hispidula			4	
Eucalyptus cyanophylla			3	
Zygophyllum ammophilum			5	
			4	

Appendix VII (continued...)

Dune-fields of the Big Desert



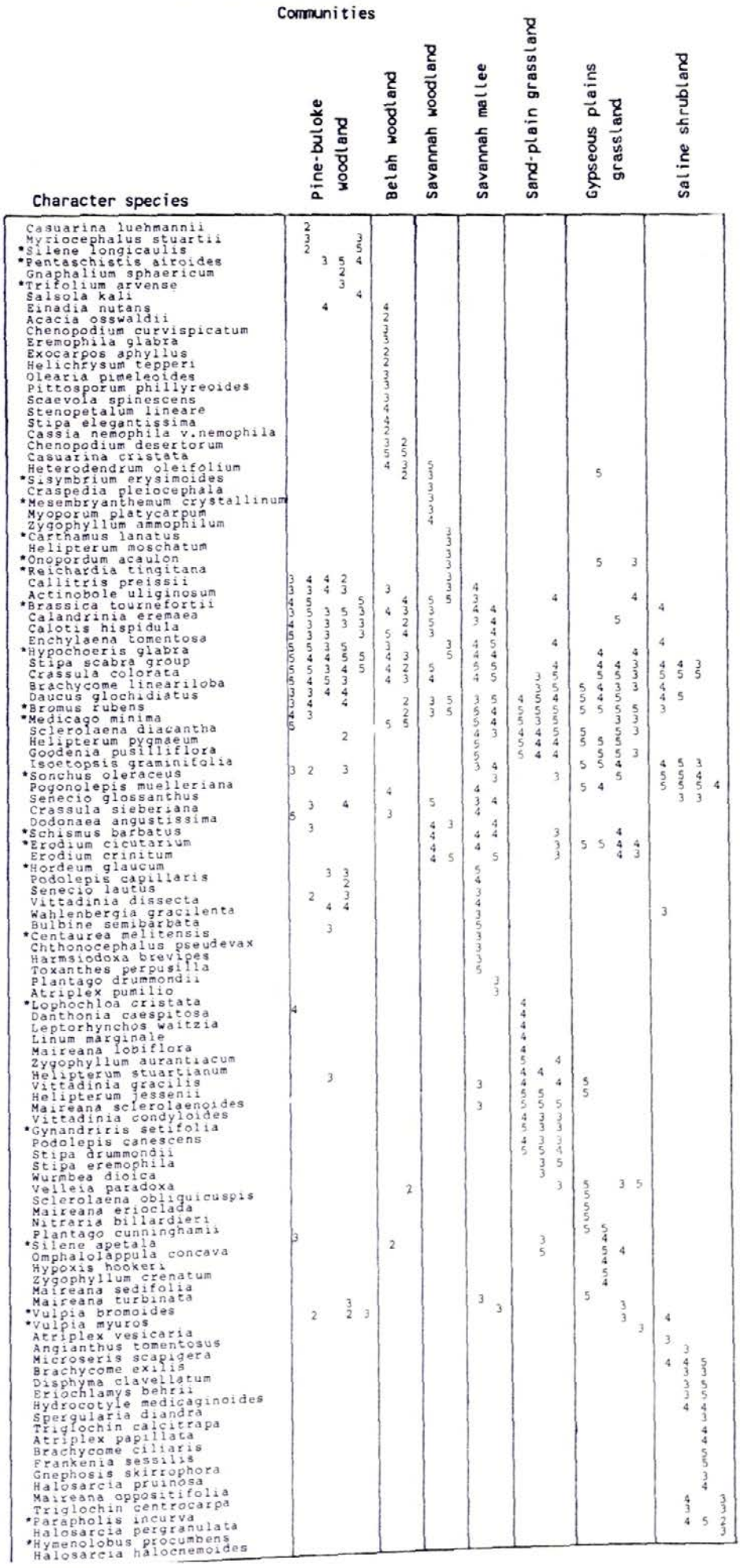
Appendix VII (continued...)

Dune-fields with underlying sandstone ridges

Character species	Communities: Sandstone-rise broombush	Broombush mallee	Heath woodland	Red-swale mallee	Big mallee	Yellow gum woodland
Eutaxia microphylla	5	3				
Acacia calamifolia		5				
Calytrix alpestris		5				
Casuarina muelleriana		5				
Lomandra leucocephala		5				
Leucopogon cordifolius		4				
Phebalium bullatum		4				
Lomandra collina		4				
Spyridium subochreatum		3				
Aotus ericoides		3				
Grevillea pterosperma		3				
Leucopogon rufus		4	5			
Hakea muelleriana		5	5			
Cryptandra leucophracta		3	5			
Astroloma conostephioides		4	5			
Brachycome perpusilla		4				
Calandrinia corrigioloides		3				
Calandrinia granulifera		5				
Plantago drummondii		4				
Triglochin calcitrapa		4				
Trachymene cyanopetala		4				
Hydrocotyle rugulosa		3				
Helipterum demissum		3	2			
Isolepis marginata		3	3			
Millotia tenuifolia		5	4			
Podotheca angustifolia	3	5	5			
Stenopetalum sphaerocarpum		5	4			
Toxanthes muelleri		4	5	2		
Lasiopetalum behrii	3		3			
Thysanotus patersonii			3			
Poranthera microphylla			4			
Helichrysum leucopsideum			2			
Centrolepis cephaloformis			3			
Acacia spinescens						
Eucalyptus foecunda						
Brachyloma daphnoides						
Brachyloma ericoides						
Casuarina pusilla						
Correa reflexa						
Dillwynia hispida						
Eucalyptus baxteri						
Grevillea ilicifolia						
Grevillea lavandulacea						
Calytrix tetragona			3			
Stipa mollis	4		3			
Glischrocaryon behrii	5 4		4			
Callitris verrucosa	5 3	3	4	5		
Eucalyptus incrassata	5 5	5 4	5			
Melaleuca uncinata	5 5	5 5	5			
Baeckea behrii	5 4	5	5	5		
Lepidosperma viscidum	5 4	4	4			
Leptospermum coriaceum	4 5	5	3			
Hibbertia riparia	5 5	5	4			
Baeckea crassifolia	5	5	4			
Calandrinia eremaea		5	3	4	5	5 3
Actinobole uliginosum		5	2	4		4
Helipterum pygmaeum		4		3	4	
Lepidobolus drapetocoleus	3					
Lepidosperma carphoides						
Leptospermum myrsinoides						
Micromyrtus ciliata	5					
Pultenaea tenuifolia						
Triodia irritans						
Bursaria spinosa						
Cryptandra tomentosa						
Lomandra juncea						
Gnaphalium sphaericum				3		
Isoetopsis graminifolia				3		
Senecio lautus				3		
Thysanotus baueri				2		
Brachycome lineariloba		5		4 4	5	
Calotis hispidula				4 3		
Chenopodium desertorum				3 4	5	
Crassula colorata		4 5		4 4 4	3	
Crassula sieberiana				3 3 4		4
Danthonia caespitosa		5		4 4 2		
Daucus glochidiatus		5		4 4		
Senecio glossanthus		3		3 4		
Stenopetalum lineare		2		3 5	3	
Vittadinia dissecta				2 2		4
Wahlenbergia gracilenta		3 5		3		3
Eucalyptus dumosa				5 5 5 4		
Stipa scabra group		5		5 4 4 4	5	4
Beyeria opaca				3	3	
Dodonaea bursariifolia		4		5 2		
Eucalyptus socialis				4		
Eucalyptus calycogona				4 4	4	
Westringia rigida				2	4	
Eucalyptus oleosa				3		
Omphalolappula concava				2		
Ptilotus spathulatus				4		
Zygophyllum aurantiacum				2		
Sclerolaena diacantha				4	3	
Dianella revoluta			3			
Melaleuca lanceolata			3			
Maireana enchylaenoides			3		4	
Eucalyptus gracilis						
Zygophyllum apiculatum					3	
Acacia bivenosa					3	
Carpobrotus modestus					3	
Einadia nutans					3	
Enchylaena tomentosa					3	
*Pentaschistis airoides					3	5
*Hypochoeris glabra		5		3	4	4
*Vulpia bromoides		2				4
Brachycome ciliaris						3
Senecio quadridentatus						3
Eucalyptus leucoxylon						5

Appendix VII (continued...)

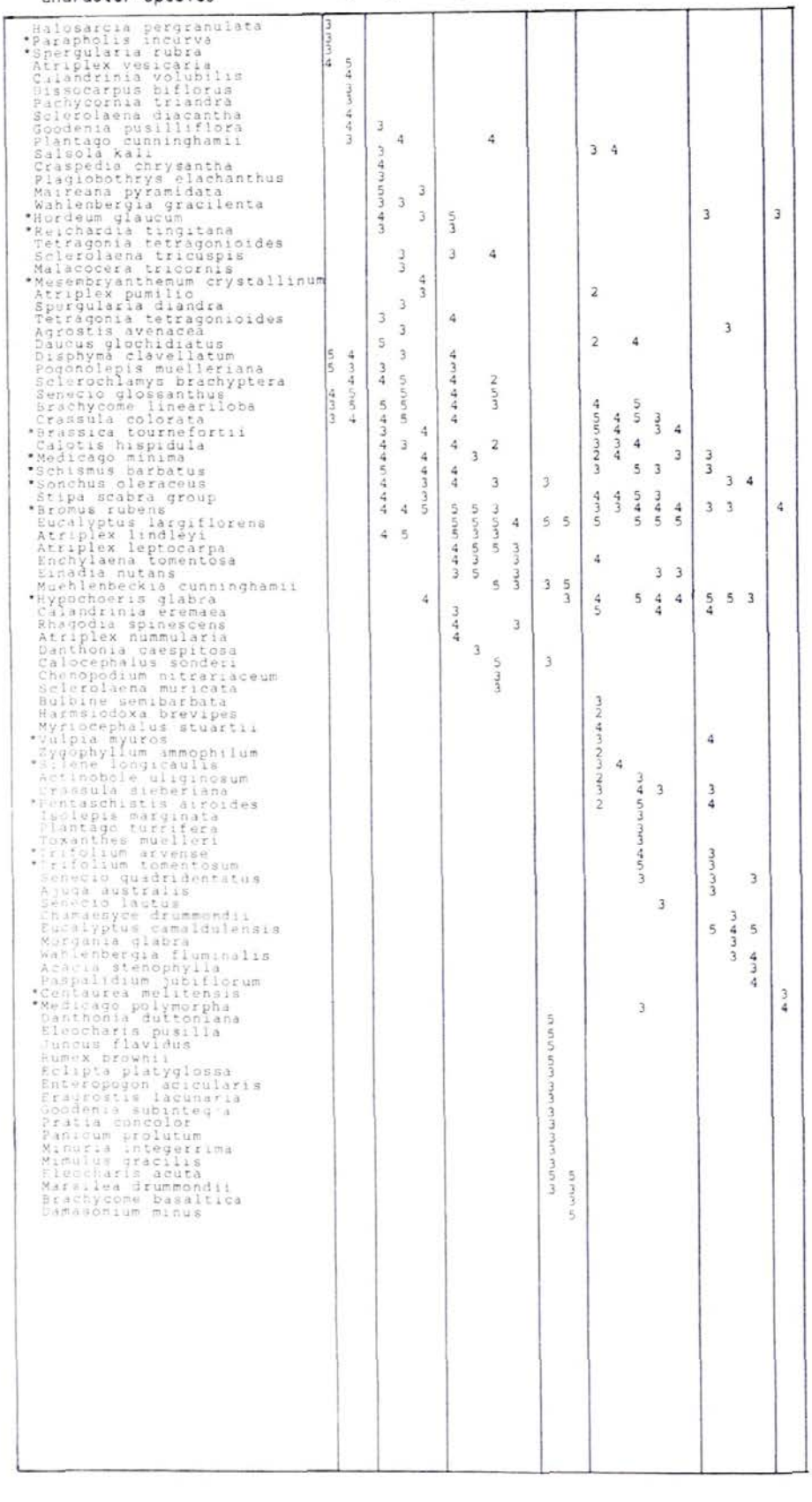
Lunettes, ridges, and evaporative basins



Appendix VII (continued...)

Alluvial terraces and riverine plain

Communities



Character species

Halosarcia pergranulata
*Parapholis incurva
*Spergularia rubra
Atriplex vesicaria
Calandrinia volubilis
Dissocarpus biflorus
Pachycornia triandra
Sclerolaena diacantha
Goodenia pusilliflora
Plantago cunninghamii
Salsola kali
Craspedia chrysantha
Plagiobothrys elachanthus
Maireana pyramidata
Wahlenbergia gracilenta
*Hordeum glaucum
*Reichardia tingitana
Tetragonia tetragonioides
Sclerolaena tricuspis
Malacocera tricornis
*Mesembryanthemum crystallinum
Atriplex pumilio
Spergularia diandra
Tetragonia tetragonioides
Agrostis avenacea
Daucus glochidiatus
Disphyma clavellatum
Podolepis muelleriana
Sclerochlamys brachyptera
Senecio glossanthus
Brachycome lineariloba
Crassula colorata
*Brassica tournefortii
Calotis hispidula
*Medicago minima
*Schismus barbatus
*Sonchus oleraceus
Stipa scabra group
*Bromus rubens
Eucalyptus largiflorens
Atriplex lindleyi
Atriplex leptocarpa
Enchylaena tomentosa
Einadia nutans
Muehlenbeckia cunninghamii
*Hypochoeris glabra
Calandrinia eremaea
Rhagodia spinescens
Atriplex nummularia
Danthonia caespitosa
Calocephalus sonderi
Chenopodium nitrariaceum
Sclerolaena muricata
Bulbine semibarbata
Harmsiodoxa brevipes
Myriocephalus stuartii
*Vulpia myuros
Zygophyllum ammophilum
*Silene longicaulis
Actinobole uliginosum
Crassula sieberiana
*Pentaschistis atroides
Isoetopsis marginata
Plantago turrifera
Toxanthes muelleri
*Trifolium arvense
*Trifolium tomentosum
Senecio quadridentatus
Ajuga australis
Senecio lactus
Chamaesyce drummondii
Eucalyptus camaldulensis
Morgania glabra
Wahlenbergia fluminalis
Acacia stenophylla
Paspalidium jubiflorum
*Centaurea melitensis
*Medicago polymorpha
Danthonia duttoniana
Eleocharis pusilla
Juncus flavidus
Rumex brownii
Eclipta platyglossa
Enteropogon acicularis
Eragrostis lacunaria
Goodenia subintegra
Pratia concolor
Panicum prolutum
Minuria integerrima
Mimulus gracilis
Eleocharis acuta
Marsilea drummondii
Brachycome basaltica
Damasonium minus

RARE OR THREATENED PLANT SPECIES

Key to Appendix VIII

Status code - 'Aust.' indicates the Australia-wide status of the plants according to Leigh, Briggs, and Hartley (1981)
'Vic.' indicates the status of the plants in Victoria; status elsewhere in Australia not being considered

Australia		Victoria	
V	vulnerable	d	depleted
E	endangered	v	vulnerable
R	rare	e	endangered
X	presumed extinct	r	rare
		x	presumed extinct

Reserved in the Mallee area: indicates whether or not the plant is found in a conservation reserve in the study area (Y = yes, N = no)

Species	Common name	Family	Status code Aust.	Status code Vic.	Reserved in Mallee area	Notes
Abutilon fraseri	Dwarf lantern-flower	Malvaceae		e	N	A small subshrub of rocky shallow soils; recorded from Red Cliffs Scenic Reserve, where it is threatened by competition from alien species
Abutilon otocarpum	Desert lantern	Malvaceae		v	Y	Variable subshrub found on most soil types; although reserved in Hattah--Kulkyne National Park it remains threatened by heavy grazing pressures
Abutilon oxycarpum	Straggly lantern-bush	Malvaceae		v	N	A straggly subshrub restricted to grey cracking clays on floodplains
Acacia colletioides	Wait-a-while	Mimosaceae		r	Y	A rigid prickly shrub of sandy calcareous soils in woodlands and mallee shrublands

Appendix VIII (continued...)

Species	Common name	Family	Status code Aust.	Vic.	Reserved in Mallee area	Notes
Acacia glandulicarpa	Hairy-pod wattle	Mimosaceae	V	v	N	A dense, much branched shrub with a restricted distribution. In the Mallee recorded only from the Big Desert, just south-west of Wyperfeld National Park
Acacia havilandii	Needle wattle	Mimosaceae		e	N	A shrub or small tree for many years presumed extinct in Victoria, but recently rediscovered on private land
Acacia lineata	Streaked wattle	Mimosaceae		r	Y	A bushy spreading shrub recorded from Wyperfeld National Park
Acacia loderi	Nealie	Mimosaceae		v	N	A tall shrub or small tree recorded from the Murray River floodplain west of Merbein
Acacia melvillei	Wattle	Mimosaceae		v	N	A tall shrub or small tree occuring as small scattered colonies near Nyah West, Lake Boga, and Merbein south
Acacia notabilis	Wattle	Mimosaceae		v	N	A tall spreading shrub recorded from a small number of locations in the northern Sunset Country
Acacia osswaldii	Umbrella wattle	Mimosaceae		d	Y	Dense shrub or small tree found on a wide range of soil types. Depleted due to a lack of regeneration
Acacia trineura	Three-nerve wattle	Mimosaceae		v	Y	Shrub or small tree, restricted to riverine communities along Outlet Creek, particularly at Lake Albacutya. Lack of flooding is the major threat
Amaranthus macrocarpus	Amaranth	Maranthaceae		v	N	A small erect annual found mostly on floodplains. Recorded from Wallpolla Island and Coonimur
Ammannia multiflora	Jerry-jerry	Lythraceae		v	N	A herb dependant on floods for its regeneration
Amyema linophyllum	Buloke mistletoe	Loranthaceae		v	Y	A stem parasite of *Casuarina luehmannii* and *C. cristata*. Threatened by reduction in distribution of its host species

Angianthus brachypappus	Spreading angianthus	Compositae	v	N	A grey, slightly woolly annual with prostrate stems. Grows in heavier soils on poorly vegetated sites. Not common
Aristida browniana	Wire-grass	Gramineae	v	Y	A tufted perennial grass of deep sandy soils
Asperula gemella	Twin-leaf bedstraw	Rubiaceae	v	N	A perennial herb associated with damp riverine forest. Recorded from Lindsay Island and Lake Powell
Atriplex angulata	Angular saltbush	Chenopodiaceae	v	N	Short-lived sub-shrub recorded from Boundary Bend
Atriplex rhagodioides	Silver saltbush	Chenopodiaceae	v	N	A rounded shrub usually found on river banks or flats. Recorded from Kings Billabong, Burra Swamp, and Hayesdale
Atriplex stipitata	Kidney saltbush	Chenopodiaceae	v	Y	An erect shrubby perennial found in a variety of vegetation types. Recorded in the Hattah--Kulkyne National Park
Boronia inornata	Desert boronia	Rutaceae	v	N	An erect shrub recorded from 'sandy desert', towards Lake Lalbert
Bossiaea walkeri	Cactus bossiaea	Papilionaceae	v	N	A tangled leafless shrub restricted to a small area of mallee communities on calcareous soils near Boundary Bend
Brachycome debilis	Weak daisy	Compositae	v	N	An annual or ephemeral daisy; not recorded during the 1985--87 survey
Brachycome exilis	Slender daisy	Compositae	v	Y	An annual daisy generally found on swampy and frequently saline ground. Recorded at eleven sites including the Wyperfeld National Park
Caesia lateriflora	Sand lily	Liliaceae	r	Y	A perennial herb of sand dunes and sandplains with either *Casuarina--Callitris* woodlands or siliceous

Appendix VIII (continued...)

Species	Common name	Family	Status code Aust.	Vic.	Reserved in Mallee area	Notes
Caladenia leptochila	Narrow-lip spider-orchid	orchidaceae		v	N	A slender hairy orchid with a scattered distribution
Calandrinia volubilis	Twining purslane	Portulacaceae	R	r	Y	A climbing annual herb normally associated with *Halosarcia* and *Sclerostegia* communities. Recorded from Pink Lakes State Park
Callistemon brachyandrus	Prickly bottlebrush	Myrtaceae		r	Y	A prickly spreading shrub, most frequent in river red gum communities, particularly in Hattah--Kulkyne National Park
Callitris columellaris	White cypress pine	Cupressaceae		d	N	A tall straight tree, restricted to a few isolated individuals in the Millewa
Calostemma purpureum	Garland lily	Amaryllidaceae		r	Y	A perennial herb found on floodplains and other damp areas, particularly in the Hattah--Kulkyne National Park
Cassia artemisioides	Silver cassia	Caesalpiniaceae		x	N	Grey-green shrub presumed extinct in Victoria
Casuarina obesa	Swamp she-oak	Casuarinaceae		e	N	Dioecious shrub or tree found on grey heavy clays. Recorded from the western edge of Karadoc Swamp, on private property
Centipeda thespidioides	Desert sneezeweed	Compositae		r	N	An aromatic perennial herb usually found in areas subject to flooding. Recorded at four locations north of the Sunset Country
Cheilanthes lasiophylla	Woolly cloak-fern	Adiantaceae		r	Y	A woolly perennial fern found on rocky and stoney ridges. Recorded for the Red Bluff Wildlife Reserve
Choretrum spicatum	Spiked sour-bush	Santalaceae		r	Y	Sparcely branched shrub found in mallee communities. Recorded for Wyperfeld National Park

Comesperma scorparium	Broom milkwort	Polygalaceae	v	Y	Erect perennial shrub found on deep sands in mallee communities. Threatened by grazing and high fire frequencies
Cratystylis conocephala	Blue-bush daisy	Compositae	x	N	Recorded once in the 19th Century, not recorded since
Crinum flaccidum	Murray lily	Amaryllidaceae	v	N	A perennial bulbous herb found on sandy flats along the Murray River. Recorded for Lake Walla Walla, and Lindsay and Wallpolla Islands
Cymbonotus lawsonianus	Bear's-ears	Compositae	r	Y	A perennial stemless herb recorded in Hattah--Kulkyne National Park
Cymbopogon obtectus	Silky heads	Gramineae	v	Y	Tussocky, strongly aromatic perennial grass, found growing on red sands. Extremely rare in Victoria
Cyperus concinnus	Flat-sedge	Cyperaceae	v	N	A perennial sedge of heavy clay soils in shallow water. Recorded at Leaghur State Forest
Cyperus flaccidus	Flat-sedge	Cyperaceae	v	N	Very rare and localized in Victoria
Cyperus nervulosus	Flat-sedge	Cyperaceae	e	Y	Perhaps a recent introduction to Victoria where known by a single collection from the Hattah--Kulkyne National Park
Cyperus pygmaeus	Flat-sedge	Cyperaceae	v	Y	Small annual sedge found on the margins of lakes and waterways. Recorded for the Murray--Kulkyne and Hattah--Kulkyne parks
Cyperus rigidellus	Flat-sedge	Cyperaceae	e	Y	Rare and very localized in Victoria. Recorded for the Hattah--Kulkyne National Park and Lake Carpel
Cyperus squarrosus	Nut grass	Cyperaceae	v	Y	Perennial herb restricted in Victoria to damp situations. Recorded from Kings Billabong and Hattah--Kulkyne National Park

Appendix VIII (continued...)

Species	Common name	Family	Status code Aust.	Vic.	Reserved in Mallee area	Notes
Dactyloctenium radulans	Finger grass	Gramineae		r	N	Short-lived semi-erect annual grass. Restricted in Victoria to inundated ground near the north-western rivers, but apparently rare
Daviesia genistifolia	Broom bitter-pea	Papilionaceae		r	N	A spiny slender shrub found on dry rocky or sandy sites
Digitaria ammophila	Silky umbrella	Gramineae		v	Y	A tussocky perennial grass recorded at Kings Billabong, Murray--Kulkyne Regional Park, and Lake Powell
Dillwynia uncinata	Silky parrot-pea	Papilionaceae		r	Y	A silky erect shrub recorded from the Big Desert
Diplachne fusca	Brown beetle-grass	Gramineae		r	N	A perennial tussock grass generally associated with floodplain. Sensitive to grazing
Dissocarpus biflorus	Twin-flower saltbush	Chenopodiaceae		r	N	A straggling perennial subshrub found on a variety of soils. Recorded mainly from the Raak Plains
Diuris palustris	Swamp diuris	Orchidaceae		v	N	A small terrestrial orchid found on clay or limestone soils in a variety of vegetation communities
Dodonaea hexandra	Hop-bush	Sapindaceae		r	N	A dioecious spreading shrub found in mallee dune field communities
Drosera indica	Indian sundew	Droseraceae		v	Y	Short lived flood ephemeral. The only Victorian record is in the Hattah--Kulkyne National Park
Dysphania simulans	Pigweed	Chenopodiaceae		e	N	Small annual herb found on saline, gypseous plains
Elachanthus glaber	Elachanth	Compositae		r	Y	An annual herb recorded from Towan Plains, the Raak Plains, and Red Ochre Lake

Eleocharis pallens	Pale spike-rush	Cyperaceae		v	N	A tufted slender rush found on heavy clay soils
Epaltes tatei	Small nut-heads	Compositae	V	v	Y	Compact annual herb recorded from salt lakes in the Sunset Country, including Pink Lakes State Park
Eragrostis australasica	Cane grass	Gramineae		v	N	Stout inland perennial 1--3 m high found growing around lakes and on water-logged heavy clay soils
Eragrostis falcata	Love-grass	Gramineae		r	N	Perennial tussock grass in woodlands near the Murray River
Eragrostis molybdea	Love-grass	Gramineae		r	N	A tufted perennial grass found on moist clay areas. Recorded for the Murray River near Red Cliffs
Eremophila bignoniiflora	Bignonia emu-bush	Myoporaceae		e	Y	A tall shrub or small tree found on periodically flooded heavy clay soils. Recorded for the Hattah--Kulkyne National Park (2 plants only), Lindsay Island, Lake Walla Walla, and Ned's Corner station
Eremophila maculata	Spotted emu-bush	Myoporaceae		r	Y	A dense leafy shrub of clay soils, especially with black box
Eremophila oppositifolia	Twin-leaf emu-bush	Myoporaceae		v	Y	Shrub or small tree to 4m high. Only found in belah woodland communities, which were once common, but are now restricted due to clearing for crops. Grazing is still a threat
Eremophila polyclada	Twiggy emu-bush	Myoporaceae		v	N	A spreading shrub of heavy textured alkaline soils on river flats. Recorded from Lindsay and Wallpolla Islands
Eremophila scoparia	Silvery emu-bush	Myoporaceae		v	N	Erect broom-like shrub to 1.5m. Localized in the far north-west Mallee, south of Benetook
Eremophila sturtii	Narrow-leaf emu-bush	Myoporaceae		e	N	An erect shrub found in various woodland communities. Not recorded during the 1985--87 survey

Appendix VIII (continued...)

Species	Common name	Family	Status code Aust.	Vic.	Reserved in Mallee area	Notes
Eriostemon angustifolius	Narrow-leaf wax-flower	Rutaceae		r	Y	A small-leaved shrub, recorded in Wyperfeld National Park
Eriostemon difformis	Small-leaf wax-flower	Rutaceae		r	N	A low glandular warty shrub, found in mallee communities and hilly areas with skeletal soils. Recorded near Walpeup
Eryngium plantagineum	Long eryngium	Umbelliferae		v	N	A perennial herb found mainly on heavy clay soils of floodplains
Eucalyptus cyanophylla	Blue mallee	Myrtaceae	R	r	N	A multistemmed shrub restricted to the Murray Mallee area on the border of Victoria and South Australia, but locally common
Euphorbia parvicaruncula	Rough-seeded spurge	Euphorbiaceae		e	N	An annual herb recorded from the extreme north-west of Victoria near Millewa
Euphorbia planiticola	Desert spurge	Euphorbiaceae		e	N	A perennial herb found on grey cracking clays
Euphorbia tannensis	Spurge	Euphorbiaceae		e	N	Annual forb, 30--50cm high found growing on heavier clay soils
Frankenia crispa	Hoary sea-heath	Frankeniaceae	R	r	Y	A low, densely branched shrub of salt lakes and pans. Recorded for Hattah-Kulkyne National Park, Pink Lakes State Park, and Towan Plains Flora and Fauna Reserve
Frankenia gracilis	Slender sea-heath	Frankeniaceae	R	r	Y	A low, densely branched shrub found on slightly elevated saline reddish sands. Recorded at Pink Lakes State Park
Geijera parviflora	Wilga	Rutaceae		e	N	Rare tree of north-west Riverina between Piamble and Kerley, the most southerly point of its range. Known only from roadsides and private property

Glycine canescens	Silky glycine	Papilionaceae	e	Y	A perennial twiner found on sandy or stoney soils. Recorded for Hattah--Kulkyne National Park
Gnephosis burkittii	Gnephosis	Compositae	v	N	A prostrate annual herb of open sandy flats in mallee communities
Gnephosis skirrophora	Woolly gnephosis	Compositae	v	Y	A woolly annual herb recorded at the Pink Lakes State Park and the Raak Plains
Hakea leucoptera	Silver needlewood	Proteaceae	d	Y	A bushy shrub or small tree found on various sandy textured soils. Threatened by mammalian grazing
Hakea repullulans	Furze hakea	Proteaceae	r	N	An erect open shrub found on sandy soil in sclerophyllous shrubland or woodland
Hakea tephrosperma	Hooked needlewood	Proteaceae	d	Y	A small tree found on various sandy textured soils. Threatened by grazing
Halosarcia flabelliformis	Samphire	Chenopodiaceae	e	N	A woody perennial inhabiting the margins of salt lakes. Recorded from a single site on the Raak Plain
Halosarcia lylei	Wiry glasswort	Chenopodiaceae	r	N	Succulent rare plant restricted to the margins of salt lakes and salt-pans
Heliotropium asperrimum	Rough heliotrope	Boraginaceae	v	N	Stiff rough perennial forb, 30--60cm high, found growing in damp situations like soaks, creek beds, or drainage tracks. Extremely rare
Helipterum molle	Soft sunray	Compositae	v	N	Grey woolly annual herb, generally on clay soils but occurs on a range of other soil textures
Hemichroa diandra	Mallee hemichroa	Chenopodiaceae	e	N	Rare plant of saline clay-pans. Endangered in Victoria with only one plant known (on private property 5km west of Nowingi)

Appendix VIII (continued...)

Species	Common name	Family	Status code Aust.	Vic.	Reserved in Mallee area	Notes
Heterodendrum oleifolium	Cattle-bush	Sapindaceae		d	Y	A small tree widespread on the inland plains, often co-dominant with *Casuarina cristata*. Threatened by poor seedling establishment and heavy grazing
Ixiolaena chloroleuca	Ixiolaena	Compositae		e	N	A low-growing perennial subshrub growing on heavy soils near the Murray River. A very small number of plants are growing in the Mildura area
Ixiolaena tomentosa	Woolly ixiolaena	Compositae		v	N	Bushy perennial herb mainly restricted to heavy clay soils
Jasminum lineare	Desert jasminum	Oleaceae		v	Y	Stout shrub to 1.5m, typically forming small thickets. Often associated with woodland communities but now quite rare
Kippistia suaedifolia	Fleshy minuria	Compositae		v	Y	Compact dwarf shrub restricted to saline copi rises. Recorded in the Pink Lakes State Park
Lawrencia berthae	Showy lawrencia	Malvaceae		v	N	Small grey-green dioecious shrub restricted to the extreme north-west of Victoria
Leichardtia australis	Austral doobah	Asclepiadaceae		v	Y	Scattered and rare slender twiner of north-west Mallee
Lepidium monoplocoides	Winged pepper-cress	Cruciferae	E	e	Y	Erect annual herb, recorded from saline scalds, heavy soils and seasonally flooded sites. Recorded for the Hattah--Kulkyne and Wyperfeld National Parks
Lepidium phlebopetalum	Veined pepper-cress	Crufiferae		v	N	Erect annual or perennial herb recorded from Kings Billabong and Boundary Point
Lepidium pseudopapillosum	Pepper-cress	Cruciferae	E	e	N	An erect subshrub recorded from three locations including Lindsay Island

Leptorhynchos panaetioides	Woolly buttons	Compositae		r	N	Grey woolly perennial subshrub generally restricted to grey heavy clay soils
Leptorhynchos waitzia	Button immortelle	Compositae		v	N	White, woolly slender ascending annual forb. Found on sandplains on deep red sandy soils. Recorded from the plains in the Sunset Country
Lotus cruentus	Red Bird's-foot trefoil	Papilionaceae		d	Y	Pubescent perennial herb found on a wide range of soil types. Recorded for the Wyperfeld and Hattah--Kulkyne National Parks
Maireana aphylla	Leafless bluebush	Chenopodiaceae		r	N	Compact leafless perennial shrub to 1m high. Associated with alluvial plain communities where it is not common
Maireana cheelii	Chariot blue-bush	Chenopodiaceae	V	v	N	Small erect perennial found mainly on grey clay soils in bladder saltbush communities
Maireana humillima	Dwarf blue-bush	Chenopodiaceae		r	N	Decumbent perennial found on clay soils in a range of vegetation communities
Maireana lobiflora	Lobed blue-bush	Chenopodiaceae		v	N	Perennial herb or small shrub of sandy soil near permanent or ephemeral water. Recorded from the plains of the Sunset Country
Maireana rohrlachii	Rohrlach's blue-bush	Chenopodiaceae		r	Y	Intricately branched shrub usually growing on loamy soils. Recorded for the Hattah--Kulkyne National Park
Maireana triptera	Three-winged blue-bush	Chenopodiaceae		r	N	Bluish-green perennial subshrub 50-70 cm high. Found on slightly heavier soils associated with mallee. Palatable to stock
Malacocera tricornis	Goat head	Chenopodiaceae		r	N	Succulent grey shrub of the Murray floodplain west from Mildura

Appendix VIII (continued...)

Species	Common name	Family	Status code Aust.	Vic.	Reserved in Mallee area	Notes
Melaleuca halmaturorum	Salt paper-bark	Myrtaceae		d	Y	A tree 4--5 m high growing on the edge of salt lakes in the Mallee and Wimmera
Microcybe multiflora	Red microcybe	Rutaceae		v	N	A shrub recorded from isolated blocks near Murrayville and Manya
Microcybe pauciflora	Yellow microcybe	Rutaceae		e	N	A shrub recorded from near Murrayville and the Bronze-wing Wildlife Reserve
Minuria denticulata	Woolly minuria	Compositae		r	N	A perennial herb or subshrub found mainly on clay loam soils in bladder saltbush communities. Recorded from Lindsay Island
Minuria intergerrima	Smooth minuria	Compositae		r	N	A glabrous perennial herb found mainly on grey clay soils in a wide range of vegetation communities. Recorded from Kings Billabong and Leaghur State Forest
Muehlenbeckia horrida	Spiny lignum	Polygonaceae		r	Y	A rigid spiny shrub always associated with clay soils on river flats and alluvial plain communities. Remains threatened by grazing
Myoporum deserti	Turkey-bush	Myoporaceae		d	N	Erect green shrub on rocky or sandy soils. Recorded from Marmal and Yarraby Bushland Reserves
Myoporum montanum	Waterbush	Myoporaceae		r	N	Erect green shrub found along drier inland creek courses. Recorded from a water reserve at Nyah
Myriophyllum porcatum	Ridged water-milfoil	Haloragaceae	R	r	N	Perennial or annual aquatic herb. Endemic to Victoria. Recorded from Wathe Wildlife Reserve

Neobassia proceriflora	Soda-bush	Chenopodiaceae		r	N	Small perennial shrub found on heavy soil often in slightly saline situations
Nicotiana goodspeedii	Smooth-flower tobacco	Solanaceae		r	N	Tall ascending herb. Recorded from the Sunset Country, 25km west of Rocket Lake
Olearia passerinoides	Daisy-bush	Compositae		r	N	Glutinous shrub to 2.5m high. Not recorded during the 1985--87 survey.
Olearia picridifolia	Rasp daisy-bush	Compositae		v	N	A shrub of mallee and heath communities on calcareous soils. Recorded from the Big Desert between Kaniva and Lake Albacutya
Olearia subspicata	Spiked daisy-bush	Compositae		v	Y	Erect shrub of deep sandy red earths in mallee communities. Recorded from the Hattah--Kulkyne National Park
Ophioglossum polyphyllum	Adder's-tongue	Ophioglossaceae		v	Y	Small fern, with a short erect rhizome, producing numerous light yellow-brown wiry roots. Found on deep sandy dunes where it is not common. Recently recorded from the Wyperfeld and Hattah--Kulkyne National Parks
Pachycornia triandra	Desert glasswort	Chenopodiaceae		r	N	Bright green leafless shrub. Restricted in Victoria to the Murray floodplain and at Rocket Lake
Panicum decompositum	Australian millet	Gramineae		r	N	Densely tufted perennial grass found mainly on heavy clay soils of floodplain areas. Recorded near Vinifera Wildlife Reserve
Phebalium lowanense	Lowan phebalium	Rutaceae	V	v	Y	A shrub recorded from the southern Big Desert
Philydrum lanuginosum	Woolly waterlily	Philydraceae		r	N	Perennial herb with glabrous, linear, pointed leaves 15--40 cm long. Scattered through lowland Victoria in shallow freshwater swamps, but very localized

Appendix VIII (continued...)

Species	Common name	Family	Status code Aust.	Vic.	Reserved in Mallee area	Notes
Phlegmatospermum eremaeum	Phlegmatospermum	Cruciferae		v	N	Prostrate spreading downy annual forb with slender stems. Far north-west Mallee
Phyllanthus lacunarius	Lagoon spurge	Euphorbiaceae		v	Y	Small blue-green annual or perennial herb occuring on most soil types along waterways. Recorded from the Hattah--Kulkyne National Park, Lindsay Island, Swan Hill, and Lake Walla Walla.
Phyllota remota	Slender phyllota	Papilionaceae		r	Y	A tap-rooted shrub localized in the Big Desert near the South Australian border
Pimelea simplex	Desert rice-flower	Thymelaeaceae		r	Y	An erect woody plant found on most soil types but generally in areas subject to infrequent flooding. Recorded from the Hattah--Kulkyne National Park
Pimelea williamsonii	Williamson's rice-flower	Thymelaeaceae		x	Y	A bushy shrub, short-lived post fire pioneer. Presumed extinct in Victoria
Poa drummondiana	Knotted poa	Gramineae		r	Y	Perennial grass confined to mallee shrublands. Recorded from the Hattah--Kulkyne National Park
Podolepis arachnoidea	Cottony podolepis	Compositae		x	N	Erect annual herb occuring on deep sands in mallee shrublands
Podolepis canescens	Grey podolepis	Compositae		v	Y	Annual herb occuring on red loamy soils in a wide range of vegetation communities. Recorded from the Wyperfeld National Park
Prasophyllum fuscum	Tawny leek-orchid	Orchidaceae		r	Y	Slender ground orchid occuring in open forests to dry grasslands in western Victoria. Recorded from the Wyperfeld National Park

Psoralea australasica	Psoralea	Papilionaceae		e	N	Erect subshrub generally occuring on heavy soils. Threatened by grazing
Psoralea cinerea	Hoary psoralea	Papilionaceae		e	Y	Annual or perennial herb generally found on grey clays. Appears after flooding. Threatened by grazing
Psoralea patens	Spreading psoralea	Papilionaceae		e	Y	Prostrate perennial herb generally occuring on sandy soil. Recorded from the Wyperfeld National Park
Psoralea tenax	Tough psoralea	Papilionaceae		e	Y	Small erect perennial herb usually found on grey heavy clays. Strongly flood dependant. Threatened by grazing
Pterostylis boormanii	Boorman's greenhood	Orchidaceae		r	N	Slender ground orchid recorded from the Wandown Wildlife Reserve and Wood Wood Flora and Fauna Reserve
Pterostylis hamata	Scaly greenhood	Orchidaceae		r	N	Very localized and rare in Victoria and known from only a few widely separated localities
Ptilotus erubescens	Hairy-tails	Amaranthaceae		e	N	A grazing sensitive herb recorded from Quambatook Wildlife Reserve
Ptilotus nobilis	Yellow-tails	Amaranthaceae		e	N	Stout perennial herb found on the heavy clay of flood-plains. Recorded from Kings Billabong, White Cliffs Irrigation settlement, and the Murray River near Abbotsford Bridge
Ptilotus polystachyus	Long-tails	Amaranthaceae		e	N	A perennial herb often on dunes and sandplains and in a variety of vegetation communities
Pultenaea acerosa	Bristly bush-pea	Papilionaceae	R	v	Y	Small rigid shrub recorded from the Big Desert Wilderness
Pultenaea densifolia	Dense bush-pea	Papilionaceae		r	Y	Rigid diffuse shrub recorded from the Wyperfeld National Park and the Big Desert

Appendix VIII (continued...)

Species	Common name	Family	Status code Aust.	Vic.	Reserved in Mallee area	Notes
Radyera farragei	Desert rose mallow	Malvaceae		v	Y	Velvety shrub found on sandy, often calcareous soils in open mallee communities
Ranunculus undosus	Buttercup	Ranunculaceae		v	N	Perennial herb found on swamp margins in shallow water and in wet or drying mud
Rhagodia ulicina	Spiny goosefoot	Chenopodiaceae		r	N	Low shrub recently recorded in the northern Sunset Country
Rhyncharrhena linearis	Purple pentatrope	Asclepiadaceae		v	Y	Extremely rare in Victoria and confined to the study area. (Sunny Cliffs, Hattah--Kulkyne National Park, and Pink Lakes State Park.)
Rutidosis helichrysoides	Grey wrinklewort	Compositae		v	Y	White-woolly erect perennial forb, 25--50 cm high, found on heavy red sands. Confined to the north-west Mallee and uncommon
Santalum acuminatum	Sweet quandong	Santalaceae		v	Y	Shrub or small tree on sand, sandy loams and gravel ridges in woodland communities
Santalum lanceolatum	Northern sandalwood	Santalaceae		e	Y	Shrub or small tree on a range of soils and woodland communities. Recorded from Narrung Flora Reserve
Scaevola depauperata	Skeleton fan-flower	Goodeniaceae		e	Y	Scrambly tangled leafless shrub occuring on sand-plain and dune-field areas. Recorded from the Hattah--Kulkyne National Park
Scaevola spinescens	Prickly fan-flower	Goodeniaceae		d	Y	Rigid bushy shrub generally associated with belah woodlands in Victoria
Schoenus racemosus	Bog-rush	Cyperaceae		r	N	Tufted perennial rush recorded from the Big Desert Wilderness

Sclerolaena convexula	Tall copperburr	Chenopodiaceae		v	N	Perennial subshrub to 40 cm high with rigid branches covered in soft matted hairs. Restricted to the study area and rare
Sclerolaena uniflora	Two-spined saltbush	Chenopodiaceae		r	Y	Perennial herb found on limestone soil. Recorded from the Hattah--Kulkyne National Park and Pink Lakes State Park
Sclerolaena ventricosa	Salt copperburr	Chenopodiaceae		v	N	Perennial subshrub to 30 cm high, with reddish branches bearing white-woolly hairs. Restricted to the study area and rare
Sclerostegia moniliformis	Ruby glasswort	Chenopodiaceae		r	Y	Shrub of moderately saline areas that are periodically water-logged. Recorded from the Hattah--Kulkyne and Pink Lakes parks
Senecio behrianus	Stiff groundsel	Compositae	X	x	N	Erect woolly perennial subshrub once recorded from near Lake Tyrrell. Sensitive to grazing
Senecio magnificus	Tall yellow-top	Compositae		r	Y	Stout bushy shrub occuring on sandy alluvial soils. Recorded for the Wyperfeld National Park
Sida ammophila	Sand sida	Malvaceae		v	Y	Sprawling subshrub occuring on a variety of soil types. Sensitive to grazing
Sida fibulifera	Pin sida	Malvaceae		v	Y	Prostrate perennial occuring on clay floodplain soils. Recorded from Kings Billabong, Red Cliffs Scenic Reserve, and the Hattah--Kulkyne National Park
Solanum lacunarium	Lagoon nightshade	Solanaceae		v	N	A sprawling herbaceous perennial confined to flood plains. Recorded from Lindsay Island and Lake Walla Walla
Sporobolus caroli	Yakka grass	Gramineae		r	N	Tufted perennial grass found on a variety of soils and vegetation communities

Appendix VIII (continued...)

Species	Common name	Family	Status code Aust.	Vic.	Reserved in Mallee area	Notes
Spyridium tridentatum	Trident spyridium	Rhamnaceae	R	x	Y	Slender shrub recorded from near the Hattah township
Stenopetalum velutinum	Velvet thread-petal	Cruciferae		v	Y	Erect branched annual forb, 10--40 cm high, densely downy. Extremely rare plant of the Mallee and Wimmera
Stipa hemipogon	Half-bearded spear-grass	Gramineae		r	Y	A tussock-forming perennial typically of deep, sandy soils. Two records of this species exist from Victoria; one from near Stawell and the other during the 1985--87 survey from the Patchewollock region
Stipa nullanulla	Spear-grass	Gramineae		v	N	A small tussock grass to 50 cm high. Found growing on small copi rises. Only one population known in the Nowingi area
Stipa pilata	Prickly spear-grass	Gramineae		v	N	Tussock grass recorded from the extreme north-west of Victoria near Millewa
Stipa setacea	Corkscrew spear-grass	Gramineae		r	N	Perennial grass generally associated with woodland communities
Stipa tuckeri	Spear-grass	Gramineae		e	N	Tussocky perennial grass, 20--50 cm high. Extremely rare in Victoria and known from only two locations - Robinvale and Boonoonar salt-pans west from Carwarp
Styphelia exarrhena	Desert styphelia	Epacridaceae		r	Y	Erect shrub occuring on sandy soils over limestone. Recorded from the Big Desert Wilderness
Swainsona greyana	Hairy darling Pea	Papilionaceae		v	N	Shrub-like perennial asociated with heavy soils on floodplains. Recorded from Lindsay Island
Swainsona laxa	Yellow swainson pea	Papilionaceae		v	Y	A subshrub on loamy sands that only appears after fires

Swainsona murrayana	Murray swainson-pea	Papilionaceae	e	N	Slender erect herb found on clay soils in bladder saltbush, black box, and grassland communities
Swainsona phacoides	Dwarf swainson-pea	Papilionaceae	v	Y	Perennial spreading herb found on dunes and sandplains. Recorded at the Hattah--Kulkyne National Park
Swainsona plagiotropis	Red swainson-pea	Papilionaceae	e	N	Variable perennial found on hard setting or cracking clays. Recorded from Beulah in the Hopetoun area
Swainsona stipularis	Swainson-pea	Papilionaceae	v	N	Erect bushy downy grey forb to 70 cm high, found growing on small sand rises within Raak communities. Vulnerable in Victoria but common Australia-wide
Swainsona swainsonoides	Downy swainson-pea	Papilionaceae	e	N	Rare and endangered in Victoria. Found on heavier clay soils within saltbush plains
Templetonia egena	Rough templetonia	Papilionaceae	d	Y	Erect leafless shrub found on a variety of soil types and principally in woodland communities
Templetonia stenophylla	Leafy templetonia	Papilionaceae	d	N	A grazing sensitive shrub recorded from the Quambatook area
Tetragonia eremaea	Annual spinach	Aizoaceae	r	N	Prostrate annual herb recorded from the extreme north-west of Victoria, near Millewa
Thelymitra canaliculata	Azure sun-orchid	Orchidaceae	v	Y	A slender orchid found on limestone or calcareous sands in heathland communities
Tragus australianus	Small burr-grass	Gramineae	r	Y	Localized and rare in Victoria where confined to sandy open parts of the northern Mallee
Triglochin hexagona	Six-point arrow grass	Juncaginaceae	v	N	Small ephemeral on the margins of salt lakes
Trigonella suavissima	Sweet fenugreek	Papilionaceae	r	N	An annual herb found in association with river banks and floodplains on heavy clay soils

Appendix VIII (continued...)

Species	Common name	Family	Status code Aust.	Vic.	Reserved in Mallee area	Notes
Triraphis mollis	Needle grass	Gramineae		r	Y	Perennial tussock grass of non-riverine woodlands
Velleia arguta	Velleia	Goodeniaceae		r	Y	A perennial herb generally found in plains, grasslands, and mallee shrublands. Recorded from the Hattah--Kulkyne National Park
Vittadinia blackii	Western New Holland daisy	Compositae		v	N	A perennial undershrub recorded near Wandown Wildlife Reserve
Vittadinia megacephala	Giant New Holland daisy	Compositae		v	Y	A perennial herb recorded from the Wyperfeld National Park
Vittadinia pterochaeta	New Holland daisy	Compositae		e	N	An annual or perennial herb recorded from the White Cliffs Irrigation Settlement
Xanthorrhoea semiplana	Grass-tree	Liliaceae		r	Y	Recorded from the Big Desert Wilderness
Zieria veronicea	Pink zieria	Rutaceae		r	Y	A small lemon-scented shrub recorded from 15km north of Yanac, and recently from the Red Bluff Wildlife Reserve
Zygophyllum compressum	Rabbit-ears twin-leaf	Zygophyllaceae		v	N	An erect annual herb found in salty claypans and may be gypsophilous

Appendix IX

ISOLATED BLOCKS OF SIGNIFICANCE FOR VEGETATION

Location	Reason for significance	Public land use[1]
Hardwood production areas		
Potterwallkagee Creek - west of Mildura	Black box forest formation Rare species: *Eremophila bignoniflora* *Swainsona greyana*	E1
Wallpolla Island - west of Mildura	Vegetation communities of national and State significance; areas largely undisturbed Rare species: *Neobassia proceriflora* *Sporobolus mitchellii* *Pachycornia triandra* *Ammania multiflora* *Crinum flaccidum* *Epaltes australis* *Sida ammophila* *Eremophila maculata*	E1
Yelta - west of Merbein, at the confluence of the Darling and Murray Rivers	A full range of major river terraces within a small area; unreserved communities present Rare species: *Eremophila sturtii* *Pachycornia triandra* *Sclerostegia tenius*	E2
Horseshoe Bend - Merbein	A diverse range of plant communities present, although they are heavily grazed Rare species: *Frankenia* sp.	E2

Appendix IX (continued...)

Location	Reason for significance	Public land use[1]
Bottle Bend - east of Red Cliffs	Extensive stands of black box present with prolific regeneration Rare species: *Ammania multiflora* *Marsilea angustifolia* *Ptilotus nobilis* Area has high scenic values	E3
Snaggy Point to Browns Bend - south-east of Red Cliffs	Diverse array of river red gum and black box communities Rare species: *Lotus australis* *Sporobolus mitchellii* *Frankenia* sp. *Dissocarpus biflorus* *Calandrinia volubilis*	E3
Tarpaulin Bend - east of Colignan	High diversity of black box and river red gum woodlands; regionally significant populations of *Atriplex nummularia, Rhagodia spinescens, Stelligera endecaspinis,* and *Malacocera tricornis*	E4
Bumbang Island - Robinvale	High habitat diversity; areas of *Atriplex nummularia* shrubland Rare species: *Eryngium plantagineum*	E4
Walshe's Bend - Robinvale	Rare species: *Asperula gemella* *Eryngium plantagineum*	E4
Belcher Island - south-east of Robinvale	High habitat diversity comparable with Hattah--Kulkyne National Park Rare species: *Eulalia fulva*	E5

Murray--Murrumbidgee Rivers junction	Most extensive array of billabong formation, extensive tall river red gum forest Rare species: *Eulalia fulva*	E5
Major Mitchell Lagoon - west of Piambie	Black box--*Danthonia* sp. communities with extensive *Danthonia* sp. cover; grazing currently absent	E5
Nyah and Vinifera Forest - north-east of Nyah West	Restricted river red gum and swamp communities of regional significance	E9
Leaghur State Forest - south of Kerang	Restricted, poorly reserved black box wetland community	E6
Uncommitted land		
South-west of Kulwin	Relatively intact salt-lake lunette complex; communities present very poorly reserved	S1
Allotment 13, Parish of Manya - north-west of Murrayville	Large undisturbed isolate Rare species: *Microcybe multiflora*	S1
Allotments 1 and 2, Parish of Koonda - north-east of Cowangie	Large relatively undisturbed isolate of mallee shrubland	S1
Three blocks west of Wathe Wildlife Reserve	These isolates serve as important 'stepping stones' between Wathe Wildlife Reserve and Wyperfeld National Park	S1
Wildlife (D) and flora and fauna (G) reserves		
Yarrara	Large, relatively undisturbed block of *Casuarina cristata* woodland	G1 & G2

Appendix IX (continued...)

Location	Reason for significance	Public land use[1]
	Rare or threatened species present include: *Heterodendrum oleifolium* *Hakea tephrosperma* *Eremophila oppositifolia* *Acacia osswaldii* *Scaevola spinescens* *Ixiolaena tomentosa*	
Wemen	Large, relatively undisturbed block of *Casuarina cristata* woodland Rare or threatened species present include: *Heterodendrum oleifolium* *Hakea tephrosperma* *Acacia osswaldii* *Scaevola spinescens*	
East of Wemen	Large, relatively undisturbed areas of mallee shrubland and *Casuarina* and *Callitris* woodlands	G7
North of Bolton	Relatively intact mallee shrubland surrounding a saltpan; large isolate	G10
Kulwin	Large, relatively undisturbed isolate of mallee shrubland	G11
Wandown	Large, relatively undisturbed isolate of mallee shrubland	D3
South of Robinvale	Larger isolate of mallee shrubland in an area generally cleared of native vegetation	G8

Bannerton	Relatively undisturbed areas of *Casuarina cristata* woodland and mallee shrubland	G9
North-west of Linga	Relatively undisturbed areas of *Casuarina cristata* woodland Rare species: *Heterodendrum oleifolium* *Acacia osswaldii* *Scaevola spinescens*	G12
Timberoo - south-west of Ouyen	Large area of mallee shrubland and *Callitris preissii* and *Casuarina cristata* woodland	G15
Nyang Reserve - near Torrita	Mallee shrubland and regenerating *Callitris* woodland; rare and endangered species include: *Scaevola spinescens* *Heterodendrum oleifolium* *Hakea tephrosperma*	G13
South-west of Manangatang	*Casuarina cristata* woodland with a saltbush understorey	G20
Pine Reserve - east of Cocamba	Relatively undisturbed isolate of mallee shrubland	G21
South-west of Chinkapook	*Casuarina* woodland with a chenopod understorey	G24
South of Chinkapook	*Heterodendrum oleifolium* shrublands and *Casuarina--Callitris* woodlands in a relatively undisturbed condition	G25
West of Chillingollah	Relatively undisturbed examples of *Stipa* grassland and *Callitris--Heterodendrum* communities	G26
Towan Plains - east of Chinkapook	Relatively undisturbed boinka	G22

Appendix IX (continued...)

Location	Reason for significance	Public land use[1]
Dartagook - south-east of Lake Boga	Black box wetlands and swamp communities of regional significance; eastern-most occurrence of *Eremophila divaricata*	D9
South-east of Piangle	Relatively undisturbed shrubland	G23
Lake Marlbed - north of Birchip	Black box woodland and *Muehlenbeckia cunninghamii* shrubland Rare species: *Muehlenbeckia horrida*	G30
Bushland and other reserves		
North-west at Walpeup	Relatively undisturbed area of *Casuarina cristata* woodland Rare species: *Scaevola depauperata* *Heterodendrum oleifolium* *Santalum acuminatum* *Hakea tephrosperma*	I19
North of Walpeup	*Eucalyptus porosa* woodland/shrubland; a poorly reserved community in the region	I27
South of Wemen	Regenerating *Callitris preissii* woodland present; no recent disturbance within this reserve	I43
West of Kulwin	Relatively undisturbed isolate near G11; bridging isolate between G11 and the significant uncommitted block to the south	I50
Murrayville	Large, relatively undisturbed isolate; areas of *Callitris preissii* woodland regenerating Rare species: *Microcybe multiflora* *Eucalyptus porosa*	I62

East of Murrayville	Regenerating *Callitris* woodland	I63
North-east of Murrayville	Regenerating *Callitris* woodland	I65
North of Linga	Regenerating *Callitris preissii* woodland in association with *Dodonaea viscosa* shrubland	I61
South-east of Speed	Significant species: *Eucalyptus behriana* and *Hakea leucoptera*	I126
North of Underbool	Large area of *Casuarina cristata* woodland	I74
Walpeup	Regenerating *Callitris* woodland	I78
West of Chillingollah	*Acacia melvillei*	I148
South-east Chillingollah	*Acacia melvillei*	I149
Township of Goschen	*Acacia melvillei*	Township reserve
South of Goschen	*Acacia melvillei*	Water reserve (S1)
East of Lalbert	Relatively undisturbed *Eucalyptus calycogona* shrubland	I200
North-west of Quambatook	*Casuarina* woodland Rare species: *Eryngium plantagineum*	I202
South of Quambatook	Poorly reserved vegetation community - *Casuarina luehmannii, Eucalyptus largiflorens,* and *E. leucoxylon* woodlands with *Acacia pycnantha* and *Bursaria spinosa* understorey	I208, I210, and I207

Note:
1. As indicated on Map 8

Appendix X

OCCURRENCE OF VERTEBRATE FAUNA IN PLANT COMMUNITIES

Key to Appendix X

Major habitats and plant communities

Assessment of the occurrence of vertebrate species in plant communities is based largely on the 1985--87 survey results, while occurrence in the seven major habitats includes all other available information wherever possible. (A blank entry does not necessarily imply that a species does not occur in a particular community, only that it was not recorded during the survey. See also Note 1 below.)

x in the first column of each major habitat indicates that the species is present in that category

\+ indicates that the species is present in that plant community

Mallee-dependent in Victoria

\+ indicates that the species is dependent on mallee vegetation in Victoria

Distribution and abundance in the study area

Both distribution and abundance are subjective assessments based on the scientific literature and on research conducted in the study area during 1985--87. (A blank entry implies not assessed.)

Distribution:

- R restricted (occurs in less than 10% of the area)
- M moderate (occurs in 10 to 50% of the area)
- W widespread (occurs in greater than 50% of the area)
- ? not known

Abundance:

- E extinct
- R rare
- U uncommon
- C common
- A abundant
- ? not known

* Introduced species are indicated by an asterisk before the scientific name.

Notes:

1. The sites examined during the 1985--87 survey were selected to cover as wide a range of plant communities as possible. However, they were not necessarily sampled at equal intensities, and not all plant communities were sampled. This must be recognized when assessing the information contained within the appendix. Those communi-

Appendix X (continued...)

ties not sampled during the survey were: sand-plain heath, broom baeckea heath, tea-tree scrub, scrub-pine woodland, sandstone-rise broombush, heath woodland, savannah woodland, grassland, sand-plain grassland, black box wetland, and lake-bed herbfield. Furthermore, some of the plant communities were aggregated to facilitate analysis. This was done in essentially the same manner as is shown on Map 10 - Floristic Vegetation; the groupings are listed in Note 3.

2. Nomenclature for scientific and common names used throughout Chapter 8 and listed in this appendix follows Schodde and Tidemann (1986) for birds; Cogger (1986) for reptiles and amphibians (except where stated otherwise); and Menkhorst (1983) for mammals [except for *Nycticieus* which becomes *Scotorepens* (Kitchener and Caputi, 1985), *Taphozous* which becomes *Saccolaimus* (Koopman, 1984), the inclusion of *Planigale gilesi*, and the inclusion of the common name Mallee Ningaui]. Common names have been used throughout the text, except for species of reptiles and amphibians that do not have recognized common names.

3. Major faunal habitats shown here correspond to the regional assemblages of plant communities described in Chapter 7. Aggregation of the plant communities within each regional assemblage (major faunal habitat) was undertaken as follows:

Dune-fields of the Sunset Country
- East--west-dune mallee
- Chenopod mallee
- Shallow-sand mallee
- Deep-sand mallee

Dune-field of the Big Desert and Wyperfeld
- Dune-crest tree-heath
- Sand-plain heath
  - including broom baeckea heath
  - including tea-tree scrub
- Mallee heath
  - including swale mallee-heath
  - including loamy sand mallee (in part)
- Scrub-pine woodland

Dune-field with underlying sandstone ridge
- Broombush mallee
  - including sandstone-rise broombush
- Heath woodland
- Red-swale mallee
  - including loamy sand mallee (in part)
- Big mallee
- Yellow gum woodland

Lunettes and ridges
- Pine--buloke woodland
- Belah woodland
- Savannah woodland
  - including savannah mallee
  - including grassland

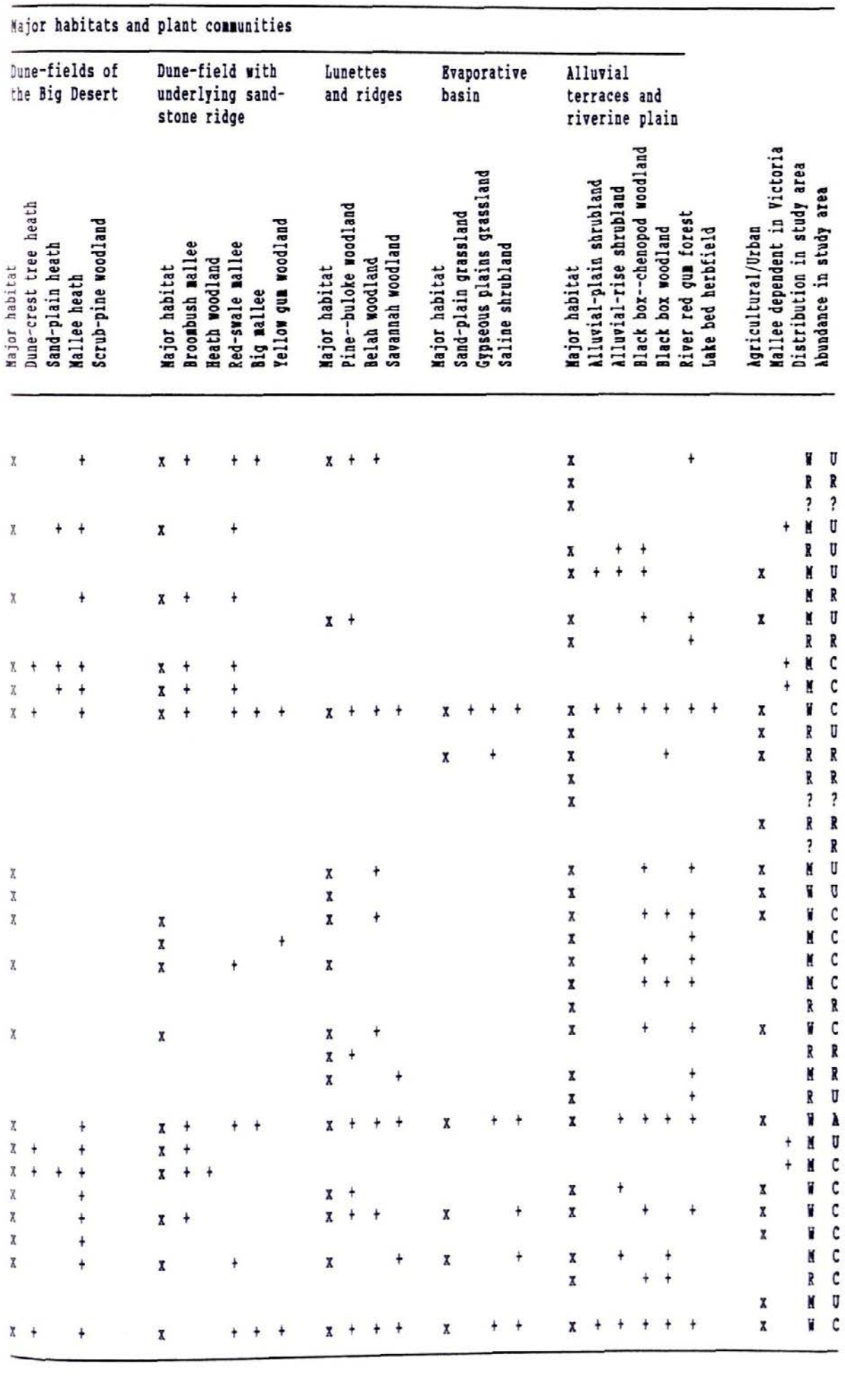
Evaporative basin (boinka)
- Sand-plain grassland
- Gypseous plains grassland
- Saline shrubland

Alluvial terraces and riverine plain
- Alluvial-plain shrubland
- Alluvial-rise shrubland
- Black box--chenopod woodland
  - including black box wetland
- Black box woodland
- River red gum forest
- Lake-bed herbfield

Agricultural and urban

Appendix X (continued...)

Common name	Scientific name	Dune-fields of the Sunset Country				
		Major habitat	East--west dune mallee	Chenopod mallee	Shallow-sand mallee	Deep-sand mallee
MAMMALS						
Short-beaked echidna	*Tachyglossus aculeatus*	x	+	+	+	+
Platypus	*Ornithorhynchus anatinus*					
Yellow-footed antechinus	*Antechinus flavipes*					
Mallee ningaui	*Ningaui yvonneae*	x	+		+	+
Paucident planigale	*Planigale gilesi*					
Fat-tailed dunnart	*Sminthopsis crassicaudata*					
Common dunnart	*Sminthopsis murina*	x	+	+		+
Common brushtail possum	*Trichosurus vulpecula*					
Feathertail glider	*Acrobates pygmaeus*					
Western pygmy-possum	*Cercartetus concinnus*					
Little pygmy-possum	*Cercartetus lepidus*	x			+	
Western grey kangaroo	*Macropus fuliginosus*	x	+	+	+	+
Eastern grey kangaroo	*Macropus giganteus*					
Red kangaroo	*Macropus rufus*	x		+		
Swamp wallaby	*Wallabia bicolor*					
Koala	*Phascolarctos cinereus*					
Little red flying-fox	*Pteropus scapulatus*					
Yellow-bellied sheathtail-bat	*Saccolaimus flaviventris*					
Little mastiff-bat	*Mormopterus planiceps*	x				
White-striped mastiff-bat	*Tadarida australis*	x				
Gould's wattled bat	*Chalinolobus gouldii*	x	+	+		+
Chocolate wattled bat	*Chalinolobus morio*	x	+	+		+
King River eptesicus	*Eptesicus regulus*	x	+	+		
Little forest eptesicus	*Eptesicus vulturnus*	x		+		+
Large-footed myotis	*Myotis adversus*					
Lesser long-eared bat	*Nyctophilus geoffroyi*	x	+	+		+
Greater long-eared bat	*Nyctophilus timoriensis*	x				
Western broad-nosed bat	*Scotorepens balstoni*					
Water-rat	*Hydromys chrysogaster*					
House mouse	**Mus musculus*	x	+	+	+	+
Mitchell's hopping-mouse	*Notomys mitchelli*	x	+		+	+
Silky mouse	*Pseudomys apodemoides*					
Dog	**Canis familiaris*	x			+	
Red fox	*Vulpes vulpes*	x	+	+	+	+
Cat	**Felis catus*	x	+			
Goat	**Capra hircus*	x	+	+	+	+
Pig	**Sus scrofa*					
Brown hare	**Lepus capensis*	x		+	+	
European rabbit	**Oryctolagus cuniculus*	x		+	+	+


Major habitats and plant communities
Dune-fields of the Big Desert
Dune-field with underlying sand-stone ridge
Lunettes and ridges
Evaporative basin
Alluvial terraces and riverine plain
Major habitat
Dune-crest tree heath
Sand-plain heath
Mallee heath
Scrub-pine woodland
Major habitat
Broombush mallee
Heath woodland
Red-swale mallee
Big mallee
Yellow gum woodland
Major habitat
Pine--buloke woodland
Belah woodland
Savannah woodland
Major habitat
Sand-plain grassland
Gypseous plains grassland
Saline shrubland
Major habitat
Alluvial-plain shrubland
Alluvial-rise shrubland
Black box--chenopod woodland
Black box woodland
River red gum forest
Lake bed herbfield
Agricultural/Urban
Mallee dependent in Victoria
Distribution in study area
Abundance in study area

Appendix X (continued...)

Common name	Scientific name	Dune-fields of the Sunset Country				
		Major habitat	East--west dune mallee	Chenopod mallee	Shallow-sand mallee	Deep-sand mallee
BIRDS - Non-Passerines						
Emu	*Dromaius novaehollandiae*	x	+	+	+	+
Great crested grebe	*Podiceps cristatus*					
Australasian grebe	*Tachybaptus novaehollandiae*					
Hoary-headed grebe	*Poliocephalus poliocephalus*					
Pied cormorant	*Phalacrocorax varius*					
Great cormorant	*Phalacrocorax carbo*					
Little black cormorant	*Phalacrocorax sulcirostris*					
Little pied cormorant	*Phalacrocorax melanoleucos*					
Darter	*Anhinga melanogaster*					
Australian pelican	*Pelecanus conspicillatus*					
Pacific heron	*Ardea pacifica*					
White-faced heron	*Ardea novaehollandiae*					
Cattle egret	*Ardea ibis*					
Great egret	*Ardea alba*					
Little egret	*Ardea garzetta*					
Intermediate egret	*Ardea intermedia*					
Rufous night heron	*Nycticorax caledonicus*					
Little bittern	*Ixobrychus minutus*					
Australasian bittern	*Botaurus poiciloptilus*					
Glossy ibis	*Plegadis falcinellus*					
Sacred ibis	*Threskiornis aethiopicus*					
Straw-necked ibis	*Threskiornis spinicollis*					
Royal spoonbill	*Platalea regia*					
Yellow-billed spoonbill	*Platalea flavipes*					
Letter-winged kite	*Elanus scriptus*					
Black-shouldered kite	*Elanus notatus*					
Black kite	*Milvus migrans*					
Whistling kite	*Milvus sphenurus*					
Square-tailed kite	*Lophoictinia isura*					
Black-breasted buzzard	*Hamirostra melanosternon*					
Brown goshawk	*Accipiter fasciatus*					
Grey goshawk	*Accipiter novaehollandiae*					
Collared sparrowhawk	*Accipiter cirrhocephalus*					
Little eagle	*Hieraaetus morphnoides*	x	+		+	
Spotted harrier	*Circus assimilis*	x		+		
Swamp harrier	*Circus approximans*					
White-bellied sea-Eagle	*Haliaeetus leucogaster*					
Wedge-tailed eagle	*Aquila audax*	x		+		
Grey falcon	*Falco hypoleucos*	x		+		

Major habitats and plant communities

Dune-fields of the Big Desert				Dune-field with underlying sandstone ridge					Lunettes and ridges			Evaporative basin			Alluvial terraces and riverine plain											
Major habitat	Dune-crest tree heath	Sand-plain heath	Mallee heath	Scrub-pine woodland	Major habitat	Broombush mallee	Heath woodland	Red-swale mallee	Big mallee	Yellow gum woodland	Major habitat	Pine--buloke woodland	Belah woodland	Savannah woodland	Major habitat	Sand-plain grassland	Gypseous plains grassland	Saline shrubland	Major habitat	Alluvial-plain shrubland	Alluvial-rise shrubland	Black box--chenopod woodland	Black box woodland	River red gum forest	Lake bed herbfield	Agricultural/Urban	Mallee dependent in Victoria	Distribution in study area	Abundance in study area
																			X				+				W	U
																			X								M	
																			X							X	W	
																			X							X	W	
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					X					+	X	+	+						X			+				X	W	U
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		+			X														X							X	W	U
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					X	+		+	+	+									X	+			+	+		X	W	U
																			X	+						X	W	R

Appendix X (continued...)

Common name	Scientific name	Dune-fields of the Sunset Country				
		Major habitat	East--west dune mallee	Chenopod mallee	Shallow-sand mallee	Deep-sand mallee
Brown falcon	*Falco berigora*	x	+	+	+	+
Australian kestrel	*Falco cenchroides*	x		+	+	
Australian hobby	*Falco longipennis*					
Peregrine falcon	*Falco peregrinus*					
Black falcon	*Falco subniger*					
Magpie goose	*Anseranas semipalmata*					
Wandering whistling-duck	*Dendrocygna arcuata*					
Plumed whistling-duck	*Dendrocygna eytoni*					
Black swan	*Cygnus atratus*					
Freckled duck	*Stictonetta naevosa*					
Australian shelduck	*Tadorna tadornoides*					
Maned duck	*Chenonetta jubata*					
Pink-eared duck	*Malacorhynchus membranaceus*					
Grey teal	*Anas gibberifrons*					
Chestnut teal	*Anas castanea*					
Pacific black duck	*Anas superciliosa*					
Mallard	*Anas platyrhynchos*					
Australasian shoveler	*Anas rhynchotis*					
Hardhead	*Aythya australis*					
Blue-billed duck	*Oxyura australis*					
Musk duck	*Biziura lobata*					
Malleefowl	*Leipoa ocellata*	x			+	+
Stubble quail	*Coturnix pectoralis*					
Brown quail	*Coturnix ypsilophora*					
Painted button-quail	*Turnix varia*	x				
Little button-quail	*Turnix velox*	x				
Red-chested button-quail	*Turnix pyrrhothorax*					
Lewin's rail	*Dryolimnas pectoralis*					
Buff-banded rail	*Gallirallus philippensis*					
Australian crake	*Porzana fluminea*					
Spotless crake	*Porzana tabuensis*					
Baillon's crake	*Porzana pusilla*					
Black-tailed native-hen	*Gallinula ventralis*					
Dusky moorhen	*Gallinula tenebrosa*					
Purple swamphen	*Porphyrio porphyrio*					
Eurasian coot	*Fulica atra*					
Kori bustard	*Ardeotis kori*					
Brolga	*Grus rubicundus*					
Painted snipe	*Rostratula benghalensis*					
Pied oystercatcher	*Haematopus longirostris*					

Major habitats and plant communities

| Dune-fields of the Big Desert | | | | Dune-field with underlying sandstone ridge | | | | Lunettes and ridges | | | Evaporative basin | | | Alluvial terraces and riverine plain | | | |

Appendix X (continued...)

Common name	Scientific name	Dune-fields of the Sunset Country
		Major habitat East--west dune mallee Chenopod mallee Shallow-sand mallee Deep-sand mallee
Plains-wanderer	*Pedionomus torquatus*	
Black-winged stilt	*Himantopus himantopus*	
Red-necked avocet	*Recurvirostra novaehollandiae*	
Banded stilt	*Cladorhynchus leucocephalus*	
Bush thick-knee	*Burhinus grallarius*	
Australian pratincole	*Stiltia isabella*	
Banded lapwing	*Vanellus tricolor*	
Masked lapwing	*Vanellus miles*	
Lesser golden plover	*Pluvialis dominica*	
Grey plover	*Pluvialis squatarola*	
Red-kneed dotterel	*Erythrogonys cinctus*	
Black-fronted dotterel	*Charadrius melanops*	
Inland dotterel	*Peltohyas australis*	
Double-banded plover	*Charadrius bicinctus*	
Red-capped plover	*Charadrius ruficapillus*	
Oriental plover	*Charadrius veredus*	
Mongolian plover	*Charadrius mongolus*	
Ruddy turnstone	*Arenaria interpres*	
Bar-tailed godwit	*Limosa lapponica*	
Black-tailed godwit	*Limosa limosa*	
Whimbrel	*Numenius phaeopus*	
Little curlew	*Numenius minutus*	
Eastern curlew	*Numenius madagascariensis*	
Wood sandpiper	*Tringa glareola*	
Greenshank	*Tringa nebularia*	
Marsh sandpiper	*Tringa stagnatilis*	
Common sandpiper	*Actitus hypoleucos*	
Grey phalarope	*Phalaropus fulicarius*	
Red-necked phalarope	*Phalaropus lobatus*	
Wilson's phalarope	*Phalaropus tricolor*	
Red knot	*Calidris canutus*	
Great knot	*Calidris tenuirostris*	
Pectoral sandpiper	*Calidris melanotos*	
Sharp-tailed sandpiper	*Calidris acuminata*	
Baird's sandpiper	*Calidris bairdii*	
Little stint	*Calidris minuta*	
Red-necked stint	*Calidris ruficollis*	
Long-toed stint	*Calidris subminuta*	
Curlew sandpiper	*Calidris ferruginea*	
Sanderling	*Calidris alba*	
Buff-breasted sandpiper	*Tryngites subruficollis*	

Major habitats and plant communities

Dune-fields of the Big Desert	Dune-field with underlying sandstone ridge	Lunettes and ridges	Evaporative basin	Alluvial terraces and riverine plain								
Major habitat	Major habitat	Major habitat	Major habitat	Major habitat						Agricultural/Urban	Mallee dependent in Victoria	Distribution in study area	Abundance in study area
Dune-crest tree heath	Broombush mallee	Pine--buloke woodland	Sand-plain grassland	Alluvial-plain shrubland						X	M	R
Sand-plain heath	Heath woodland	Belah woodland	Gypseous plains grassland										
Mallee heath	Red-swale mallee	Savannah woodland	Saline shrubland	X						X	W		
Scrub-pine woodland	Big mallee			X							W		
	Yellow gum woodland			X							M		
				X						X	W	R	
				X						X	M		
				X	+					X	W	U	
				X			+			X	W	U	
				X							R		
				X							R		
				X						X	W		
				X			+			X	W		
				X						X	W	R	
				X							R		
				X						X	W		
				X							R		
				X							R		
				X							R		
				X							R		
				X							R		
				X							R		
				X							R		
				X							R		
				X						X	R		
				X						X	M		
				X						X	M		
				X							M		
				X							R		
				X							R		
				X							R		
				X							R		
				X							R		
				X							R		
				X						X	M		
				X							R		
				X							R		
				X						X	M		
				X							R		
				X						X	M		
				X							R		
				X							R		

Appendix X (continued...)

Common name	Scientific name	Dune-fields of the Sunset Country				
		Major habitat	East--west dune mallee	Chenopod mallee	Shallow-sand mallee	Deep-sand mallee
Broad-billed sandpiper	*Limicola falcinellus*					
Ruff	*Philomachus pugnax*					
Latham's snipe	*Gallinago hardwickii*					
Silver gull	*Larus novaehollandiae*					
Caspian tern	*Sterna caspia*					
Gull-billed tern	*Sterna nilotica*					
Whiskered tern	*Chlidonias hybrida*					
White-winged tern	*Chlidonias leucoptera*					
Feral pigeon	**Columba livia*					
Spotted turtle-dove	**Streptopelia chinensis*					
Common bronzewing	*Phaps chalcoptera*	x	+	+	+	+
Brush bronzewing	*Phaps elegans*					
Crested pigeon	*Geophaps lophotes*	x		+	+	+
Bar-shouldered dove	*Geopelia humeralis*					
Diamond dove	*Geopelia cuneata*	x				
Peaceful dove	*Geopelia placida*	x			+	
Cockatiel	*Leptolophus hollandicus*					
Pink cockatoo	*Cacatua leadbeateri*	x	+	+	+	+
Sulphur-crested cockatoo	*Cacatua galerita*	x			+	
Little corella	*Cacatua pastinator*					
Long-billed corella	*Cacatua tenuirostris*					
Galah	*Cacatua roseicapilla*	x	+	+	+	+
Rainbow lorikeet	*Trichoglossus haematodus*					
Musk lorikeet	*Glossopsitta concinna*					
Purple-crowned lorikeet	*Glossopsitta porphyrocephala*	x				
Little lorikeet	*Glossopsitta pusilla*					
Regent parrot	*Polytelis anthopeplus*	x	+	+	+	+
Superb parrot	*Polytelis swainsonii*					
Budgerigar	*Melopsittacus undulatus*	x			+	
Night parrot	*Pezoporus occidentalis*	x				
Mallee ringneck	*Barnardius zonarius barnardi*	x	+	+	+	+
Yellow rosella	*Platycercus elegans flaveolus*	x		+	+	
White-cheeked rosella	*Platycercus eximius*					
Blue bonnet	*Northiella haematogaster*	x			+	
Mulga parrot	*Psephotus varius*	x	+	+	+	+
Red-rumped parrot	*Psephotus haematonotus*	x		+		
Blue-winged parrot	*Neophema chrysostoma*	x				
Elegant parrot	*Neophema elegans*	x				
Scarlet-chested parrot	*Neophema splendida*	x				
Swift parrot	*Lathamus discolor*					
Pallid cuckoo	*Cuculus pallidus*	x		+	+	+

Major habitats and plant communities

Dune-fields of the Big Desert					Dune-field with underlying sandstone ridge						Lunettes and ridges				Evaporative basin				Alluvial terraces and riverine plain										
Major habitat	Dune-crest tree heath	Sand-plain heath	Mallee heath	Scrub-pine woodland	Major habitat	Broombush mallee	Heath woodland	Red-swale mallee	Big mallee	Yellow gum woodland	Major habitat	Pine--buloke woodland	Belah woodland	Savannah woodland	Major habitat	Sand-plain grassland	Gypseous plains grassland	Saline shrubland	Major habitat	Alluvial-plain shrubland	Alluvial-rise shrubland	Black box--chenopod woodland	Black box woodland	River red gum forest	Lake bed herbfield	Agricultural/Urban	Mallee dependent in Victoria	Distribution in study area	Abundance in study area
																			x										R
																			x										R
																			x							x		R	R
																			x									W	
																			x									M	
																			x							x		M	
																			x							x		M	
																			x									R	
																										x		W	
																										x		R	
x		+			x			+	+	+	x	+	+						x			+		+		x		W	C
x																												R	R
					x				+										x				+	+		x		W	U
																			x									R	
																			x									M	R
					x				+		x	+							x		+	+		+		x		W	U
					x				+		x	+		+	x		+		x		+	+		+		x		W	U
x		+									x	+	+		x		+		x			+	+			x		W	U
																			x		+	+		+		x		W	U
																			x		+	+		+		x		M	U
																			x							x		M	U
x	+	+			x			+	+	+	x	+	+	+	x		+	+	x		+	+	+	+		x		W	C
																										x		R	
																										x		M	
x																										x		M	
																										x		R	
x		+									x			+	x			+	x				+	+		x	+	W	U
											x								x									E	
																										x		W	U
																												R	R
x		+			x			+	+		x		+	+	x		+	+	x				+	+		x		W	U
																			x				+	+		x		R	U
																			x							x		M	U
					x				+						x			+	x							x		W	U
x		+			x	+	+	+	+	+	x	+	+	+	x		+	+	x				+			x		W	U
x		+			x				+		x	+	+		x		+		x					+		x		W	U
																										x		W	R
																												M	
																											+	M	R
																										x		R	
					x			+	+		x	+	+		x		+	+		x			+	+		x		W	U

Appendix X (continued...)

Common name	Scientific name	Dune-fields of the Sunset Country				
		Major habitat	East--west dune mallee	Chenopod mallee	Shallow-sand mallee	Deep-sand mallee
Fan-tailed cuckoo	*Cacomantis flabelliformis*					
Black-eared cuckoo	*Chrysococcyx osculans*	x			+	
Horsfield's bronze-cuckoo	*Chrysococcyx basalis*	x	+	+	+	+
Shining bronze-cuckoo	*Chrysococcyx lucidus*					
Southern boobook	*Ninox boobook*					
Barking owl	*Ninox connivens*					
Barn owl	*Tyto alba*					
Masked owl	*Tyto novaehollandiae*					
Tawny frogmouth	*Podargus strigoides*	x				
Australian owlet-nightjar	*Aegotheles cristatus*	x		+		+
Spotted nightjar	*Caprimulgus argus*	x			+	+
White-throated needletail	*Hirundapus caudacutus*					
Fork-tailed swift	*Apus pacificus*					
Laughing kookaburra	*Dacelo novaeguineae*					
Sacred kingfisher	*Todiramphus sanctus*					
Red-backed kingfisher	*Todiramphus pyrrhopygius*	x		+		
Azure kingfisher	*Alcedo azurea*					
Rainbow bee-eater	*Merops ornatus*	x	+	+	+	
Dollarbird	*Eurystomus orientalis*					
BIRDS - Passerines						
Singing bushlark	*Mirafra javanica*					
Skylark	**Alauda arvensis*					
White-backed swallow	*Cheramoeca leucosternum*					
Welcome swallow	*Hirundo neoxena*	x		+		
Tree martin	*Hirundo nigricans*	x		+		+
Fairy martin	*Hirundo ariel*					
Richard's pipit	*Anthus novaeseelandiae*	x				+
Black-faced cuckoo-shrike	*Coracina novaehollandiae*	x		+	+	+
White-bellied cuckoo-shrike	*Coracina papuensis*					
Ground cuckoo-shrike	*Coracina maxima*					
White-winged triller	*Lalage tricolor*	x		+		+
White's thrush	*Zoothera dauma*					
Blackbird	**Turdus merula*					
Flame robin	*Petroica phoenicea*					
Scarlet robin	*Petroica multicolor*					
Red-capped robin	*Petroica goodenovii*	x		+	+	+
Hooded robin	*Melanodryas cucullata*	x	+	+	+	
Southern scrub-robin	*Drymodes brunneopygia*	x	+		+	+

Major habitats and plant communities

Dune-fields of the Big Desert				Dune-field with underlying sandstone ridge						Lunettes and ridges				Evaporative basin			Alluvial terraces and riverine plain									
Major habitat	Dune-crest tree heath	Sand-plain heath	Mallee heath	Scrub-pine woodland	Major habitat	Broombush mallee	Heath woodland	Red-swale mallee	Big mallee	Yellow gum woodland	Major habitat	Pine--buloke woodland	Belah woodland	Savannah woodland	Major habitat	Sand-plain grassland	Gypseous plains grassland	Saline shrubland	Major habitat	Alluvial-plain shrubland	Alluvial-rise shrubland	Black box--chenopod woodland	Black box woodland	River red gum forest	Lake bed herbfield	Agricultural/Urban	Mallee dependent in Victoria	Distribution in study area	Abundance in study area
x		+																	x							x		W	R
																			x			+					W	U
x		+			x			+		+	x	+			x			+	x		+	+				x		W	U
																			x							x		W	R
																			x					+		x		W	U
																			x									R	R
																			x							x		W	U
																												?	
x		+																	x							x		W	U
					x			+	+	+					x			+	x		+	+		+				W	U
x		+																										W	U
																			x							x		M	
																			x							x		M	
																			x			+	+	+		x		W	U
																			x			+		+		x		W	U
																			x							x		W	R
																			x									R	R
x		+			x	+		+	+	+	x	+	+	+	x		+	+	x		+	+		+			x		W	C
																			x							x		W	U
																			x									R	R
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x		+			x			+		+	x	+		+					x							x		W	U
																										x		R	R
																			x							x		W	U
																										x		M	R
																										x		R	R
x		+			x	+		+	+	+	x	+	+	+	x		+	+	x		+	+	+			x		W	C
x					x										x			+	x									W	U
x		+			x	+		+		+	x	+															+	W	U

Appendix X (continued...)

Common name	Scientific name	Dune-fields of the Sunset Country				
		Major habitat	East--west dune mallee	Chenopod mallee	Shallow-sand mallee	Deep-sand mallee
Jacky winter	*Microeca leucophaea*	x	+	+	+	+
Crested shrike-tit	*Falcunculus frontatus*					
Rufuous whistler	*Pachycephala rufiventris*	x	+	+	+	+
Gilbert's whistler	*Pachycephala inornata*	x				+
Red-lored whistler	*Pachycephala rufogularis*	x				
Golden whistler	*Pachycephala pectoralis*	x	+	+	+	+
Grey shrike-thrush	*Colluricincla harmonica*	x	+	+	+	+
Crested bellbird	*Oreoica gutturalis*	x	+	+	+	+
Restless flycatcher	*Myiagra inquieta*	x		+	+	
Grey fantail	*Rhipidura fuliginosa*	x		+		+
Willie wagtail	*Rhipidura leucophrys*	x	+	+	+	+
Western whipbird	*Psophodes nigrogularis*					
Chirruping wedgebill	*Psophodes cristatus*					
Chestnut quail-thrush	*Cinclosoma castanotum*	x	+	+	+	+
Grey-crowned babbler	*Pomatostomus temporalis*					
White-browed babbler	*Pomatostomus superciliosus*	x	+	+	+	+
Chestnut-crowned babbler	*Pomatostomus ruficeps*					
Clamorous reed-warbler	*Acrocephalus stentoreus*					
Little grassbird	*Megalurus gramineus*					
Golden-headed cisticola	*Cisticola exilis*					
Rufous songlark	*Cinclorhamphus mathewsi*	x		+		
Brown songlark	*Cinclorhamphus cruralis*					
Superb fairy-wren	*Malurus cyaneus*					
Splendid fairy-wren	*Malurus splendens*	x	+	+	+	+
Variegated fairy-wren	*Malurus lamberti*	x	+	+	+	
White-winged fairy-wren	*Malurus leucopterus*					
Mallee emu-wren	*Stipiturus mallee*	x	+			+
Striated grasswren	*Amytornis striatus*	x	+			
Shy hylacola	*Sericornis cautus*	x	+	+	+	+
Redthroat	*Sericornis brunneus*					
Rufous calamanthus	*Sericornis campestris*					
Weebill	*Smicrornis brevirostris*	x	+	+	+	+
Western gerygone	*Gerygone fusca*					
White-throated gerygone	*Gerygone olivacea*					
Brown thornbill	*Acanthiza pusilla pusilla*					
Inland thornbill	*Acanthiza pusilla apicalis*	x	+	+	+	+
Chestnut-rumped thornbill	*Acanthiza uropygialis*	x	+	+	+	+
Slender-billed thornbill	*Acanthiza iredalei*					
Buff-rumped thornbill	*Acanthiza reguloides*	x		+		
Striated thornbill	*Acanthiza lineata*					
Yellow-rumped thornbill	*Acanthiza chrysorrhoa*	x		+	+	+

Major habitats and plant communities

Dune-fields of the Big Desert					Dune-field with underlying sandstone ridge						Lunettes and ridges				Evaporative basin			Alluvial terraces and riverine plain									
Major habitat	Dune-crest tree heath	Sand-plain heath	Mallee heath	Scrub-pine woodland	Major habitat	Broombush mallee	Heath woodland	Red-swale mallee	Big mallee	Yellow gum woodland	Major habitat	Pine--buloke woodland	Belah woodland	Savannah woodland	Major habitat	Sand-plain grassland	Gypseous plains grassland	Saline shrubland	Major habitat	Alluvial-plain shrubland	Alluvial-rise shrubland	Black box--chenopod woodland	Black box woodland	River red gum forest	Lake bed herbfield	Agricultural/Urban	Mallee dependent in Victoria	Distribution in study area	Abundance in study area
					x			+	+		x		+		x		+	+	x							x		W	U
																			x					+				M	R
x			+		x	+		+	+	+	x	+	+		x		+	+	x			+	+	+		x		W	U
x			+								x	+	+						x									W	R
x																											+	M	R
x			+		x	+		+			x	+							x							x		W	U
x	+	+	+		x	+	+	+	+	+	x	+	+	+	x		+	+	x			+	+	+		x		W	U
x			+								x	+	+		x		+	+	x			+	+					W	U
															x		+		x			+				x		W	R
																			x			+				x		W	C
					x			+	+		x	+	+	+	x		+	+	x			+	+	+		x		W	C
					x																						+	R	R
																			x									R	R
x			+		x	+		+		+	x	+															+	W	U
											x		+						x							x		R	R
x			+		x			+			x	+	+		x		+	+	x									W	C
											x			+					x		+	+						W	U
																			x									W	
																			x									W	
																			x							x		M	
					x				+		x	+		+	x		+		x	+	+			+		x		W	U
											x	+							x							x		W	C
											x			+					x			+				x		M	U
x			+		x	+		+	+	+	x	+	+	+	x		+	+	x			+						W	U
x			+		x			+			x	+		+					x			+						W	U
																			x	+						x		M	C
																											+	M	R
x			+																								+	M	U
x	+	+	+		x	+		+			x	+															+	M	U
																			x									R	R
																			x									M	R
x	+	+	+		x	+		+	+	+	x	+	+	+	x		+	+	x			+	+	+		x		W	A
																			x									M	R
																			x									R	R
																			x									R	R
x	+	+	+		x	+	+	+		+	x	+		+	x			+	x									W	C
x			+		x			+	+	+	x	+	+	+	x		+	+	x			+	+	+		x		W	C
x		+																										R	R
x		+	+		x			+		+																		M	R
																			x									R	R
											x	+		+					x			+				x		W	C

Appendix X (continued...)

Common name	Scientific name	Dune-fields of the Sunset Country				
		Major habitat	East--west dune mallee	Chenopod mallee	Shallow-sand mallee	Deep-sand mallee
Yellow thornbill	*Acanthiza nana*					
Southern whiteface	*Aphelocephala leucopsis*	x		+	+	
Varied sittella	*Daphoenositta chrysoptera*	x		+	+	
White-browed treecreeper	*Climacteris affinis*					
Brown treecreeper	*Climacteris picumnus*	x		+	+	
Red wattlebird	*Anthochaera carunculata*	x	+	+	+	+
Striped honeyeater	*Plectorhyncha lanceolata*	x		+	+	
Spiny-cheeked honeyeater	*Acanthagenys rufogularis*	x	+	+	+	+
Noisy friarbird	*Philemon corniculatus*					
Little friarbird	*Philemon citreogularis*	x			+	+
Regent honeyeater	*Xanthomyza phrygia*					
Blue-faced honeyeater	*Entomyzon cyanotis*					
Yellow-throated miner	*Manorina flavigula flavigula*	x		+	+	
Black-eared miner	*Manorina flavigula melanotis*	x				
Noisy miner	*Manorina melanocephala*					
Yellow-faced honeyeater	*Lichenostomus chrysops*					
Singing honeyeater	*Lichenostomus virescens*	x		+		
Yellow-tufted honeyeater	*Lichenostomus melanops*					
White-eared honeyeater	*Lichenostomus leucotis*	x	+	+	+	+
Purple-gaped honeyeater	*Lichenostomus cratitius*					
Yellow-plumed honeyeater	*Lichenostomus ornatus*	x	+	+	+	+
Grey-fronted honeyeater	*Lichenostomus plumulus*	x				
Yellow-tinted honeyeater	*Lichenostomus flavescens*					
White-plumed honeyeater	*Lichenostomus penicillatus*					
Black-chinned honeyeater	*Melithreptus gularis*					
Brown-headed honeyeater	*Melithreptus brevirostris*	x	+	+	+	+
White-naped honeyeater	*Melithreptus lunatus*					
Painted honeyeater	*Grantiella picta*					
New Holland honeyeater	*Phylidonyris novaehollandiae*					
White-fronted honeyeater	*Phylidonyris albifrons*	x	+	+	+	+
Tawny-crowned honeyeater	*Phylidonyris melanops*	x	+		+	
Black honeyeater	*Certhionyx niger*	x				
Pied honeyeater	*Certhionyx variegatus*					
Eastern spinebill	*Acanthorhynchus tenuirostris*					
Crimson chat	*Epthianura tricolor*					
Orange chat	*Epthianura aurifrons*					
White-fronted chat	*Epthianura albifrons*	x	+	+		
Mistletoebird	*Dicaeum hirundinaceum*	x		+	+	
Spotted pardalote	*Pardalotus punctatus punctatus*					
Yellow-rumped pardalote	*Pardalotus punctatus xanthopygus*	x	+	+	+	+
Striated pardalote	*Pardalotus striatus*	x	+	+	+	+

Major habitats and plant communities

Dune-fields of the Big Desert					Dune-field with underlying sandstone ridge						Lunettes and ridges				Evaporative basin				Alluvial terraces and riverine plain									
Major habitat	Dune-crest tree heath	Sand-plain heath	Mallee heath	Scrub-pine woodland	Major habitat	Broombush mallee	Heath woodland	Red-swale mallee	Big mallee	Yellow gum woodland	Major habitat	Pine--buloke woodland	Belah woodland	Savannah woodland	Major habitat	Sand-plain grassland	Gypseous plains grassland	Saline shrubland	Major habitat	Alluvial-plain shrubland	Alluvial-rise shrubland	Black box--chenopod woodland	Black box woodland	River red gum forest	Lake bed herbfield	Agricultural/Urban	Mallee dependent in Victoria	Distribution in study area	Abundance in study area
											X	+	+		X		+		X			+	+	+		X		W	U
					X				+		X	+	+	+	X		+	+	X	+	+	+	+			X		W	C
					X				+	+	X	+	+						X			+				X		W	U
											X	+	+															R	R
					X				+		X	+	+	+					X			+	+	+		X		W	U
X	+	+	+		X	+	+	+		+	X	+							X			+	+			X		W	U
X			+		X			+	+		X	+	+		X			+	X									W	U
X	+		+		X	+	+	+	+	+	X	+	+	+	X		+	+	X			+	+	+		X		W	C
																			X							X		R	R
X			+								X	+							X			+	+	+		X		M	U
																												R	R
																			X					+		X		M	U
											X			+	X		+	+								X		W	C
																											+	M	R
																			X				+	+		X		M	C
																										X		R	R
									+	+	X	+	+	+	X		+		X							X		W	C
																												R	R
X	+		+		X	+	+	+	+	+	X	+			X			+	X									W	C
X	+				X	+																					+	M	R
X	+		+		X	+	+	+		+	X	+	+														+	W	C
X																											+	R	R
X																			X							X		R	R
											X			+					X			+	+	+		X		W	C
																			X									R	R
X	+		+		X	+	+	+	+	+	X	+			X			+	X			+				X		W	U
																										X		R	R
																			X			+						R	R
X																												M	R
X	+		+		X	+	+	+	+	+	X	+	+	+	X			+	X				+						W	U
X	+	+	+		X		+	+		+	X	+																M	U
X																										X		M	R
																												R	R
																												R	R
																			X							X		W	R
																			X							X		W	R
X			+		X	+			+		X	+	+		X		+	+	X		+					X		W	U
											X	+	+		X			+	X			+	+	+		X		W	U
																			X							X		R	R
X	+		+		X	+		+		+																	+	W	C
					X			+	+	+	X	+	+	+	X		+	+	X			+	+	+		X		W	C

Appendix X (continued...)

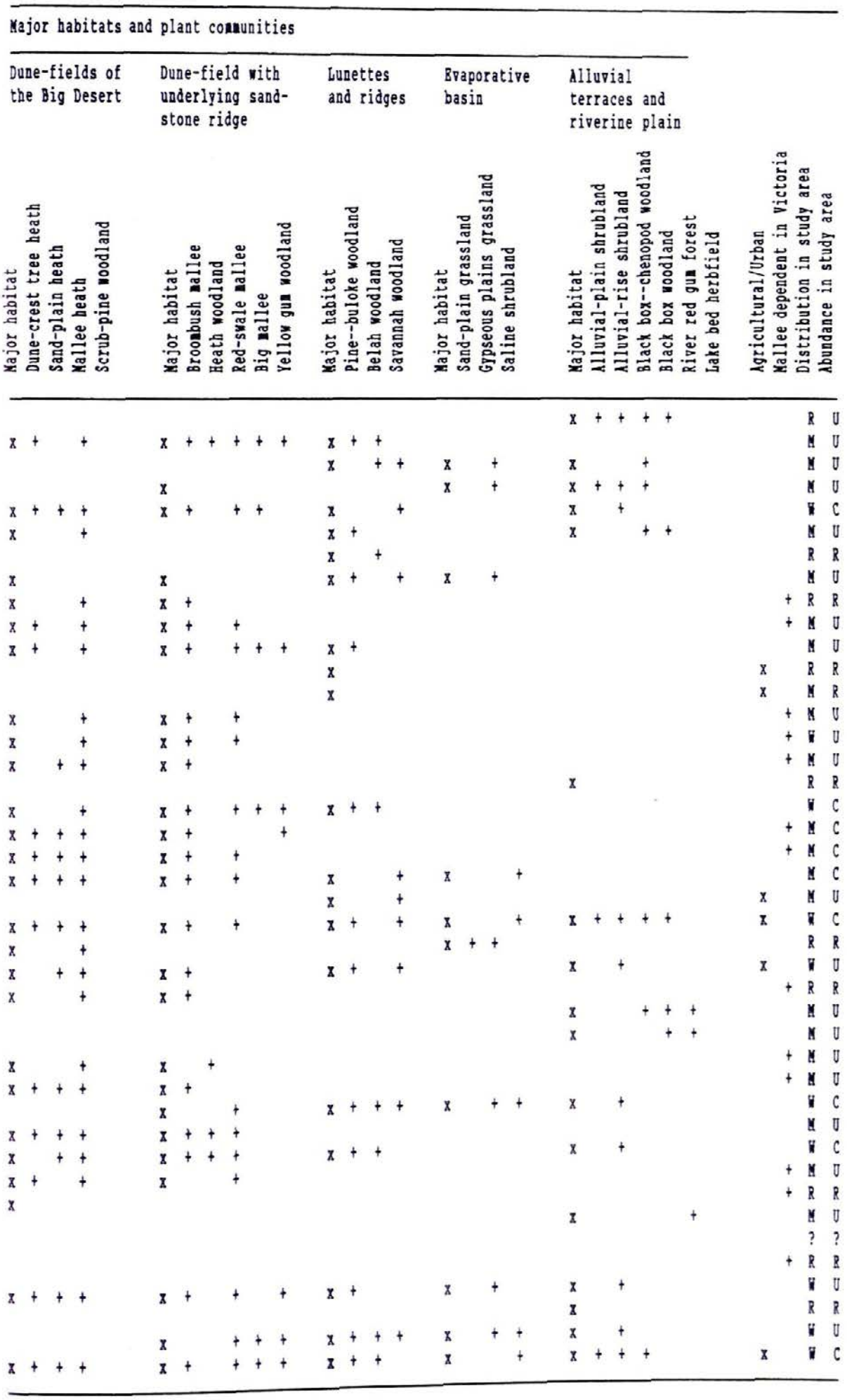
Common name	Scientific name	Dune-fields of the Sunset Country				
		Major habitat	East--west dune mallee	Chenopod mallee	Shallow-sand mallee	Deep-sand mallee
Silvereye	*Zosterops lateralis*					
European goldfinch	**Carduelis carduelis*					
House sparrow	**Passer domesticus*					
Diamond finch	*Stagonopleura guttata*					
Zebra finch	*Taeniopygia guttata*					
Common starling	**Sturnus vulgaris*	x		+	+	
Olive-backed oriole	*Oriolus sagittatus*					
Spotted bowerbird	*Chlamydera maculata*					
White-winged chough	*Corcorax melanorhamphus*	x		+	+	+
Apostlebird	*Struthidea cinerea*					
Australian magpie-lark	*Grallina cyanoleuca*	x		+	+	
Black-faced woodswallow	*Artamus cinereus*	x		+		
Masked woodswallow	*Artamus personatus*	x		+		+
White-browed woodswallow	*Artamus superciliosus*	x		+	+	+
White-breasted woodswallow	*Artamus leucorhynchus*					
Dusky woodswallow	*Artamus cyanopterus*	x	+	+	+	
Grey butcherbird	*Cracticus torquatus*	x	+	+	+	+
Pied butcherbird	*Cracticus nigrogularis*					
Australian magpie	*Gymnorhina tibicen*	x	+	+	+	+
Pied currawong	*Strepera graculina*					
Black-winged currawong	*Strepera versicolor melanopter*	x	+	+	+	+
Australian raven	*Corvus coronoides*	x	+	+	+	+
Little raven	*Corvus mellori*	x	+	+	+	+
Little crow	*Corvus bennetti*	x				
REPTILES AND AMPHIBIANS						
Peron's tree frog	*Litoria peronii*					
-	*Litoria raniformis*					
-	*Crinia parinsignifera*					
Common eastern froglet	*Crinia signifera*					
Eastern banjo frog	*Limnodynastes dumerilii*	x				
Long-thumbed frog	*Limnodynastes fletcheri*					
Spotted grass frog	*Limnodynastes tasmaniensis*					
-	*Neobatrachus pictus*	x				
-	*Neobatrachus sudelli*	x	+		+	+
Brown toadlet	*Pseudophryne bibronii*					
Broad-shelled river turtle	*Chelodina expansa*					
Eastern long-necked tortoise	*Chelodina longicollis*					
Murray turtle	*Emydura macquarii*					
Eastern spiny-tailed gecko	*Diplodactylus intermedius*	x	+	+	+	+

Major habitats and plant communities

Dune-fields of the Big Desert					Dune-field with underlying sandstone ridge					Lunettes and ridges				Evaporative basin			Alluvial terraces and riverine plain										
Major habitat	Dune-crest tree heath	Sand-plain heath	Mallee heath	Scrub-pine woodland	Major habitat	Broombush mallee	Heath woodland	Red-swale mallee	Big mallee	Yellow gum woodland	Major habitat	Pine--buloke woodland	Belah woodland	Savannah woodland	Major habitat	Sand-plain grassland	Gypseous plains grassland	Saline shrubland	Major habitat	Alluvial-plain shrubland	Alluvial-rise shrubland	*Black box--chenopod* woodland	Black box woodland	River red gum forest	Lake bed herbfield	Agricultural/Urban	Mallee dependent in Victoria	Distribution in study area	Abundance in study area
X			+		X	+		+		+	X	+							X			+	+					W	U
																			X							X		W	U
																			X		+					X		W	C
											X		+															W	R
																			X	+	+	+				X		W	U
					X			+			X	+		+	X			+	X		+	+		+		X		W	C
																			X									R	R
																			X							X		R	R
X			+		X	+			+		X	+	+	+	X		+		X			+	+	+		X		W	U
											X			+					X			+				X		M	U
											X	+		+					X			+	+	+		X		W	U
											X			+	X		+		X		+					X		W	U
											X	+	+						X							X		W	U
X			+		X			+	+		X	+	+						X							X		W	C
																			X							X		W	R
X			+		X	+	+	+			X	+			X		+		X			+		+		X		W	U
X	+	+	+		X	+		+	+	+	X	+	+	+	X		+	+	X			+	+	+		X		W	U
																			X		+	+	+	+		X		W	R
X	+		+		X	+			+	+	X	+	+	+	X		+	+	X	+	+	+	+			X		W	C
											X		+	+	X		+	+								X		R	R
X	+		+		X	+		+			X	+							X	+	+	+	+				+	W	U
X			+		X	+		+	+	+	X	+	+	+	X		+	+	X		+		+	+		X		W	U
											X		+	+	X		+	+								X		W	U
																										X		W	R
																			X					+				M	C
																			X							X		M	U
																			X					+		X		M	A
																			X					+		X		M	C
X			+		X	+		+			X	+							X				+	+		X		W	C
																			X					+				R	U
																			X			+	+	+		X		W	A
X			+		X	+		+																				M	U
X			+		X			+	+		X	+							X					+				W	C
																			X							X		R	U
																			X									M	U
																			X					+	+			M	C
																			X									M	U
X	+	+	+		X	+		+			X	+	+	+														M	U

Appendix X (continued...)

Common name	Scientific name	Dune-fields of the Sunset Country				
		Major habitat	East--west dune mallee	Chenopod mallee	Shallow-sand mallee	Deep-sand mallee
Tessellated gecko	*Diplodactylus tessellatus*					
Wood gecko	*Diplodactylus vittatus*	x	+	+	+	+
Tree dtella	*Gehyra variegata*	x		+		
Bynoe's gecko	*Heteronotia binoei*	x		+		
Beaded gecko	*Lucasium damaeum*	x	+	+	+	+
Marbled gecko	*Phyllodactylus marmoratus*					
Beaked gecko	*Rhynchoedura ornata*					
Thick-tailed gecko	*Underwoodisaurus milii*	x				
-	*Aprasia aurita*					
-	*Aprasia inaurita*	x	+		+	+
-	*Delma australis*	x	+	+	+	+
-	*Delma impar*					
-	*Delma inornata*					
-	*Delma nasuta*	x	+	+	+	+
Burton's snake-lizard	*Lialis burtonis*	x			+	+
Common scaly-foot	*Pygopus lepidopodus*	x				
Hooded scaly-foot	*Pygopus nigriceps*					
Nobbi dragon	*Amphibolurus nobbi*	x	+	+	+	+
-	*Amphibolurus norrisi*					
Mallee dragon	*Ctenophorus fordi*	x	+	+	+	+
Painted dragon	*Ctenophorus pictus*	x	+	+	+	+
Bearded dragon	*Pogona barbatus*					
-	*Pogona vitticeps*	x	+	+	+	+
-	*Tympanocryptis lineata lineata*					
Sand goanna	*Varanus gouldii*	x	+	+	+	+
-	*Varanus rosenbergi*					
Tree goanna	*Varanus varius*					
-	*Cryptoblepharus carnabyi*					
-	*Ctenotus brachyonyx*	x	+		+	+
-	*Ctenotus brooksi iridis*	x	+		+	+
-	*Ctenotus regius*	x	+	+	+	+
-	*Ctenotus robustus*					
-	*Ctenotus uber orientalis*	x	+	+	+	+
Desert skink	*Egernia inornata*	x	+		+	+
-	*Egernia multiscutata*					
Tree skink	*Egernia striolata*					
Narrow-banded sand swimmer	*Eremiascincus fasciolatus*					
-	*Hemiergis millewae*	x				+
-	*Lerista bougainvillii*	x	+	+	+	+
-	*Lerista muelleri*					
	Lerista punctatovittata	x	+	+	+	+
-	*Menetia greyii*	x	+	+	+	+


Major habitats and plant communities
Dune-fields of the Big Desert
Dune-field with underlying sand-stone ridge
Lunettes and ridges
Evaporative basin
Alluvial terraces and riverine plain
Major habitat
Dune-crest tree heath
Sand-plain heath
Mallee heath
Scrub-pine woodland
Major habitat
Broombush mallee
Heath woodland
Red-swale mallee
Big mallee
Yellow gum woodland
Major habitat
Pine--buloke woodland
Belah woodland
Savannah woodland
Major habitat
Sand-plain grassland
Gypseous plains grassland
Saline shrubland
Major habitat
Alluvial-plain shrubland
Alluvial-rise shrubland
Black box--chenopod woodland
Black box woodland
River red gum forest
Lake bed herbfield
Agricultural/Urban
Mallee dependent in Victoria
Distribution in study area
Abundance in study area

Appendix X (continued...)

Common name	Scientific name	Dune-fields of the Sunset Country				
		Major habitat	East--west dune mallee	Chenopod mallee	Shallow-sand mallee	Deep-sand mallee
-	*Morethia adelaidensis*					
-	*Morethia boulengeri*	x		+	+	+
-	*Morethia obscura*	x	+		+	+
Eastern water skink	*Sphenomorphus quoyii*					
Western blue-tongued lizard	*Tiliqua occipitalis*	x	+		+	+
Eastern blue-tongued lizard	*Tiliqua scincoides*					
Shingle-back	*Trachydosaurus rugosus*	x	+	+	+	+
-	*Ramphotyphlops australis*	x	+	+	+	+
-	*Ramphotyphlops bituberculatus*	x	+	+	+	+
-	*Ramphotyphlops broomi*					
-	*Ramphotyphlops ligatus*					
-	*Ramphotyphlops nigrescens*					
-	*Ramphotyphlops pinguis*					
-	*Ramphotyphlops proximus*					
-	*Ramphotyphlops unguirostris*					
Carpet python	*Morelia spilota variegata*					
Common death adder	*Acanthophis antarcticus*					
Yellow-faced whip snake	*Demansia psammophis*	x				+
Masters snake	*Drysdalia mastersii*					
Bardick	*Echiopsus curta*	x				
Red-naped snake	*Furina diadema*					
Eastern tiger snake	*Notechis scutatus*					
Fierce snake	*Parademansia microlepidota*					
Red-bellied black snake	*Pseudechis porphyriacus*					
Western brown snake	*Pseudonaja nuchalis*	x	+	+		+
Eastern brown snake	*Pseudonaja textilis*	x		+		
Coral snake	*Simoselaps australis*	x	+	+	+	+
Curl snake	*Suta suta*					
-	*Unechis nigriceps*	x	+	+	+	+
-	*Unechis spectabilis*					
Bandy-bandy	*Vermicella annulata*	x		+		

Major habitats and plant communities

Dune-fields of the Big Desert					Dune-field with underlying sandstone ridge						Lunettes and ridges				Evaporative basin				Alluvial terraces and riverine plain											
Major habitat	Dune-crest tree heath	Sand-plain heath	Mallee heath	Scrub-pine woodland	Major habitat	Broombush mallee	Heath woodland	Red-swale mallee	Big mallee	Yellow gum woodland	Major habitat	Pine--buloke woodland	Belah woodland	Savannah woodland	Major habitat	Sand-plain grassland	Gypseous plains grassland	Saline shrubland	Major habitat	Alluvial-plain shrubland	Alluvial-rise shrubland	Black box--chenopod woodland	Black box woodland	River red gum forest	Lake bed herbfield	Agricultural/Urban	Mallee dependent in Victoria	Distribution in study area	Abundance in study area
															X			+	X									R	U
					X				+		X	+	+		X		+		X	+	+	+	+	+		X		W	C
X	+	+	+		X	+		+		+																	+	M	C
																			X				+					R	U
X			+		X	+		+																			+	M	U
											X															X		M	R
X	+		+		X	+		+	+	+	X	+	+	+	X			+	X	+	+	+				X		W	C
X	+		+		X	+		+	+	+	X	+																M	U
X			+		X	+			+		X	+	+	+	X		+	+	X		+	+	+	+				W	U
																												?	?
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																												?	?
																			X				+	+				R	R
																												?	?
					X																					X		M	R
X			+		X	+																					+	M	U
X			+		X	+																					+	M	R
																												?	?
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																			X									M	R
					X						X		+	+												X		M	R
X			+		X	+		+			X		+		X				X			+		+		X		W	C
X			+		X			+			X		+															M	R
																			X		+							R	R
X	+	+	+		X	+		+	+	+	X	+	+	+														W	U
X			+		X	+					X	+															+	M	R
																												M	R

Appendix XI

SIGNIFICANT AND NOTABLE VERTEBRATE FAUNA

Key to Appendix XI

Distribution:

R restricted (occurs in less than 10% of the area)
M moderate (occurs in 10 to 50% of the area)
W widespread (occurs in greater than 50% of the area)
? not known

Abundance:

R rare
U uncommon
C common
A abundant
? not known

Both distribution and abundance are subjective assessments based on:

for Australia - the scientific literature
for Victoria - the scientific literature and extensive survey data throughout the State
for the Mallee area - the literature and recent research

Conservation status

Australia

A blank entry implies not assessed
\+ taxa considered threatened on a national basis as listed by Ahern *et al* (1985)

Victoria

E endangered
V vulnerable
R restricted distribution, or rare, or both
I indeterminate, possibly threatened
M requires careful monitoring
O not considered threatened
? status not known

Status in Victoria is derived from current assessments by the National Parks and Wildlife Division of the Department of Conservation, Forests and Lands and from that department's publication 1987 (see References).

Appendix XI (continued...)

Population trend in Victoria

D	decrease (the number or distribution of records has decreased since European settlement)
D?	possibly decrease (based on known habitat)
S	stable (there has been no apparent change in the number or distribution of records)
S?	possibly stable (based on known habitat)
I	increase (the number or distribution of records has increased)
I?	possible increase (based on known habitat)
?	unknown
Ir	irruptive (taxa that may suddenly appear and then disappear from Victoria)

Appendix XI (continued...)

Species	Distribution			Abundance		
	Aust.	Vic.	Mallee	Aust.	Vic.	Mallee
SIGNIFICANT TAXA						
Little pygmy-possum	R	R	M	U	C	C
Large-footed myotis	M	M	R	R	R	R
Silky mouse	R	R	M	C	C	C
Freckled duck	M	M	R	R	R	R
Malleefowl	M	M	M	U	U	U
Kori bustard	W	R	M	U	R	R
Plains-wanderer	M	M	M	U	R	R
Regent parrot	M	R	W	U	U	U
Red-lored whistler	R	R	M	R	R	R
Western whipbird	R	R	R	R	R	R
Mallee emu-wren	R	R	M	R	R	R
Slender-billed thornbill	M	R	R	R	R	R
White-browed treecreeper	M	R	R	U	R	R
Black-eared miner	R	R	M	R	R	R
Aprasia aurita	R	R	R	R	R	R
Delma impar	R	M	R	U	U	R
Ctenotus brachyonyx	R	R	M	U	U	U
Hemiergis millewae	R	R	R	R	R	R
Carpet python	W	R	R	U	R	R

Conservation status		Population trend in Victoria	Comments
Aust.	Vic.		
+	O	D?	The Mallee area in Victoria comprises a significant proportion of the mainland distribution
+	V	?	Considered to be a vulnerable species on a national basis
+	O	D?	Distribution restricted to the Big Desert and Little Desert in Victoria, and adjacent areas in South Australia
+	O	Ir	Uses wetlands in the south-east as a refuge especially during inland drought
+	V	D	Victorian population is now less than a thousand pairs and still declining
+	E	D	Persistent reports from the Big Desert suggest a small population is resident there
+	R	D	Cryptic ground-dwelling species that is probably not as rare as records indicate
+	M	D	Hollow-dependent species now primarily using river red gums for nesting
+	R	D	Even though Victoria is its stronghold, there are less than a few hundred left here
+	E	D	Although not sighted in Victoria for decades, individuals have been heard calling in the Big Desert
+	R	D?	*Triodia*-dependent species that are very vulnerable to fire
+	R	D?	Occurs in small groups that are restricted to low heath in the Big Desert
	R	D	Hollow-dependent species restricted to *Callitris--Casuarina* woodland
+	E	D	Nearly extinct as a result of hybridization with the yellow-throated miner
+	E	D?	The only known population of this very rare legless lizard occurs in the study are, in long-unburnt mallee
+	V	D?	A grassland species, rare in the study area and vulnerable to agricultural development
+	R	D?	An uncommon species, with a restricted distribution centred on the "Murray mallee" of north-western Victoria and adjacent parts of New South Wales and South Australia
+	R	?	This recently-described small skink is dependent on large *Triodia* hummocks, and in Victoria is found only in the south-west of the Sunset Country
+	V	D	Now rare in Victoria and usually restricted to riverine environments. It appears to have suffered directly from human interference

Appendix XI (continued...)

Species	Distribution			Abundance		
	Aust.	Vic.	Mallee	Aust.	Vic.	Mallee
NOTABLE TAXA						
Mallee ningaui	M	R	M	U	U	U
Paucident planigale	M	R	R	U	U	U
Common dunnart	M	M	M	C	R	R
Western pygmy-possum	M	R	M	C	U	U
Feathertail glider	M	W	R	C	C	R
Red kangaroo	W	R	R	A	R	R
Swamp wallaby	M	W	R	C	C	R
Yellow-bellied sheath-tail bat	W	R	R	R	R	R
Greater long-eared bat	M	R	R	U	R	R
Mitchell's hopping-mouse	M	R	M	U	U	U
Letter-winged kite	W	W	W	R	R	R
Square-tailed kite	W	W	W	R	R	R
White-bellied sea-eagle	M	M	R	U	R	R
Grey falcon	W	M	W	R	R	R
Australian hobby	W	W	W	R	R	R
Peregrine falcon	W	W	W	R	R	R
Black falcon	W	W	W	R	R	R
Red-chested button-quail	M	M	M	U	R	R
Brolga	W	R	M	U	R	R
Painted snipe	M	W	R	U	R	R
Bush thick-knee	W	M	W	U	R	R
Inland dotterel	M	R	W	U	R	R

Conservation status		Population trend in Victoria	Comments
Aust.	Vic.		
+	O	D?	Occurrence in Victoria is restricted to mallee vegetation where hummocks of *Triodia* are present
	R	?	First records for Victoria 1985, where it occurs only in riverine woodlands in the Mallee area
+	I	D?	Rare throughout its range in Victoria
+	O	D?	In Victoria restricted to the Mallee and Wimmera regions where it is dependent on heath, mallee-heath, and broombush vegetation
	O	D?	In the Mallee area found only in the riverine woodlands along the Murray River
	M	I?	In Victoria only occurs in the Mallee area. Found in open country and may have increased in abundance since European settlement
	O	D?	Sightings of animals in the east of the Big Desert represent the limit of its north-westerly distribution
+	I	?	Two of only 13 confirmed records for Victoria are from the Mallee area
	I	?	All three records known for Victoria are from the Mallee region, the most recent being in 1987
+	O	D?	Distribution in Victoria is restricted to the Mallee area
		Ir	Irregularly irrupts in Victoria apparently after die-off of the plague rat in the inland
+	R	D?	Rare, migratory bird of prey that occurs throughout Victoria
+	R	D?	Tiny population is vulnerable to pesticide contamination due to its fish-eating habits
+	R	D?	Very rare species whose successful breeding is often thwarted by theft of eggs and young
	M	D?	Pesticide contamination has already resulted in a 2% thinning of egg-shells of this species
	M	D?	Victorian population has already suffered a 20% thinning of egg-shells due to pesticides
+	R	D?	Another bird of prey that is vulnerable to pesticides and theft of eggs and young
	R	?	Grassland species that is probably not as rare as records indicate
+	R	D	Victorian population is thought to be down to between 600 and 650 birds
+	R	?	Cryptic wetland species that is rarely observed throughout Victoria
+	R	D	Although rare and declining, it still persists in suitable habitat throughout the study area
		R	Open-country species occurring in fluctating numbers in the Mallee

Appendix XI (continued...)

Species	Distribution			Abundance		
	Aust.	Vic.	Mallee	Aust.	Vic.	Mallee
Latham's snipe	M	W	R	U	U	R
Long-billed corella	R	M	M	C	C	U
Night parrot	M	R	R	R	R	R
Yellow rosella	R	R	R	C	C	U
Scarlet-chested parrot	M	R	M	R	R	R
Barking owl	W	W	R	U	R	R
Ground cuckoo-shrike	W	R	M	U	R	R
Gilbert's whistler	M	M	W	R	R	R
Grey-crowned babbler	W	M	R	C	R	R
Striated grasswren	M	R	M	U	U	U
Rufous calamanthus	M	R	M	U	R	R
Painted honeyeater	M	M	R	U	R	R
Spotted bowerbird	M	R	R	U	R	R
Long-thumbed frog	R	M	R	U	U	U
Brown toadlet	R	M	R	C	C	U
Tessellated gecko	M	R	R	U	R	U
Beaked gecko	W	R	R	C	R	R
Aprasia inaurita	R	R	M	U	U	U
Delma nasuta	W	R	M	U	U	U
Hooded scaly-foot	W	R	R	U	R	R
Amphibolurus norrisi	R	R	M	C	C	C

Conservation status		Population trend in Victoria	Comments
Aust.	Vic.		
+	M	D	Uses south-east wetlands when it arrives from its breeding grounds in Japan
+	M	I	Hollow-dependent species that has reached pest proportions in western Victoria, but still has a restricted range
+		Ir	Possibly occured in the Big Desert in the 1950s
	O	S	Hollow-dependent species confined to river red gum and black box woodland along the Murray River
+		Ir	Sporadic reports from the Victorian Mallee in recent years
+	R	D?	Hollow-dependent species confined to river red gum and black box woodland
		Ir	Small groups occasionally reported mainly from the drier parts of the study area
+	I	D?	Prefers *Callitris--Casuarina* woodland and old mallee
+	R	D	Shrinking distribution, now occurs only in the south-east of the study area
+	I	D?	*Triodia*-dependent species widespread in the remaining mallee vegetation
	R	D?	Restricted to low chenoped shrubland and Big Desert heath
+	R	D	Follows mistletoe bloom especially in black box of the study area
+	E	D	Formerly a common breeding resident and now a rare vagrant generally between Hattah and Robinvale
	O	D?	Requires permanent waters, and is restricted to riverine areas
	O	S?	A Bassian species, present only in the extreme south-east of the study area
	M	D?	A terrestrial gecko, restricted in the study area to the cracking alluvial soils associated with the Murray River
	V	D?	A terrestrial gecko, in Victoria is now known from only one small remnant of *Callitris--Casuarina* woodland with a relatively undisturbed understorey
+	O	D?	This burrowing legless lizard is rarely encountered, but widespread in sandy habitats It may be a specialist feeder on ants
	O	D?	Only recently recognised as occurring in Victoria, this species is widespread in sandy areas and dependent on *Triodia*
	I	D	Very rare in Victoria, this large legless lizard is known from only one recent record, in black box woodland in the south-east of the study area
	O	D?	A recently described species, restricted in the study area to the mallee-heaths in the south of the Big Desert

Appendix XI (continued...)

Species	Distribution			Abundance		
	Aust.	Vic.	Mallee	Aust.	Vic.	Mallee
Tympanocryptis l. lineata	W	R	R	U	R	R
Varanus rosenbergi	R	R	R	U	R	R
Ctenotus b. iridis	R	R	M	U	U	U
Egernia multiscutata	R	R	R	U	R	R
Narrow-banded sand swimmer	W	?	?	U	?	?
Lerista muelleri	W	R	R	U	R	R
Morethia adelaidensis	M	R	R	U	R	U
Eastern water skink	M	R	R	C	U	U
Western blue-tongued lizard	M	R	M	U	U	U
Ramphotyphlops spp.						
" *broomi*	?	?	?	?	?	?
" *ligatus*	?	?	?	?	?	?
" *nigrescens*	R	M	?	U	U	?
" *pinguis*	?	?	?	?	?	?
" *proximus*	M	M	?	?	R	?
" *unguirostris*	?	?	?	?	?	?
Common death adder	W	?	?	U	?	?
Yellow-faced whip snake	W	R	M	U	R	R

Conservation status		Population trend in Victoria	Comments
Aust.	Vic.		
	V	D?	This very rare, small terrestrial dragon is known from only four localities in the study area, generally open chenopodiaceous grasslands
+	I	D?	This large goanna occurs as an isolated population on the eastern limit of its distribution in the mallee-heaths in the south of the Big Desert. Was vulnerable to poisoning aimed at feral dogs
	O	D?	Restricted in Victoria to deep sand areas in the Big Desert and southern Sunset Country
+	V	?	This large skink constructs extensive communal burrow systems. It is on the eastern edge of its distribution in the southern Big Desert, where it is known from only three large dunes
	I	?	Known in Victoria from only one record, labelled 'Mildura', perhaps of doubtful origin
	R	D?	A fossorial skink, in Victoria found only in open chenopodiacious woodlands in the Red-cliffs--Merbein area
	M	I?	Widespread in north-western Victoria, but restricted to samphire communities or their margins, or lake margins
	M	?	In Victoria, confined to the Murray River downstream from its junction with the Darling River. An active diurnal skink strictly confined to margins of watercourses in river red gum areas
	M	D?	This widespread, but uncommon, large lizard occurs only in mallee, and may be another species vulnerable to poisoning
		)	These blind snakes have not been recorded
+	I	?)	recently from the study area, and even their
+	I	?)	past status is uncertain. Some are known
	O	D?)	only from old literature records which, given
+	I	?)	the difficulty of identification, may not be
+	I	D?)	reliable. Others may have been affected by
+	I	?)	early land clearing of specialised habitats. Blind snakes are specialist feeders on termites (or ants?), which are profoundly affected by agricultural development
	I	?	Known in Victoria from two literature records of observations made last century. Probably no longer present in the study area
			This species is known to be vulnerable to both frequent fire and grazing
	R	D?	Rare in Victoria, and found only in the north-western parts of the study area. It is a fast-moving diurnal snake which feeds only on lizards

Appendix XI (continued...)

Species	Distribution			Abundance		
	Aust.	Vic.	Mallee	Aust.	Vic.	Mallee
Bardick	R	R	M	U	R	R
Red-naped snake	M	?	?	U	?	?
Fierce snake	R	?	?	R	?	?
Western brown snake	W	R	M	U	R	R
Coral snake	R	R	M	U	R	R
Curl snake	W	R	R	U	R	R
Unechis spectabilis	R	R	M	U	R	R
Bandy-bandy	W	M	M	U	R	R

Conservation status		Population trend in Victoria	Comments
Aust.	Vic.		
+	R	D?	Widespread but rare in mallee-heath and *Triodia* areas in north-western Victoria, the nocturnal snake feeds on a variety of vertebrates, including the Mallee ningaui
	I	?	This small snake is known in Victoria from only one record, presumably from the riverine environment
+	I	?	The type specimens of this large snake were collected late last century from the junction of the Murray and Darling Rivers, soon after extensive floods. It is probably no longer present in Victoria
	R	D?	This snake reaches the south-eastern limit of its distribution in the Sunset Country, where it is widespread but rare
+	R	D?	This attractive little snake is a nocturnal, burrowing species which feeds on lizards. It is found in sandy and loamy areas in the northern parts of the study area
	R	D?	The curl snake is generally associated with alluvial soils in the north of the study area, where it shelters in ground crevices. It is nocturnal and rarely encountered
+	R	?	Little is known about this small, burrowing snake. In Victoria it is known only from the Big Desert, where it is rarely encountered
+	V	D	Once widespread across northern Victoria, this burrowing snake appears to have declined markedly in the State. It is a specialist feeder on blind snakes, and once known from a variety of drier habitats

Appendix XII

AREAS OF IMPORTANCE FOR SELECTED VERTEBRATES

This list is not exhaustive nor is it presented in order of priority. Only areas important for some significant and notable species are included, and many of the areas listed (as well as many not listed) may be of equal importance for other species not considered here.

Areas	Species
Annuello block	Mallee ningaui Mitchell's hopping-mouse Black-eared miner Striated grasswren Western brown snake Coral snake
Big Desert (widespread)	Little pygmy-possum Mitchell's hopping-mouse Mallee ningaui Malleefowl Red-lored whistler Striated grasswren Bardick *Unechis spectabilis*
Big Desert (north)	Western whipbird? Black-eared miner Night parrot?
Big Desert (south)	Rufous calamanthus *Amphibolurus norrisi* *Tympanocryptis lineata* *Varanus rosenbergi* *Egernia multiscutata*
Big Desert (south-west)	Kori bustard Western whipbird
Big Desert (heathlands)	Western pygmy-possum Silky mouse Slender-billed thornbill
Bronzewing Wildlife Reserve	Little pygmy-possum Malleefowl Coral snake
Chenopod plains (north of the Sturt Highway)	Inland dotterel Ground cuckoo-shrike Curl snake
Copi Plains (north-west of the Sunset Country)	Red kangaroo Various raptors

Appendix XII (continued...)

Areas	Species
Cullulleraine area	Paucident planigale
	Grey falcon
	Tessellated gecko
Grasslands (native remnants in the east)	Plains-wanderer
	Red-chested button-quail
	Bush thick-knee
	Delma impar
Hattah--Kulkyne area	Mallee ningaui
	Red kangaroo
	Greater long-eared bat
	Mitchell's hopping-mouse
	Regent parrot
	Mallee emu-wren
	White-bellied sea-eagle
	Scarlet-chested parrot
	Barking owl
	Gilbert's whistler
	Striated grasswren
	Long-thumbed frog
Kerang wetlands	Freckled duck
	White-bellied sea-eagle
	Brolga
	Plains-wanderer
	Bush thick-knee
	Red-chested button-quail
	Painted snipe
	Latham's snipe
	Barking owl
	Rufous calamanthus
	Grey-crowned babbler
	Carpet python
	Long-thumbed frog
	Morethia adelaidensis
	Curl snake
Lake Tyrell	Rufous calamanthus
	Tympanocryptis lineata
	Morethia adelaidensis
Lindsay Island area	Paucident planigale
	Regent parrot
	Carpet python
	Tessellated gecko
	Eastern water skink
	Curl snake
Liparoo State forest	Painted honeyeater
	Spotted bowerbird
	Tessellated gecko

Appendix XII (continued...)

Areas	Species
Murray River (riverine forests generally)	Feathertail glider Large-footed myotis Yellow rosella Barking owl Carpet python Long-thumbed frog
Murray River (Boundary Bend to Colignan)	Regent parrot Carpet python
Murray River (west of Mildura)	Eastern water skink Red-naped snake Fierce snake
Outlet Creek (including the Wyperfeld park and Lake Albacutya)	Kori bustard Freckled duck Latham's snipe Bush thick-knee White-bellied sea-eagle Regent parrot Barking owl
Pine Plains	Red kangaroo White-browed treecreeper
Quambatook area	Hooded scaly-foot
Raak Plain	Rufous calamanthus *Morethia adelaidensis*
Red Cliffs to Merbein area	*Lerista muelleri*
Roadside vegetation remnants (north of the Sunset Country)	Various raptors
Robinvale area	Spotted bowerbird
Sunset Country (north)	Mallee ningaui Scarlet-chested parrot Yellow-faced whip snake Western brown snake Coral snake Bandy-bandy
Sunset Country (south)	Little pygmy-possum Mallee ningaui Red-lored whistler Mallee emu-wren Black-eared miner Gilbert's whistler Striated grasswren Yellow-faced whip snake Western brown snake

Appendix XII (continued...)

Areas	Species
Sunset Country (grassland plains)	Red kangaroo Greater long-eared bat *Tympanocryptis lineata*
Timberoo Flora and Fauna Reserve	White-browed treecreeper
Walpolla Island	Paucident planigale Long-thumbed frog Tessellated gecko Eastern water skink
Wandown Wildlife Reserve	Malleefowl
Wathe Wildlife Reserve	Little pygmy-possum Striated grasswren Malleefowl *Aprasia aurita*
Wyperfeld National Park (north)	Malleefowl
Yarrara Flora and Fauna Reserve	White-browed treecreeper Gilbert's whistler Beaked gecko Coral snake

Appendix XIII

MAMMAL SPECIES NOW EXTINCT IN THE MALLEE

This lists the species recorded during the Blandowski expedition (1856--57), to the junction of the Murray and Darling Rivers, that are no longer present in the region. Those believed to have occurred on the Victorian side of the river are indicated by the symbol 'x' before the common name.

Scientific name	Common name
Antechinomys laniger	xKultarr
Dasyurus geoffroii	xWestern quoll
Myrmecobius fasciatus	Numbat
Phascogale calura	xRed-tailed phascogale
Chaeropus ecaudatus	xPig-footed bandicoot
Isoodon sp.	xBrown bandicoot species
Macrotis lagotis	Bilby
Perameles bougainville	xWestern barred bandicoot
Bettongia leseuer	Burrowing bettong
Bettongia penicillata	xBrush-tailed bettong
Lagorchestes leporides	Eastern hare-wallaby
Onychogalea fraenata	xBridled nail-tail wallaby
Onychogalea lunata	Crescent nail-tail wallaby
Leporillus apicalis	xLesser stick-nest rat
Leporillus conditor	xGreater stick-nest rat
Pseudomys desertor	xDesert mouse
Pseudomys gouldii	Gould's mouse
Pseudomys hermannsburgensis	xSandy inland mouse

Appendix XIV

DISTRIBUTION OF GROUND-DWELLING INVERTEBRATES IN MAJOR HABITATS

Invertebrate taxa	Major habitat categories																				
	Dune-fields of the Sunset Country				Dune-fields of the Big Desert		Dune-fields; underlying sandstone ridge				Lunettes and ridges			Evaporative Basin		Riverine plain and alluvial terraces				
	East--west dune mallee	Chenopod mallee	Shallow-sand mallee	Deep-sand mallee	Dune-crest tree-heath	Mallee heath	Broombush mallee	Red-swale mallee	Big mallee	Yellow gum woodland	Pine--buloke woodland	Belah woodland	Savannah woodland	Gypseous plains grassland	Saline shrubland	Alluvial-plain shrubland	Alluvial-rise shrubland	Black box--chenopod woodland	Black box woodland	River red gum forest
Thysanura	*	*	*	*		*	*		*	*		*	*	*		*		*	*	*	
Blattodea	*	*	*	*		*	*		*	*	*	*	*	*	*			*	*	*	*
Isoptera		*					*										*				
Manotodea	*	*	*	*		*	*		*	*								*	*		*
Orthoptera	*	*	*	*		*	*		*	*	*	*	*	*	*	*	*	*	*	*	*
Phasmatodea	*	*	*	*			*			*			*					*			
Hemiptera	*	*	*	*		*	*		*	*	*	*	*	*	*	*	*	*	*	*	*
Coleoptera	*	*	*	*		*	*		*	*	*	*	*	*	*	*	*	*	*	*	*
Diptera	*	*	*	*			*			*			*	*	*			*	*		*
Lepidoptera	*	*	*	*		*	*		*	*	*	*	*	*	*			*	*	*	*
Hymenoptera	*	*	*	*		*	*		*	*	*	*	*	*	*	*	*	*	*	*	*
Formicoidea	*	*	*	*		*	*		*	*	*	*	*	*	*	*	*	*	*	*	*
Scorpionida	*	*	*	*		*	*		*	*	*	*	*	*	*			*	*	*	*
Araneae	*	*	*	*		*	*		*	*	*	*	*	*	*	*	*	*	*	*	*
Opiliones		*	*				*		*	*											*
Diplopoda	*	*	*	*			*		*	*		*	*								*
Chilopoda	*	*	*	*		*	*		*	*	*	*	*	*	*	*	*	*	*	*	*
Symphyla		*																			
Isopoda	*	*	*	*		*	*					*	*			*	*	*	*	*	*
Gastropoda																			*		
Oligochaeta						*	*		*	*										*	*

Notes:

1. A number of habitats were not sampled and do not appear on this table. A complete inventory of the major habitats is listed under Note 3 to Appendix X.

2. An additional table listing the distribution of ground-dwelling beetle species in major habitats is appended to the original report to the Council.

Appendix XV

FISH IN THE MALLEE

Common name	Scientific name	Murray River	Avoca River	North Loddon River	Lake Albacutya	Species of recreational or commercial value	Relative abundance
Australian smelt	Retropinna semoni	X	X	X			+
Bony bream	Nematalosa erebi	X	X	X		X	+
Brown trout	*Salmo trutta	X	X	X		X	+
Crimson-spotted rainbowfish	Melanotaenia splendida fluviatilis	X	X				+
European carp	*Cyprinus carpio	X	X	X	(1)	X	+++
Flatheaded galaxian	Galaxias rostratus		X	X			+
Flatheaded gudgeon	Philypnodon grandiceps	X	X	X			+
Freshwater catfish	Tandanus tandanus	X	X	X		X	+
Freshwater hardyhead	Craterocephalus stercusmuscarum	X	X	X			+
Golden perch	Macquaria ambigua	X	X	X		X	++
Goldfish	*Carassius auratus	X	X	X			+++
Lake Eyre hardyhead	Craterocephalus eyresii			X			+
Long-finned eel	Anguilla reinhardtii	X					(2)
Macquarie perch	Macquaria australasica	X					(3)
Mosquitofish	*Gambusia affinis	X	X	X			+++
Murray cod	Maccullochella peeli	X	X	X		X	+
Redfin	*Perca fluviatilis	X	X	X	(1)	X	+++
River black-fish	Gadopsis marmoratus	X		X		X	+
Short-finned eel	Anguilla australis	X		X			(2)
Shortheaded lamprey	Modacia mordax	X					+
Silver perch	Bigyanus bidyanus	X	X	X		X	++
Southern pigmy perch	Nannoperca australis	X					+
Southern purple-spotted gudgeon	Mogurnda adspersa	X					+
Tench	*Tinca tinca	X	X	X		X	+++
Trout cod	Maccullochella macquariensis	X				X	(3)
Western carp gudgeon	Hypseleotris klunzingeri	X	X	X			+++
Western chandra perch	Ambassis castelnaui	X					+

Notes:

(1) Lake is now dry (1987)
(2) Few individuals - outside normal range
(3) Present occurrence in Mallee uncertain
* Introduced species

Appendix XVI

REFERENCES USED IN PREPARATION OF CHAPTER 8 - FAUNA

Ahern, L.D., Brown, P.R., Robertson, P., and Seebeck, J.H. (1985). Application of a taxon priority system to some Victorian vertebrate fauna. *Arthur Rylah Institute Environmental Research Technical Report* No. 32.

Aitken, P.F. (1977). The little pygmy-possum *Cercartetus lepidus* (Thomas) found living on the Australian mainland. *South Australian Naturalist*, 51, 63--6.

Anderson, A.N., and Yen, A.L. (1985). Immediate effects of fire on ants in the semi-arid mallee region of north-western Victoria. *Australian Journal* of *Ecology*, 10, 25--30.

Andrew, M.H., and Lange, R.T. (1986). Development of a new piosphere in arid chenopod shrubland grazed by sheep: changes to soil surface; changes to the vegetation. *Australian Journal of Ecology*, 11, 395--410; 411--24.

An Old Bushman (1861). Notes of a tour in the Wimmera District. *The Yoeman and Australian Acclimatizer*, 1.

Archer, M. (1975). *Ningaui*, a new genus of tiny dasyurids (Marsupialia) and two new species, *N. timealeyi* and *N. ridei* from arid Western Australia. *Museum of Queensland, Memoirs*, 17, 237--49.

Armstrong, J.A. (1979). Biotic pollination mechanisms in the Australian flora - a review. *New Zealand Journal of Botany*, 17, 467--508.

Ashby, E. (1918). Notes on some birds met with in the neighbourhood of Pungonda. *Emu*, 17, 219--20.

Balzer, L. (1981). The effect of the European honeybee (*Apis mellifera*) on Australian native bees. *Honours thesis, School of Biological Services, University of Sydney.*

Barritt, A.K., and Mowling, F.A. (1979). 'The Natural Vegetation of the Murray Lands. Results of a 1978 survey of the S.A. Murray Lands south and east of the River Murray.' (Nature Conservation Society of South Australia: Adelaide.)

Bernhardt, P., and Walker, K. (1984). Bee foraging on three sympatric species of Australian *Acacia*. *International Journal of Entomology*, 26, 322--30.

Bond, H.W., and Brown, W.L. (1979). The exploitation of floral nectar in *Eucalyptus incrassata* by honeyeaters and honeybees. *Oecologia*, 44, 105--11.

Burbidge, A. (1985). The regent parrot. A report on the breeding distribution and habitat requirements along the Murray River in south-eastern Australia. *Australian National Parks and Wildlife Service Report* No. 4.

Burbidge, A., Fuller, P., Johnson, K., and Southgate, R. (1987). Vanishing desert dwellers. *Landscope*, 2(4), 7--12.

Appendix XVI (continued...)

Caughley, J. (1985). Effect of fire on the reptile fauna of the Mallee. In 'Biology of Australian Frogs and Reptiles', ed. G. Grigg, R. Shine, and H. Ehmann. pp. 31--4 (Royal Zoological Society of New South Wales, with Surrey Beatty and Sons: Sydney.)

Chandler, L.G. (1913). Bird life of Kow Plains (Victoria). *Emu*, 13, 33--45.

Charley, J.L., and Cowling, S.W. (1968). Changes in soil nutrient status resulting from over-grazing and their consequences in plant communities of semi-arid areas. *Proceedings, Ecological Society of Australia*, 3, 28--38.

Cockburn, A. (1981a). Diet and habitat preference of the silky desert mouse, *Pseudomys apodemoides* (Rodentia). *Australian Wildlife Research*, 8, 475--97.

Cockburn, A. (1981b). Population processes of the silky desert mouse, *Pseudomys apodemoides* (Rodentia), in mature heathlands. *Australian Wildlife Research*, 8, 499--514.

Cogger, H.G. (1986). 'Reptiles and Amphibians of Australia.' 4th ed. (Reed: Sydney.)

Cogger, H.G., Cameron, E.E., and Cogger, H.M. (1983). 'Zoological Catalogue Australia: Amphibia and Reptilia.' (Australian Government Publishing Service: Canberra.)

Department of Conservation, Forests and Lands (1987). 'Conservation in Victoria. 1: Plants and Animals at Risk' (Government Printer: Melbourne.)

Dixon, J.M. (1978). The first Victorian and other Victorian records of the little pygmy possum *Cercartetus lepidus* (Thomas). *Victorian Naturalist*, 95, 4--7.

Douglas, A.M. (1977). Some inimical effects of the domestic bee on the native fauna and flora. *Western Australian Naturalist*, 14, 1--2.

Favaloro, N. (1940). The spotted bower bird in Victoria. *Emu*, 39, 273--7.

Fleming, M.R., and Cockburn, A. (1979). *Ningaui*: a new genus of dasyurid for Victoria. *Victorian Naturalist*, 96, 142--4.

Ford, H.A. (1979). Interspecific competition in Australian honeyeaters - depletion of common resources. *Australian Journal of Ecology*, 4, 145--64.

Ford, H.A., and Paton, D.C. (1976). The value of insects and nectar to honeyeaters. *Emu*, 76, 83--4.

Ford, H.A., and Paton, D.C. (1982). Partitioning of nectar sources in an Australian honeyeater community. *Australian Journal of Ecology*, 7, 149--59.

Appendix XVI (continued...)

French, C. (1888). Notes on the zoology of Lake Albacutya district. *Victorian Naturalist*, 5, 35--42.

Frith, H.J. (1962). Conservation of the malleefowl *Leipoa ocellata* Gould (Megapodiidae). *CSIRO Wildlife Research*, 7, 32--49.

Gell, P. A. (1985). Birds of remnant mallee isolates at Wedderburn: a biogeographic approach to nature reserve delineation and management. *Monash Publications in Geography* No. 31.

Graetz, R.D., and Tongway, D.J. (1986). Influence of grazing management on vegetation, soil structure and nutrient distribution and the infiltration of applied rainfall in a semi-arid chenopod shrubland. *Australian Journal of Ecology*, 11, 347--60.

Hill, L. (1982). The effect of the honeybee on native plants and animals. *Bogong*, 3 (6), 7---9.

Hopper, S. P. (1980). Bird and mammal pollen vectors in *Banksia* communities at Cheyne Beach, W.A. *Australian Journal of Botany*, 28, 61--75.

Howe, F.E., and Tregellas, T.H. (1914). Rarer birds of the Mallee. *Emu*, 14, 71--84.

Hunt, T. (1976). Birds in the Big Desert region of Victoria and South Australia. *Victorian Ornithological Research Group Notes*, 12 (2), 3--13.

Hunt, T. (1979). Habitat preferences of birds in the Big Desert. *Victorian Ornithological Research Group Notes*, 15 (2), 43--53.

Jones, E., and Coman, B.J. (1981). Ecology of the feral cat, *Felis catus* (L.), in south-eastern Australia. 1. Diet. *Australian Wildlife Research*, 8, 537--47.

Joseph, L. (1986). The decline and present status of the black-eared miner in South Australia. *South Australian Ornithologist*, 30, 5--13.

Kenyon, A.S. (1982). The story of the Mallee (reprinted from original publication of 1914--15). *Victorian Historical Magazine*, 4.

Kitchener, D.J., and Caputi, N. (1985). Systematic revision of Australian *Scoteanax* and *Scotorepens* (Chiroptera: Vespertilionidae), with remarks on relationships to other Nycticeiini. *Records of the Western Australian Museum*, 12, 85--146.

Kitchener, D.J., Chapman, A., Dell, J., Muir, B.G., and Palmer, M. (1980). Lizard assemblage and reserve size and structure in the Western Australian wheatbelt - some implications for conservation. *Biological Conservation*, 17, 25--62.

Appendix XVI (continued...)

Kitchener, D.J., Chapman, A., Muir, B.G., and Palmer, M. (1980). Conservation value for mammals of reserves in the Western Australian wheatbelt. *Biological Conservation*, 18, 177--205.

Kitchener, D.J., Dell, J., Muir, B.G., and Palmer, M. (1982). Birds in Western Australian wheatbelt reserves - implications for conservation. *Biological Conservation*, 22, 127--63.

Kitchener, D.J., Stoddart, J., and Henry, J. (1983). A taxonomic appraisal of the genus *Ningaui* Archer (Marsupalia: Dasyuridae), including description of a new species. *Australian Journal of Zoology*, 31, 361--79.

Koopman, K.F. (1984). Taxonomic and distributional notes on tropical Australian bats. *American Museum Novitates Report* No. 2778, 1-48.

Krefft, G. (1866). On the vertebrated animals of the lower Murray and Darling, their habits, economy, and geographical distribution. *Transactions of the Philosophical Society of New South Wales*, 1, 1--38.

Land Conservation Council (1974). 'Report on the Mallee Study Area.' (Government Printer: Melbourne.)

Littlejohn, M.J. (1966). Amphibians of the Victorian Mallee. *Proceedings of the Royal Society of Victoria*, 79, 597--604.

Littlejohn, M.J., and Rawlinson, P.A. (1971). Amphibians and reptiles of Victoria. *Victorian Year Book* No. 85, 1--36.

Lucas, A.H.S., and Frost, C. (1893). The lizards indigenous to Victoria. *Proceedings of the Royal Society of Victoria*, 6, 25--92.

McKee, E. (1986). Some thoughts on bees. *Parkwatch*, 146, 22.

McMahon, A. (1985). Fire management objectives in the Mallee region - fuel reduction *vs* conservation. *Parkwatch*, 142, 8--11.

Mather, P.B. (1979). An examination of the reptile fauna of Wyperfeld National Park using pitfall trapping. *Victorian Naturalist*, 96, 98--101.

Matthews, E. (1984). To bee or not ...?! Bees in national parks? The introduced honey bee in conservation parks in South Australia. *People Parks and Preservation*.

Mattingley, A.H.E. (1909). In the heart of the mallee. *Victorian Naturalist*, 26, 64--7.

Menkhorst, P.W. (1982). Pitfall trapping of reptiles in the Big Desert, Victoria. *Victorian Naturalist*, 99, 66--70.

Appendix XVI (continued...)

Menkhorst, P.W. (1983). Working list of Victorian mammals. *Arthur Rylah Institute of Environmental Research, Technical Report* No. 7.

Moore, R. M. (1959). Ecological observations on plant communities grazed by sheep in Australia. *Monographiae Biologicae*, 8, 500--13.

Morton, S.R., and Baynes, A. (1985). Small mammal assemblages in arid Australia: an appraisal. *Australian Mammalogy*, 8, 159--69.

Rawlinson, P.A. (1966). Reptiles of the Victorian Mallee. *Proceedings of the Royal Society of Victoria*, 79, 605--19.

Rolls, E. (1969). 'They All Ran Wild.' (Angus and Robertson: Sydney.)

Saunders, D.A. (1979). The availability of tree hollows for use as nest sites by white-tailed black cockatoos. *Australian Wildlife Research*, 6, 205--16.

Scheltema, M. (1981). To bee or not to bee: honeybee utilization of national parks in Western Australia. (*Unpublished thesis, Murdoch University.*)

Schodde, R., and Tidemann, S.C. (eds.) (1986). 'Readers Digest Complete Book of Australian Birds.' (2nd. ed.) (Reader's Digest Services: Sydney.)

Simpson, K.N.G. (1973). Amphibians, reptiles and mammals of the Murray River region between Mildura and Renmark, Australia. *Memoirs of the National Museum of Victoria*, 34, 275--9.

Strahan, R. (ed.) (1983). 'The Australian Museum Complete Book of Australian Mammals.' (Angus and Robertson: Sydney.)

Thompson, M.B. (1983). Populations of the Murray River tortoise, *Emydura* (Chelodina): the effect of egg predation by the red fox, *Vulpes vulpes*. *Australian Wildlife Research*, 10, 363--71.

Waite, E.R. (1918). A review of the Australian blind snakes (Fam. Typhlopidae). *Records of the South Australian Museum*, 1, 1--38.

Waite, E.R. (1929). 'The reptiles and amphibians of South Australia.' (Harrison Weir: Adelaide.)

Wakefield, N.A. (1966a). Mammals of the Blandowski expedition to north-western Victoria. *Proceedings of the Royal Society of Victoria*, 79, 371--91.

Wakefield, N.A. (1966b). Mammals recorded for the Mallee, Victoria. *Proceedings of the Royal Society of Victoria*, 79, 627--36.

Wilson, F.E. (1912). Oologists in the Mallee. *Emu*, 12, 30--39.

Appendix XVII

THE AUSTRALIAN HERITAGE COMMISSION

This Commonwealth statutory authority was established under the *Australian Heritage Commission Act* 1975 as the government's policy, advisory, and administrative body responsible for the National Estate. The National Estate is defined in the legislation as 'those places, being components of the natural environment of Australia, or the cultural environment of Australia, that have aesthetic, historic, scientific or social significance or other special value for future generations, as well as for the present community'.

Australia's National Estate is thus a wide-ranging concept that covers a variety of features.

The natural environment includes:

- national parks, nature reserves, and other places for the protection of flora and fauna
- the coastline and islands
- inland water expanses, rivers, lakes, and other wetlands
- special land forms, geological features, caves, forests, woodlands, and grasslands
- areas of scientific interest

The cultural environment includes:

- Aboriginal rock art sites, ceremonial grounds, and sacred sites
- Aboriginal quarries and shell mounds, camp sites, and fishtraps
- important historic and archaeological sites (both Aboriginal and European) such as old missions and cemeteries
- historic buildings and structures, either individual or in groups, including sawmills, tramlines, loading wharves, derricks, punts, equipment, and their relics
- historic towns and precincts

Establishment of the Heritage Commission

Public response to the original Committee of Inquiry into the National Estate (which reported to Federal Parliament in 1974) demonstrated that Australians do have a strong concern for the environment and that the cause of much previous neglect and destruction was a lack of public education regarding the need and means to preserve the National Estate. The Committee of Inquiry therefore recommended the establishment of a national body to be concerned with national policy and co-ordination. As a signatory to several international conventions and recommendations (the most important of these being the World Heritage Convention), Australia also has an international responsibility to protect its National Estate. Accordingly the *Australian Heritage Commission Act* was passed in 1975 and the first Commission was appointed in 1976.

Functions

One of the Commission's major responsibilities is to prepare and maintain the Register of National Estate places. This will thus form an inventory of the significant parts of the cultural and natural environment of Australia.

Compilation of the comprehensive Register will take many years and will be a continuing process, but all registrations will have the same status irrespective of the time of their entry. The Register has no gradings between different categories of places, and all places registered are professionally assessed in terms of the National Estate values.

The effect of registration

Registration of a place formally recognizes its National Estate values and in turn imposes some constraints on the actions of Commonwealth Ministers and authorities. The Act provides that Commonwealth Ministers and their agencies must not take any action that would adversely affect any place in the Register - unless there is no feasible or prudent alternative, unless all action is taken to minimize damage where no such alternative exist, and unless the Commission is informed and given time to comment. The Commission, under its Act, has no power with respect to the action that may be taken by State governments, local governments, private landowners, or institutions, nor does it imply any particular attitude by the Commission or the Commonwealth to the ownership, management, or use of a place listed in the Register.

Registration of a natural area does not, for example, mean that the Commission or the Commonwealth holds a view that the area should be a national park or public reserve. Rather, it means that the place has been recognized as an important component of the National Estate. The significance of the area might have been retained or enhanced because of or in spite of past management. Registration, therefore, should not be interpreted as endorsing or condemning any particular management practice or regime.

Traditional uses such as forest harvesting and silviculture, farming, fishing, recreation, and water regulation would be permitted to continue, as these have influenced the landscape as it presently exists and have played a role in the development of Australia.

Nomination of places for the Register

Any member of the public is entitled to nominate a place for the Register, and a special form has been prepared to assist in this regard. As the project is an ongoing one, places may be nominated at any time.

Before registration of a place, the Commission is required to enter it on an interim list and to inform the community of this through a public notice. Any individual or organization may lodge in writing to the Commission an objection to the proposed registration. The minimum time for public comment is 3 months from the date of public notice.

Appendix XVIII

RECREATION OPPORTUNITIES

The recreation opportunity spectrum approach, adopted by the Department of Conservation, Forests and Lands, assumes that the best way to provide for the diverse recreation needs of the community is to establish and maintain a variety of recreation settings. In these settings, recreation experiences will be influenced by the degree of development of access and facilities, the level of use, and the evident presence of management.

The Department has identified five major settings or classes for recreation, ranging from remote to developed:

Class I	Remote
Class II	Semi-remote
Class III	Roaded natural
Class IV	Semi-developed
Class V	Developed

The use of the recreation opportunity spectrum approach enables opportunities to be examined on either a State-wide or a regional level. In a preliminary State-wide assessment, the Department identified the proportion of public land that occurs in each of the above five recreation classes. The following table indicates the area of each major parcel of public land in the Mallee area in each class. It shows that almost 80% of the major blocks in the Mallee can be classified as offering remote or semi-remote recreation.

Semi-developed and developed recreation opportunities only require small areas of land to satisfy the needs of many people, since facility development tends to be concentrated into specific areas. Opportunities for such recreation can often be found on private or municipal lands, since facilities (for example major campgrounds or recreation centres) are either commercially viable or are best located close to urban centres.

Appendix XVIII (continued...)

RECREATION OPPORTUNITIES OF MAJOR AREAS OF PUBLIC LAND IN THE MALLEE (Preliminary assessment)

Park or reserve	Area (ha)	Symbol on Map 8	Remote (ha)	Semi-remote (ha)	Roaded natural (ha)	Semi-develop (ha)	Develop (ha)
Abbotsford/Bottle Bend	3 860	E2	0	0	3 860	0	0
Annuello block	50 000	S1	5 000	32 500	12 500	0	0
Appin/Leaghur forest	1 950	E6	0	0	1 950	0	0
Belsar/Yungera Islands	3 250	E8	0	0	3250	0	0
Big Desert	230 000	S1	23 000	161 000	46 000	0	0
Big Desert Wilderness	113 500	B1	102 150	11 350	0	0	0
Boundary Bend/Piangil	4 270	E5	0	0	3 843	427	0
Bronzewing Wildlife Res	11 200	D5	1 680	5 040	4 480	0	0
Bushland - Mildura	9 431	VAR	0	0	6 602	2 829	0
Hattah--Kulkyne National P	48 000	A2	0	28 800	19 200	0	0
Kings Billabong Wildlife R.	2 200	D1	0	0	1 760	440	0
The Marshes	2 840	D8	0	0	2 840	0	0
Lake Albacutya park	10 700	A4	0	5 350	5 350	0	0
Lake Timboram FF Reserve	2 060	G28	0	0	1 854	206	0
Lake Tyrrell	18 000	S1	0	2 700	13 500	1 800	0
Lake Wahpool	1 740	S1	0	609	870	261	0
Lambert Is/Graces Bend	2 800	E3	0	0	2 660	140	0
Lindsay Island	15 000	S1	2 250	7 500	5 250	0	0
Murray River park	1 550	A5	0	0	1 550	0	0
Pine Plains	30 000	S1	0	0	24 000	6 000	0
Pink Lakes State Park	50 700	A3	0	30 420	20 280	0	0
Potterwakagee/Wallpolla	11 600	E1	0	8 120	2 320	1 160	0
Recreation - Mildura	1 662	VAR	0	0	499	1 163	0
Red Bluff Wildlife Res.	9 800	D6	4 900	3 920	980	0	0
Sunset Country	595 000	S1	416 500	119 000	59 500	0	0
Tarpaulin B/Bonyaricall Ck	7 200	E4	0	720	6 480	0	0
Wandown Wildlife Reserve	1 591	D3	0	1 193	398	0	0
Wathe Wildlife Reserve	5 763	D4	0	4 610	1 153	0	0
Wyperfeld National Park	100 000	A1	25 000	60 000	15 000	0	0
Yarrara Flora and Fauna Res	2 700	G1	0	1 755	945	0	0
Total:	1 348 367		580 480	484 588	268 873	14 427	0
%	100		43	36	20	1	0

Note: For some of these areas, recreation is a secondary use, provided it does not conflict with management aims.

Appendix XIX

VEHICLE-BASED VISITOR FACILITIES IN MALLEE PARKS

Recreation areas	1	2	3	4	5	6
Major campground	*		*	*		
Minor campground/s	*				*	*
Dispersed camping	*	*			*	*
Visitor/interpretative centre	*		*			
Picnic facilities	*		*	*	*	*

* Indicates presence of visitor facilities

1 Hattah--Kulkyne National Park
2 Murray--Kulkyne Park
3 Wyperfeld National Park
4 Lake Albacutya Park
5 Pink Lakes State Park
6 Murray River areas

Note:

Camping facilities for walking groups are also available in the Wyperfeld National Park.

Appendix XX

DRYLAND AGRICULTURAL STATISTICS
March 1986

Item	Millewa		Central Mallee		Big Desert		Annuello		Tyrrell and Avoca		Murray River	
	Magnitude	% change since 1975	Magnitude	% change since 1975	Magnitude	% change since 1975	Magnitude	% change since 1975	Magnitude	% change since 1975	Magnitude	% change since 1975
Area freehold land (ha)	600 000		580 000		80 000		250 000		1 175 000		220 000	
Number of holdings	100	-15	340	-15	90	-18	170	-15	1 350	-15	100	-15
Av. holding size (ha)	6 000		1 700		890		1 450		870		2 200	
Area wheat (ha)	80 000	+40	98 000	+10	23 000	+5	65 000	+10	333 000	+15	40 400	+35
Area barley (ha)	7 600		28 000	+50	7 700	+60	18 000	+50	97 000	+50	9 300	+40
Area field peas (ha)	-		2 000	new crop	4 000	new crop	4 000	new crop	27 000	new crop	3 000	new crop
Intensity of cropping (% of freehold)	15	+35	28	+33	43	+43	37	+20	43	+26	25	+38
Av. wheat yields 1974--85 (tonne/ha)	1.00		1.30		1.40		1.30		1.70		1.20	
Range (tonne/ha)	0.09--1.45		0.30--2.20		0.16--2.70		0.25--2.22		0.20--2.90			
Av. barley yield 1974--85 (tonne/ha)	0.70		0.90		1.00		1.00		1.15		0.90	
Range (tonne/ha)	0.16--1.10		0.27--1.60		0.08--2.07		0.17--1.59		0.10--2.00			
Sheep numbers	106 000	-25	269 000	-20	46 000	-35	122 000	-10	778 000	-30	65 000	-18
Av. stocking rate 1974--85 (sheep/ha)	0.4		0.95		1.5		1.05		1.8		1.4	
Beef cattle numbers	1 000	-70	3 800	-65	300	-90	2 400	-70	8 000	-85	1 000	-70
Pig numbers	500	-70	3 900	+50	770	-30	2 300	-25	23 300	-	500	-70

Regional subdivisions are indicated on Figure 1.

Appendix XXI

DRY SHEEP EQUIVALENTS

The carrying capacity of grazing land or the intensity of grazing is usually expressed in terms of Dry Sheep Equivalent (DSE). The basic unit is the Merino wether (35--45 kg liveweight) maintained in good store condition by an intake of feed yielding 7 MJ of metabolizable energy per day. This unit enables both vegetation and stock to be related to an adult dry sheep or wether.

The conversion factor used for other stock is the average over 12 months, which takes into account the variation in food requirements for the year.

DSEs for the various stock types are:

wethers	1.0
ewes	1.8
weaners	0.5
rams	2.0
beef cows	15.0
beef yearlings	8.0
2-year-old steers	14.0
beef bulls	14.0
horses	18.0

Appendix XXII

NOXIOUS WEEDS OF THE MALLEE

Common name	Scientific name	Growth habit	Main infestations
Amsinckia	*Amsinckia* spp.	Erect annual	Cropping land south-east and central west
Bathurst burr	*Xanthium spinosum*	Spreading annual	Widespread
Bindweed	*Convolvulus arvensis*	Perennial herb	Mildura
Blackberry bramble	*Rubus fruticosus*	Perennial shrub	Swan Hill, Kerang, especially along streams
Boneseed	*Chrysanthemoides monilifera*	Perennial shrub	Small infestations near townships
Boxthorn	*Lycium ferocissimum*	Perennial shrub	Widespread
Buffalo burr	*Solanum rostratum*) *S. cornutum*)	Erect annual	Limited, near Ouyen and south of Mildura
Californian burr	*Xanthium orientale*	Spreading annual	Floodplains of the Murray River, other wetlands
Caltrop (bindii)	*Tribulus terrestris*	Prostrate summer annual	Widespread, especially stockyards and sidings
Camel thorn	*Alhagi pseudalhagi*	Erect perennial shrub	Limited - Mildura, Ouyen, Swan Hill
Colocynth	*Citrullus colocynthis*	Prostrate perennial	Meringur, Swan Hill, Red Cliffs
Dodder (golden dodder)	*Cuscuta* spp.	Twining parasitic annual	Mildura, Swan Hill, along Murray River
Dropping prickly pear	*Opuntia vulgaris*	Erect succulent perennial	Mildura, Ouyen
Erect prickly pear	*Opuntia stricta*	Erect succulent perennial	Widespread, especially Mildura, Wycheproof
Fennel	*Foeniculum vulgare*	Erect perennial	Near towns and watercourses

Appendix XXII (continued...)

Common name	Scientific name	Growth habit	Main infestations
Five-spined saltbush	*Sclerolaena muricata*	Native spreading perennial	Scattered; roads and railways
Headheads (thistle)	*Centaurea repens*	Erect perennial	Cropping land and vineyards
Hemlock	*Conium maculatum*	Annual/biennial herb	Watercourses in central south; limited
Hoary cress	*Cardaria draba*	Perennial herb	Follows railway lines, especially Mildura, Wycheproof
Horehound	*Marrubium vulgare*	Perennial herb	Widespread; heaviest in State
Ivy-leaf sida	*Sida leprosa*	Semi-erect/prostrate perennial	Swan Hill, Kerang Shire
Khaki weed	*Alternanthera pungens*	Creeping perennial	Southern Mallee
Musk weed	*Myagrum perfoliatum*	Erect perennial	Limited; south-central watercourses (chiefly Wimmera)
Noogoora burr	*Xanthium pungens*	Erect annual	Major river systems
Nut grass	*Cyperus rotundas*	Perennial sedge	Near towns and roadsides
One-leaf Cape tulip	*Homeria breyniana*	Erect perennial	Limited; east and south-east
Onion weed	*Asphodelus fistulosus*	Annual, biennial, or perennial herb	Widespread, especially grazing lands
Pampas lily-of-the-valley	*Salpichroa origanifolia*	Semi erect/prostrate perennial	Ouyen, Kerang Shire
Paterson's curse	*Echium plantagineum*	Erect annual/biennial	Widespread
Poverty weed	*Iva axillaris*	Erect perennial	Swan Hill, Boort
Prairie ground cherry	*Physalis lanceolata*	Erect perennial	Limited; Birchip, Kerang
Saffron thistle	*Carthamus lanatus*	Erect annual	Widespread
St Barnaby's thistle	*Centaurea solstitialis*	Erect annual	Swan Hill
St John's wort	*Hypericum perforatum*	Perennial herb	Limited; beside rivers and roads, Swan Hill
Sand rocket	*Diplotaxis tenuifolia*	Erect perennial	Along railway easements
Silver-leaf night-shade (Whitehorse nettle)	*Solanum elaeagnifolium*	Erect perennial	Patches in cropping areas
Skeleton-weed	*Chondrilla juncea*	Erect perennial	Widespread
Slender/shore thistle	*Carduus tenuiflorus*) *C. pycnocephalus*)	Erect annuals	Kerang, Swan Hill

Soldier thistle	*Cirsium acarna*	Erect annual	Channels and watercourses
Soursob	*Oxalis pes-caprae*	Perennial herb	Widespread in croplands
Spear thistle	*Cirsium vulgare*	Erect biennial	Widespread in north and east croplands
Spiny burr grass	*Cenchrus longispinus*	Erect or spreading annual; occasionally short-lived perennial	Cultivated areas and channels
Spiny emex	*Emex australis*	Prostrate annual	Roadsides, cereal crops, some unfarmed areas
Spiny rush	*Juncus acutus*	Erect perennial	Low-lying areas near watercourses
Star thistle	*Centaurea calcitrapa*	Erect bushy annual/ biennial	Roadsides and channels
Stemless thistle	*Onopordum acaulon*	Prostrate annual	Widespread
Stinkwort	*Dittrichia graveolens*	Annual herb	Roadsides
Sweet briar	*Rosa rubiginosa*	Perennial shrub	Roadsides; Kerang
Thorn apples	*Datura ferox*) *D. innoxia*) *D. stramonium*)	Erect annuals	Along river-banks; dense in irrigation areas
Tree of heaven	*Ailanthus altissima*	Perennial tree	Near towns and farmhouses
Variegated thistle	*Silybum marianum*	Erect annual	Kerang and Wycheproof
Wheel cactus	*Opuntia robusta*	Erect succulent perennial	Mildura and eastern areas
Wild garlic	*Allium vineale*	Perennial herb	Limited; on roadsides
Wild melon	*Citrullus lanatus*	Prostrate annual	Eastern and southern
Wild mignonette	*Reseda luteola*	Annual/biennial herb	Limited; Ouyen and south-east

Appendix XXIII

RABBIT CONTROL AT HATTAH--KULKYNE

A major rabbit problem has existed in the Hattah--Kulkyne National Park for many years. The Land Conservation Council made particular mention of this in its 1977 recommendations. 'The Hattah--Kulkyne area has had the worst rabbit infestation in Victoria. Enormous resources have been and continue to be used to control this pest, and the managing authority will need special resources to maintain and extend the necessary control work.'

Numerous control measures had been tried in the 20 years prior to 1980. However, this work - involving poisoning, ripping of warrens, and release of *Myxoma* virus - was not integrated. Control was undertaken mainly when rabbits reached high numbers, without any concerted attempt to maintain rabbit populations at low levels.

In 1980, the Department of Conservation, Forests and Lands produced a plan for rabbit control in the park. This plan - which aimed not only at efficiently reducing the rabbit population but also at maintaining rabbit numbers at a low level - has been in operation since 1981. It has involved four phases of control. The first involved temporary reduction of populations in key areas by ripping, fumigation, and the use of poison and *Myxoma* virus.

The construction of 60 km of rabbit-proof fencing to divide portion of the park into manageable blocks formed the critical second phase of the plan. Fences are important in preventing recolonization of treated areas. The remaining phases of control have been repeated in each fenced block.

Heavy knockdown of rabbit populations was then achieved using 1080-poisoned carrot in late summer. Poisoning has been effective in gaining a 90% to 95% kill, and no follow-up poisoning has been required.

To avoid damage to native wildlife, the Department carried out pre-poison surveys. They avoided brushtail possum colonies in the poison runs and herded red kangaroos, which are susceptible to 1080, away from the drop-zones. Following each 1080 poison operation, they undertook surveys of the drop-zones over a period of 3 days and gathered dead rabbits to avoid secondary poisoning of native fauna that prey on rabbits. The death of any non-target species was recorded. No deaths of native wildlife have been recorded during the more recent poisoning programs.

Intensive ripping of warrens and fumigation through each block followed the poisoning.

The fourth stage of the program involved the maintenance of treated areas. Pressure fumigator units were introduced in 1983, and three units are currently maintaining 12 000 ha.

Appendix XXIII (continued...)

Monitoring rabbit numbers is a key part of maintenance operations.

To avoid re-infestation of the blocks, the Department has treated areas outside the rabbit-proof fencing by low-level poisoning, ripping, and fumigation.

Fencing and the initial poisoning and ripping are estimated to cost $72.48 per ha, based on 1987 prices. Subsequent maintenance costs are $4.83 per ha per year.

COST OF RABBIT CONTROL, HATTAH--KULKYNE PARK (per hectare)

	Initial costs	Annual maintenance
Fencing	$ 24.28[1]	$ 0.50[2]
Ripping	36.50	2.00
Poisoning	10.44[3]	2.13[4]
Monitoring	3.26[5]	0.20[6]
Totals[7]	$ 72.48	$ 4.83

Notes:
1. Fence construction based on a 2500-ha block
2. Annual maintenance of fences
3. 1080-poisoned carrot
4. Pressure fumigation
5. Protection of native wildlife
6. Rabbit census
7. Costs are expressed at 1987 values

At the present rate of work, the Department expects to achieve an acceptable level of control within the fenced portions of the park by the end of 1988.

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